Data Services Transmission Requirements and Data Test Sets

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DATA SERVICES TRANSMISSION REQUIREMENTS AND VOICE BANDWIDTH DATA TEST SETS

PREFACE

Objective

The objective of the Data Services Transmission Requirements and Voice Bandwidth Data Test Sets field maintenance practice (FMP) is to furnish the Special Services, Central Office, and other interested field forces with information concerning voice bandwidth data transmission requirements and measurement techniques.

Plan of Text

In general, the information provided consists of Bell System Practices pertaining to private line data and DATAPHONE® transmission requirements and associated data test sets. For information not contained in this manual, refer to the standard BSP files.

The FMP consists of eight parts, each part dealing with a particular aspect of data services transmission. The page number for each part is shown consecutively at the top of the page with the part number preceding the page number (1-1, 2-1, 3-1, etc). The page number of each page in the practice is retained at the bottom of the page for cross-reference purposes.

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PART I

DATA GENERAL

DATA GENERAL

ANALOG TRANSMISSION PARAMETERS DESCRIPTION

DATA TRANSMISSION SYSTEMS

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1. GENERAL

1.01 This section describes the parameters, terms, and abbreviations associated with data transmission that are common to private line (PL) channels, the Public Switched Network (PSN), and Switched Services Networks (SSN).

1.02 Whenever this section is reissued, the reason(s) for reissue will be given in this paragraph.

1.03 This section augments the following Bell System Practice (BSP) layers:

- 309-200-ZZZ—Switched Services Networks Using Central Office Switching Machines
- 309-300-ZZZ—Enhanced Private Switched Communications Service (EPSCS)
- 309-400-ZZZ—Electronic Tandem Network (ETN)
- 314-205-ZZZ—DATAPHONE® System—Transmission Maintenance, Loops, and Trunks
- 314-410-ZZZ—Private Line Data Circuits

Information specific to any of the systems or networks is located in the respective layer.

2. ABBREVIATIONS AND COMMON TERMS

2.01 This part provides abbreviations and common terms used in voice bandwidth data service as well as definitions of unique terms.

A. Abbreviations

2.02 A listing of abbreviations that may be encountered in data service and circuit terminology is as follows:

AML—Actual measured loss

BER—Bit error rate

BIT—Binary digit

BLER—Block error rate

CCSA—Common control switching arrangement

CLR—Circuit layout record

CO—Central office

CPE—Customer provided equipment

CRT—Cathode-ray tube

DAS—Data auxiliary set

DATEC—Data technical support

DS—Data set

DTS—Data test set

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EML—Expected measured loss

FCC—Federal Communication Commission

HPDC—High-performance data conditioning

LC—Local channel

MODEM—Modulator-demodulator (data set)

NCO—Network control office

OCC—Other common carrier

OTC—Operating telephone company

PCO—Plant control office

PL—Private Line

S/N—Signal-to-noise ratio

SSN—Switched service network

TELCO—Telephone company

TDM—Time division multiplexer

TLP—Transmission level point

TMS—Transmission measuring set

B. Common Terms

2.03 A listing and the definition of common terms used in data service and circuit terminology are as follows:

ABSOLUTE DELAY: The total time required for a signal to pass through a network or channel; also called transmission time or circuit delay.

ACTUAL MEASURED LOSS: The actual reading of the transmission measuring set when the test is made under the same test conditions as that for which the EML was computed.

AMPLIFICATION: (1) Gain; (2) the ratio between the output signal power and the input signal power of a device; (3) the strengthening of a weak signal as opposed to attenuation.

AMPLITUDE: The magnitude of a voltage or current waveform measured from zero crossing to peak or peak to peak.

AMPLITUDE MODULATION (AM): A method of transmission whereby the signal wave voltage is impressed upon a carrier wave of higher frequency so that the amplitude of the carrier wave is varied proportionately to the amplitude of the signal wave.

ANALOG DATA: Data represented in a continuous form, as contrasted with digital data represented in a discrete or step type form. Analog data are usually represented by means of physical variables, such as voltage, resistance, and rotation.

ANSWER-BACK (DATA): A signal or tone sent by the receiving customer terminal or data set to the sending station for identification or to indicate it is ready to receive transmission.

ASYNCHRONOUS: Asynchronous data transmission is where the speed of operation is not fixed or controlled by a clock. The duration of the signal element may be variable, and the minimum element duration is controlled by the bandwidth. No clock lead is provided between the data set and the customer's terminal equipment.

ASYNCHRONOUS TRANSMISSION: Transmission in which each information character is individually synchronized (usually by the use of a start element and stop elements).

ATTENUATION: The difference between transmitted and received power due to transmission loss through equipment, lines, or other communication devices.

ATTENUATION DISTORTION: A characteristic of a transmission facility whereas the difference in loss between the 1004 Hz reference frequency and each of the other frequencies within the band of interest is expressed in dB. Attenuation distortion is a multifrequency measurement whereas slope is a three frequency measurement.

ATTENUATION EQUALIZER: Any device inserted in a transmission line or amplifier circuit to improve the shape of its frequency response.

BALANCED TO GROUND: The state of impedance on a 2-wire line when the impedance to ground as measured from one wire is equal to the impedance to ground as measured from the other wire, contrast with unbalanced (to ground).

BALANCING NETWORK: A network typically made up of inductance, capacitance, and resistance connected so as to simulate the impedance of a uniform cable or open-wire circuit over a band of frequencies. Typically, balancing networks are used with hybrids to make the 2-wire side electronically look like the 4-wire side.

BAND: A frequency range between two defined limits.

BANDPASS FILTER: A device inserted into a circuit which blocks all frequencies outside a designated bandwidth, but does not inhibit those frequencies within the bandwidth.

BANDWIDTH: The band or range of frequencies to be transmitted which a transmission system will accept without undue loss or distortion.

BASEBAND: In the process of modulation, the frequency band occupied by the aggregate of the transmitted signals when first used to modulate a carrier.

BAUD: The baud is a unit of signaling speed; the speed in bauds is equal to the number of signaling elements or symbols per second. For binary symbols the signaling rate in bits per second is equal to the speed in bauds. The term "baud" is often used erroneously as a synonym for bit.

BENCHMARK: A point of reference from which measurements can be made.

BENCHMARK MEASUREMENTS: These are measurements made on a loopback or 1-way basis when the PL data circuit is known to meet all requirements. They are performed immediately following the completion of installation and circuit order tests, and the results are recorded for later reference purposes.

BINARY: A basic 2-state (0 or 1, on or off) numbering system used by a computer. All data is represented by series of 0s and 1s called bits. The position of each bit has a specific numerical value; when put together, they form machine words.

BINARY SYNCHRONOUS TRANSMISSION: Data transmission in which synchronization of characters is controlled by timing signals generated at the sending and receiving stations.

BIT: A unit of information content. Contraction of "binary digit," a bit is the smallest unit of information in a binary system of notation. It is the choice between two possible states, usually designated one or zero or a mark or a space.

BIT RATE: The speed at which bits are transmitted, usually expressed in bits per second (b/s).

BRIDGE: A device used to interconnect more than two middle and/or end links on multipoint circuits.

BRIDGED TAP: Nonworking cable pair which is connected to a working cable pair. It exists because of cable runs which were made beyond the station-provided service, also, dead-end distribution branches or branches that run to other stations on a multiparty line.

BROADBAND: A communications channel that has sufficient frequency bandwidth to accommodate the transmission of signals wider than voice range.

BUSINESS MACHINE: In data communications, customer-provided equipment that connects to common carrier communication services for the purpose of data movement.

CHANNEL: An electrical communications path between two or more points, derived in such a manner as the TELCO may select.

CHANNEL CONDITIONING: The selection of facilities and/or the electrical balancing of a channel to match transmission levels and impedances and to equalize transmission loss and delay to establish standards and to control C-notched noise to signal ratio and intermodulation distortion.

CIRCUIT LAYOUT RECORD (CLR): The document on which is recorded all pertinent information of a customer's service including facility, station, and central office layout.

CUSTOMER-PROVIDED EQUIPMENT (CPE): Any data set and/or terminal equipment which is provided by the customer.

DATA: Any nonvoice representations, such as digital characters or analog quantities, to which meaning might be assigned.

DATA AUXILIARY SET (DAS): Provides an interface between the channel and the station equipment. The DAS also provides circuit functions that are necessary for complete operation of the data set or station.

DATA COMMUNICATION: The transmission and reception of data, often including operations such as coding, decoding, and validation.

DATA MOUNTING: Coded subassemblies intended primarily to provide physical facilities for mounting other apparatus in a cabinet or other supporting structure.

DATAPHONE SERVICE: A registered service mark of AT&T which identifies the transmission of data over the PSN. Implies the use of Bell System data sets connected to the PSN. Facility characteristics must meet stated requirements, and data error performance is specified.

DATA SET: Coded apparatus which, at a minimum, provides a modulator and/or demodulator function to transform customer terminal signals to line signals and vice versa. It may include control and supervisory functions on a standard or optional basis. Also known as modem.

DATA SET CLOCK: A time base oscillator supplied by the data set for regulating the bit rate of transmission; contrast with customer terminal clocking.

DATA STATION: Arrangements of coded apparatus which together perform all required functions for the associated customer terminal. Includes the data set, channel termination, wiring, DAS, CPE, etc.

DATEC: Data technical support—a support plan and designated personnel who are responsible for technical assistance to field repair personnel in cases of escalated data problems. This also refers to a mandatory escalation procedure from the field supervision level to the associated company headquarters and AT&T to seek quick resolution of complex technical problems.

DATA TEST CENTER (DTC): The telephone company test center which is responsible for remote testing of data station equipment.

dBm: Decibel reference to one milliwatt. This is employed in communication work as a measure of absolute power. Zero dBm equals 1 milliwatt.

DEGRADATION: A condition in which the system continues to operate but at a reduced level of performance.

DELAY EQUALIZER: A network which makes the phase delay or envelope delay essentially constant over a desired frequency range.

DIGITAL LOOPBACK: This test checks, from one location, both data sets (local and remote) in conjunction with the transmission facility. This test is performed with the data set self-test feature or a 914- or 921-type data test set.

DIGITAL SIGNALS: Signals which can only assume certain discrete values. For

example, in a system which contains binary digital signals, only "0" and "1" (that is, the presence or absence of a pulse) can exist during a specified time period.

DUPLEX, FULL: Method of operation of a communications circuit where each end can simultaneously transmit and receive (usually a 4-wire circuit). When used on a 2-wire circuit, full duplex operation requires different frequencies. A full duplex service can be used in a half duplex manner.

DUPLEX, HALF: Permits one direction electrical communications between stations. Technical arrangements may permit operation in either direction but not simultaneously. Therefore, this term is qualified by one of the following suffixes: S/O for send only, R/O for receive only, S/R for send or receive.

DYNAMIC TEST: A check of a data communications system whereby test data is sent at the customer bit rate to check out TELCO lines and data sets in an error performance test.

EIA INTERFACE: A set of electrical specifications established by the Electronic Industries Association (EIA) that standardizes the physical, electrical, and functional characteristics at the point of connection between the data set and data terminal.

EXPECTED MEASURED LOSS: The expected reading, in dB, of a transmission measuring set connected to a prescribed test point at one end of a circuit when a specific power (usually 1004 Hz at 0 dBm) is applied to a prescribed test point at the other end of the circuit.

END LINK: The facility between a central office relay switching location (not switched services network [SSN]) or a bridging location and the transmission interface at the customer premises. This definition holds regardless of whether the end link consists of only a local channel or of intercity facilities and a local channel.

EQUALIZATION: The process of reducing amplitude vs frequency and/or phase distortion of a circuit by the introduction of networks to compensate for the difference in attenuation and/or time delay at the various frequencies in the transmission band. (See definition for attenuation equalizer and delay equalizer.)

EQUAL-LEVEL LOOPBACK: A circuit arrangement interconnecting the receive and transmit paths and correcting for any differences in the signal level at the point of connection. The simplest way to accomplish this is to interconnect two identical data levels, for example, at a -16 dBm point to another -16 dBm. To interconnect a -16 dBm receive point with a 0 dBm transmit point, an amplifier with 16 dB of gain would be required in the loopback path. This ensures that signals on the line are maintained at standard data level during loopback tests when a test signal at data level is applied toward the customer station.

ERROR PERFORMANCE: The ratio of the number of bits, elements, characters, or blocks incorrectly received to the total number of bits, elements, characters, or blocks transmitted.

FACILITY: Any transmission system (eg, carrier system or cable) used (or available for use) in furnishing a communication service.

FOUR-WIRE CIRCUIT: A communication path in which four wires (two for each direction of transmission) are presented to the station equipment. Ideally, transmit and receive paths are isolated.

FOUR-WIRE TERMINATING SET: An arrangement by which 4-wire circuits are terminated on a 2-wire basis for interconnection with 2-wire circuits. See HYBRID COIL.

FREQUENCY: The number of times per second a current or voltage alternates, given in hertz (formally cycles per second).

GAIN: (1) Amplification. (2) The ratio of output voltage, current or power to the input voltage, current or power, respectively, in an amplifier stage, receiver or system, usually expressed in dB.

GROUND: Fundamentally the earth or an electrical connection to earth or to a common conductor usually connected to earth.

GROUNDING: The process or procedure of connecting to ground or to a conductor which is grounded.

HERTZ (Hz): The frequency of a waveform (formerly cycles per second). See FREQUENCY.

HIGH SPEED: Usually, data transmission rate above 2400 b/s.

HOLDING TONE: A single frequency (1004 Hz) applied at the transmitting end of a circuit or channel to simulate a data signal. It is put on at data level (-13 dBmO) and operates compandors and other signal-dependent devices. It is then filtered out at the receive end with a notched filter, and C-notched or signal-dependent noise can be measured.

HYBRID COIL: An arrangement using one or more transformers wired as a balanced bridge to provide 2- to 4-wire conversion for long-distance telecommunication circuits.

IMPEDANCE: The total opposition (resistance and reactance) afforded the flow of current in an alternating current circuit.

ISOCHRONOUS: Isochronous data transmission is a process such that between any two significant instants there is always an integral number of unit intervals. Basically, it is synchronous data transmission, but there is no clock lead provided between the data set and customer's terminal equipment. Therefore, the timing is provided by the customer's terminal equipment.

LOCAL CHANNEL: Generally considered to be that portion of the circuit extending between the customer premises and the nearest toll office which may include interoffice facilities and equipment.

LOOP: An abbreviated designation for the cable pair used to serve a customer from a local serving central office; also called subscriber line (switched service), station line (private line service), or access line.

LOOPBACK: A type of test in which the receive pair of a 4-wire facility is connected to the transmit pair so that the test signal can be received at the same point from which it was transmitted. The term also refers to the hardware that provides the receive pair to transmit pair connection.

LOW SPEED: Usually data transmission rate below 600 b/s.

MAP PLAN: Minimum acceptable performance plan specifies minimum limits for critical transmission parameters which affect data transmission on the switched message network. The plan is intended to aid in identifying those connections on which frequent or consistent substandard transmission performance is experienced.

MASTER STATION: The one station of a multistation circuit that communicates with each remote station and has circuit control.

MEDIUM SPEED: Usually, data transmission rate between 600 b/s and 2400 b/s.

MEGAHERTZ (MHz): 1,000,000 cycles per second, previously called megacycle.

MIDDLE LINK: The facility or facilities between central office switching and/or bridging locations. The connection between two bridges in the same central office is not considered to be a middle link.

End link and middle link definitions apply only to multipoint and central office relay switched circuits.

MILLISECOND: One-thousandth of a second, abbreviated ms.

MODEM: A device to modulate and demodulate signals transmitted over telephone circuits. Often used interchangeably with the term data set.

MULTIPOINT CIRCUIT: A circuit connecting three or more stations by using

bridges to interconnect more than two end links.

NETWORK CONTROL OFFICE (NCO): A designated office responsible for the coordination of all maintenance activities involving two or more circuits or links in a network.

OPEN: A condition in which a transmission path is severed so that signals cannot pass.

PARAMETER: A definable characteristic of an item, device, or system.

PHASE: The position of a point on the waveform of an alternating or other periodic quantity with respect to the start of the cycle, usually expressed in degrees.

PLANT CONTROL OFFICE (PCO): The designated office responsible for all maintenance activities on a circuit or circuit link. The PCO maintains records for each circuit or circuit link and should be informed of all trouble reports.

REGISTERED EQUIPMENT: Terminal equipment allowed to connect directly to the network that complies with Part 68 of the FCC rules and regulations and has been granted a registration number.

SEALING CURRENT: The low level direct current applied to a cable pair to break down a high resistance film which may build up at splices.

SIGNAL-TO-NOISE RATIO (SNR): The relative power of the signal to the noise in a channel.

SLOPE: Usually the term is used in connection with the attenuation distortion characteristic of a transmission facility and is the difference in loss between two frequencies and a reference frequency. The frequencies are 404 and 2804 Hz with the reference frequency of 1004 Hz. Slope is the 3-frequency measurement as opposed to attenuation distortion which is the multifrequency measurement.

SPECIAL SERVICE CENTER (SSC): Formally serving test center (STC), a test center with responsibilities for the maintenance and installation of specially installed and maintained services (SIMS).

STATIC TEST: Those tests performed on a data set either locally or remotely to measure such parameters as frequency, level, and receiver sensitivity.

SYNCHRONOUS: Synchronous data transmission is a fixed rate bit stream having a constant time interval during successive bits, characters, or events.

TARIFF: The published description for a specific unit of equipment, facility, or type of service provided by a communications common carrier; also, the vehicle by which the regulating agencies approve or disapprove such facilities or services. Thus, the tariff becomes a contract between customer and common carrier.

TIME SHARING: A method of operation in which a computer facility is shared by several users for different purposes.

TRANSMISSION ASSEMBLIES: Tariffed arrangements of facilities, equipment, and permitted interconnections with other suppliers. In all assemblies, the customer is responsible for overall performance. When various components of an assembly are combined, an acceptable transmission performance may or may not result. Therefore, no overall transmission performance, including error rate performance, is either specified or implied. See Section 314-010-103.

TRANSMISSION SYSTEMS: Networks or services provided by a telephone company (TELCO) where an expected overall performance is specified and maintained and, on data services, TELCO recommended channels and modems must be used in order to state an expected error rate performance level as defined in various Bell System publications. See Section 314-010-103.

TURNAROUND TIME: The time required for a data set to respond to another data set's signal. This includes the round trip

propagation time of the facility and the clear-to-send and request-to-send of one data set.

UNBALANCED TO GROUND: The state of impedance on a 2-wire line when the impedance to ground as measured from one wire is unequal to the impedance to ground as measured from the other wire.

VOICE FREQUENCY: That portion of the audio frequency range which is used to transmit speech and other information, usually between the limits of 300 to 3400 Hz.

VOICE-GRADE CHANNEL: A channel capable of transmitting that portion of the voice frequency spectrum suitable for speech, digital or analog data, or facsimile signals, generally with a frequency range of about 300 to 3000 Hz.

WIDEBAND: A term applied to facilities or circuits whose bandwidths are greater than that required for one voice channel, allowing for much higher data speeds.

3. DATA TRANSMISSION PHILOSOPHY

3.01 The increasing use of electronic data processing methods has led to the accelerated need for more and better communication channels. These channels must be able to accept and deliver messages in machine language, which is predominantly digital.

3.02 Modern data transmission is considered as an outgrowth of telegraph transmission. The differences are mainly in the trend toward higher bit rates and more extensive interconnections by switched networks. Existence of analog facilities which already serve similar needs for other types of communication has provided the momentum for the adaptation for data on the many transmission media originally designed for voice signals.

3.03 Digital signals must be converted to analog signals before they can be transmitted over analog facilities. The modem (data set) provides this conversion. The modem ***mod***ulates the digital signal in the form of an analog signal at one end of the channel and ***dem***odulates the analog signal back to the digital format at the other end of the channel, hence the term modem.

3.04 Data transmission channels are subject to several impairments. These impairments cause the received signal to be distorted from that which was transmitted. Impairments, when expressed with values are known as parameters. The parameters that affect voiceband data are described in Part 4.

4. DEFINITION OF TRANSMISSION PARAMETERS

4.01 Parameters are the attributes of the physical properties that determine the characteristics of the channel. The parameters listed in this section do not all apply to the three types of channels (PL, PSN, or SSN). Refer to the applicable BSP layer for the specific parameters relating to that type of channel.

4.02 The parameters are listed in the order in which they are to be tested for maintenance purposes. For the testing technique and test sets associated with each parameter, refer to Section 314-010-101.

Continuity

4.03 Continuity is the uninterrupted electrical connection free of opens (open connections) and grounds (one or both sides of the electrical path to ground). Simply, continuity is the completed path from transmitter to receiver.

1004-Hz Loss

4.04 Also known as loss, loss deviation, net loss, insertion loss, and gain, 1004-Hz loss is the difference in dB between any send point and any receive point. The send and receive points are found on the CLR. In terms of 1004-Hz loss, a reduction of level is given a positive (+) representation; gain (increase in level) is given a negative (-) representation.

4.05 Loss in transmission is calculable and is usually controlled by design. However, where excessive, loss is generally caused by a trouble condition. Local cable trouble conditions might include excessive or loaded bridged tap and improper loading. Examples of central office loss trouble conditions are:

Faulty components on carrier systems

Poor solder connections

Unterminated bridge ports.

C-Notched Noise

4.06 C-notched noise is a measure of the amount of noise on a channel with a signal present. The signal, called 1004-Hz holding tone, is ***transmitted at data level*** and is used to operate compandors on carrier systems. The ratio of the receive signal and the noise power is indicative of the signal-to-noise ratio on the channel.

4.07 In addition to the same noises found during the message circuit noise test, C-notched noise can detect singing, listener echo, and quantizing noise. In order to identify the type of noise detected during the C-notched noise test, it is necessary to use the audio monitor on the output of the noise test set.

Impulse Noise

4.08 Impulse noise consists of large amplitude peaks of noise or power that occur unpredictably in infrequent bursts against a relatively quiet background. The data signal error rate is seriously affected by impulse noise of sufficient magnitude and frequency of occurrence. Impulse noise is measured in terms of the number of peaks or hits which exceed a specified threshold during a specified time period. Only peaks and/or hits of 4 ms or less are considered impulse noise. (See hits and dropouts for hits lasting longer than 4 ms).

4.09 Some of the major causes of impulse noise are lightning, relay operations in switching centers, radio fading and the subsequent protection switching, and quantizing associated with digital carrier systems.

Phase Jitter

4.10 Phase jitter is seen as unwanted phase or frequency modulation of a transmitted signal. Various sources can cause the irregular and random movement of the instantaneous phase or zero crossings of a signal. The most common cause of phase jitter is dc power supply ripple in the master oscillator of long-haul carriers and then passing through the many stages of frequency multiplexing. Phase jitter can be detected in two frequency ranges. The two ranges are Bell (between 20 and 300 Hz) and low frequency (between 4 and 20 Hz).

Gain Slope (3 Tone)

4.11 Gain slope is the attenuation distortion of a channel characterized by the loss at two frequencies in relation to the loss at 1004 Hz. The two frequencies, 404 Hz and 2804 Hz, are each compared to the reference frequency and not to each other.

Peak-to-Average Ratio

4.12 The peak-to-average ratio (P/AR) procedure simultaneously measures the gain and phase distortion characteristics of the data channel. These characteristics (envelope delay distortion, bandwidth compression, and return loss) are evaluated by transmitting a train of precisely shaped pulses over the data channel. These pulses, having a known envelope peak to full-wave average ratio, are measured at the receiving end to determine to what extent that ratio has changed. The P/AR receiver meter is calibrated from 0 to 100. A rating of 100 indicates no change in the ratio. A rating of zero means a 50-percent change.

4.13 The P/AR procedure is simple, fast, and a single-number measure of overall quality of a data circuit. It is ideal for use as ***benchmark*** testing after determining that the overall attenuation distortion and envelope delay distortion measurements are within limits. The test equipment is largely insensitive to noise, attenuation distortion, phase jitter, intermodulation distortion, and frequency shift when within limits.

Attenuation Distortion

4.14 Amplitude characteristics, frequency response, gain deviation, and amplitude distortion are alternate terms for attenuation distortion. Attenuation distortion is the difference in loss of many frequencies with respect to the loss at a reference frequency. It is specified by placing a limit on the maximum gain and loss at any frequency in a specified band of frequencies with respect to the loss at 1004 Hz.

4.15 Like loss, attenuation distortion is also calculable and controlled by design. Where out-of-limits attenuation distortion is calculated, attenuation equalizers can be included in the design of the circuit. Excessive distortion is generally caused by a trouble condition similar to those affecting loss.

Where a trouble condition exists, care must be taken not to add equalizers to the circuit but to repair the trouble.

Intermodulation Distortion

4.16 Previously referred to as harmonic distortion and then nonlinear distortion, intermodulation distortion is the term used for multitone nonlinearities. Harmonic and nonlinear distortion refer to the degradation of a signal caused by its harmonics. Since most distortion occurs at the second and third harmonic, the amount of distortion is measured by the power of each of these harmonics and is called second and third harmonic distortion. Total harmonic distortion is the sum of the powers of all harmonics. Each harmonic power is referenced to the wanted signal (the fundamental).

4.17 Some modems transmit multiple tones simultaneously. To match the data circuit in its operational mode, intermodulation distortion is measured by transmitting four equal level tones with a composite signal power at nominal data signal level. Two of these tones are closely spaced around a center frequency "A" (860 Hz), and the other two tones are centered around a center frequency "B" (1380 Hz). The second order distortion is determined from the B-A and B+A products, while the third order distortion is determined from the 2B-A product.

Hits and Dropouts

4.18 Gain and phase hits are moderate changes (greater than 3 dB) in the amplitude or phase of a signal lasting for at least 4 ms and returning to the original value within 220 ms. A change lasting ***less than*** 4 ms is classified as impulse noise. A change in amplitude and phase lasting longer than 220 ms is considered a gain or phase change.

4.19 A major cause of gain and phase hits is the switching to backup facilities in long-haul carrier. Likewise, a gain change could occur should the backup facility be lined up at a different transmission level. As a result, gain hits are more common than phase hits.

4.20 Dropouts are short duration impairments in which the transmitted signal experiences a sudden drop in power, to the extent that the signal is undetectable. They have been defined as any sudden decrease in level equal to or greater than 12 dB which lasts longer than 4 ms. Dropouts are a serious form of performance degradation with over 40 percent lasting longer than 200 ms. They usually occur rather infrequently but have been observed to occur at a rate greater than once per hour.

4.21 Dropouts are caused by the same forms of incidental modulation that cause phase jitter, gain hits, and phase hits. In addition, dropouts are caused by maintenance activities such as facility patching.

Return Loss

4.22 Return loss is the difference in dB between the power of a transmitted signal on a channel and its reflected power at an impedance discontinuity. An impedance discontinuity can be defined as an unbalanced hybrid or on impedance mismatch. The signal reflection at an impedance discontinuity is a greater transmission impairment than the loss of the signal transmitted through the discontinuity.

Single Frequency Interference

4.23 Single-frequency interference, also known as single-tone interference, is the presence of one or more unwanted steady tones on a channel. This form of noise is commonly detected by the use of the audio monitoring arrangement on the output of a C-message noise test set. Other methods of detection are by the use of the frequency selective voltmeter and spectrum analyzer test sets.

4.24 Common causes of single-frequency interference are singing repeaters, crosstalk, and cross-modulation of single-frequency signaling tones. Occasional bursts of low-amplitude signals that occur from crosstalk of multifrequency signaling are not considered single-frequency interference.

Frequency Offset

4.25 Frequency offset, also called frequency shift, may exist on single sideband suppressed carrier systems. This offset is the result of the difference in frequency between the modulating and demodulating carriers. The resulting frequency offset contributes a constant change at all frequencies in the frequency spectrum.

Envelope Delay Distortion (EDD)

4.26 Sometimes referred to as delay, delay distortion, envelope delay, and relative delay, envelope delay distortion is not to be confused with absolute delay. (Absolute delay is defined as the time it takes for a signal to traverse between the input and output of a network or transmission medium.) Envelope delay distortion measurements indicate the difference between the delay at any frequency and that at a reference frequency. In the voiceband, the reference frequency is usually 1700 or 1800 Hz. The reference frequency should be the fastest frequency or the frequency of minimum delay.

4.27 Envelope delay distortion is also a calculable impairment and is controlled by design. Like attenuation distortion, equalizers can be included in the design of the circuit to maintain the circuit within the limits of the prescribed conditioning. A common source of delay distortion is that due to the sharp cutoff characteristics of analog multiplex equipment associated with channel banks. A second source of delay distortion is the roll-off characteristics of long lengths of loaded cable.

5. REFERENCES

5.01 The following documents provide additional information on facilities and equipment that may be associated with private line voiceband data service.

DOCUMENT	DESCRIPTION
AT&T PUB 41004	Data Communications Using Voiceband Private Line Channels—October 1973
AT&T PUB 41005	Data Communications Using The Switched Telecommunications Network—Revised May 1971
AT&T PUB 41006	Attenuation and Envelope Delay Characteristics from the 1969-70 Switched Telecommunications Network Connection Survey—June 1973
AT&T PUB 41007	1969-70 Switched Telecommunications Network Connection Survey (Reprints of Bell System Technical Journal Articles)—April 1971
AT&T PUB 41008	Transmisson Parameters Affecting Data Transmission—Description of Parameters—July 1974
AT&T PUB 41009	Transmission Parameters Affecting Voiceband Data Transmission—Measuring Techniques—January 1972
314-410-100	Voice Bandwidth Private Line Data Circuits—Description
314-410-101	Voice Bandwidth Private Line Data Circuits—Transmission Requirements of Bell System Data Sets
314-410-102	Voice Bandwidth Private Line Data Circuits—End-to-End Transmission Performance
314-410-103	Voice Bandwidth Private Line Data Circuits—Overseas Circuit
314-410-104	Voice Bandwidth Private Line Data Circuits—Circuit Conditioning Requirements Using the Collins CLA-101A System
314-410-300	Voice Bandwidth Private Line Data Circuits—Maintenance
314-410-500	Voice Bandwidth Private Line Data Circuits—Tests and Requirements
Volume 1 Principles	Telecommunications Transmission Engineering—Second Addition—1977
Volume 2 Facilities	Telecommunications Transmission Engineering—First Addition—1977
Volume 3 Networks and Services	Telecommunications Transmission Engineering—Second Addition—1977

NOTES

DATA GENERAL

DATA TESTING PRINCIPLES

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Appendix 1

1. GENERAL

1.01 This section provides the testing principles used when performing data transmission maintenance and preservice tests on circuits and trunks for private line (PL) service, the Public Switched Network, (PSN) and Special Service Networks (SSN). These testing principles include testing access, testing arrangements, recommended order of maintenance tests, and a means of identifying probable trouble locations.

1.02 This section is being reissued to change transmission limits throughout. Since this is a general revision, no revision arrows have been used to denote significant changes

1.03 This section augments Bell System Practice Division 309, Switched Services Networks; Bell System Practice layer 314-205-ZZZ, DATAPHONE® Data Communications Service—Transmission Maintenance, Loops, and Trunks; and Bell System Practice layer 314-410-ZZZ, Private Line Data Circuits. Information specific to any one of these services can be found in the appropriate sections covering the service.

2. TEST ACCESS

2.01 There may be several points where transmission tests can be made. The choice of access

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should be at a known impedance and test level. When making transmission tests on the local channel, transmission equipment, eg, pads, repeat coils, and amplifiers, are considered part of the facility and must be included in the tests. Pads, repeat coils, and amplifiers can also be components of equipment, eg, Metalic Facility Terminal (MFT) and channel interface unit (CIU), also known as Data Auxiliary Set (DAS) 829.

2.02 Access to circuits is available through manual testboards and test positions, eg, private line board, 19A testboard, 6-jacks, and full period talk (FPT) jacks. Bay mounted or portable test equipment must be plugged into the test jacks through test cords. Manual testing requires at least one other tester with similar equipment at another point on the circuit.

2.03 Access to circuits is also available from remote locations through a Switched Access Remote Test System (SARTS). Remote testing gives a tester the ability to access and test a circuit without the assistance of another tester in a distant office. Bay mounted or portable test equipment may be required for certain tests.

2.04 The actual SARTS access of circuits is provided by Switched Maintenance Access Systems (SMAS). Access point information for SMAS is found in Section 667-000-001.

3. DATA LEVEL

3.01 Data level is the signal power for a steady tone or combination of tones which meet loading objectives for broadband carrier systems. Signal power is expressed in decibels referenced to 1 milliwatt supply (abbreviated dBm) terminated into 600 ohms. Combination of tones (composite power) is discussed in paragraphs 3.07 and 3.08 .

3.02 The data levels at the various test points indicated on the circuit layout record (CLR) card must be maintained. High levels (signal power stronger than allowed) can cause overloading in our carrier systems. Low levels (signal power weaker than required) can reduce the signal-to-noise ratio.

3.03 The design rules for the use of data levels vary from service to service. Because of the differences, the rules applying data levels to PL, PSN, and SSN are discussed separately. Regardless of the design of the circuit, ***all tests are performed at data level.***

Private Line

3.04 The rules which are used in the design of PL data or alternate voice-data channels are as follows:

(a) The data level at the MOD-IN JACK of a toll grade carrier is normally a −29 dBm and at the DEMOD-OUT JACK is normally a −6 dBm.

(b) The standard data modem transmit power is 0 dBm at the CIU. Any pads, amplifiers, and equalizers are considered part of the channel.

(c) The standard 1004-Hz net loss of a channel should be one of the following:

(1) For use between data sets—16 dB

(2) For use between 4-wire tel sets—16 dB

(3) For use between 2-wire tel sets—10 dB

(d) The data transmit level for both 2-wire and 4-wire alternate voice/data channel is 0 dBm.

(e) The data level at the entrance to exchange cables at both the central office (CO) and customer premises locations should not be greater than −8 dBm. In special situations, this level can be in the range of −6 dBm to −16 dBm.

Public Switched Network

3.05 The rules which are used in the design of data service on the PSN are as follows:

(a) The FCC registration program is designed to control the output of the data set. The maximum transmitting data level for any data set is adjusted so that normally it will not exceed −12 dBm at the main frame of the dial tone office.

(b) The data level at the MOD-IN JACK of a toll-grade carrier is to be no higher than a −29 dBm and at the DEMOD-OUT JACK is to be no higher than a −6 dBm.

Switched Services Networks

3.06 The rules which are used in the design of data services on SSN are as follows:

(a) Data levels are 13 dBm below transmission level points (TLP).

(b) The level at the MOD-IN JACK of a toll-grade carrier is normally −16 TLP and at the DEMOD-OUT JACK is normally +7 TLP. The data level for the −16 TLP is −29 dBm and for the +7 TLP is −6 dBm.

(c) The standard 4-wire data modem transmit power is −13 dBm at the 0 TLP.

The standard 2-wire data modem transmit power is a −9 dBm at the +4 TLP.

Composite Power

3.07 The output power of each tone of multichannel data sets must be determined. This also applies to multipoint circuits where the remote station data sets transmit simultaneously at different frequencies. Each tone must not exceed the individual power level so as to insure that the composite power does not exceed data levels. When N is the maximum number of tones on a channel and the composite power is 0 dBm, each tone must not exceed (0-10 log N) dBm. When calculating the individual powers of multisignals at the carrier MOD-IN JACK, the formula would be −29-10 log N. Logarithms to the base 10 for from 2 to 30 tones are given in Table A.

3.08 ***Example of test:*** A data set has a maximum of four equal-level tones. So as not to exceed data levels, the maximum power per tone is computed as follows:

Maximum power per tone = 0-10 log (4)

Log 4 from Table A = 0.602

Maximum power per tone = 0-10 (0.602)

Maximum power per tone = −6.02 dBm.

4. TESTING ARRANGEMENTS

4.01 The testing arrangements described in this section correspond to the list of parameters described in Section 314-010-100. These arrangements are listed in the order in which they are to be performed when investigating trouble reports. Part 7 covers the order of tests for installation and routine as well as tests for trouble reports. The SARTS incorporates the test equipment necessary to perform many of the test arrangements listed. For purpose of this section, whenever the type of test equipment is given, SARTS is automatically included except where noted.

TABLE A

LOGARITHMS

CHANNELS	LOGARITHMS	CHANNELS	LOGARITHMS	CHANNELS	LOGARITHMS
2	0.301	12	1.079	22	1.342
3	0.477	13	1.114	23	1.362
4	0.602	14	1.146	24	1.380
5	0.699	15	1.176	25	1.398
6	0.778	16	1.204	26	1.415
7	0.845	17	1.230	27	1.431
8	0.903	18	1.255	28	1.447
9	0.954	19	1.279	29	1.463
10	1.000	20	1.301	30	1.477
11	1.041	21	1.322		

4.02 Operating procedures for test equipment is not included. Operational information must be obtained from manufacturer's manuals or Bell System Practices describing the various test equipment. Information on suitable test equipment is covered in Part 5.

Continuity

4.03 The most convenient way of testing for continuity is with the office milliwatt supply and monitor (earphone, headset, speaker, etc). A tone generator, oscillator, or transmit portion of a transmission measuring set (TMS) may be substituted for the milliwatt supply. For switched services, dial-up milliwatt numbers are used.

4.04 The continuity test checks for an uninterrupted connection between two points. It does not indicate that proper equipment has been installed or properly adjusted.

1004-Hz Loss

4.05 The 1004-Hz loss measurement is typically made with a TMS. The test set must be accurate to ±0.1 dB and capable of receiving an input signal in the level range of +10 dBm to −40 dBm. Straightaway measurements require two test sets. Measurements on access-type lines on switched services use a dial-up tone generator and the receive portion of a TMS.

4.06 The 1004-Hz loss measurements are used to determine the loss of a circuit or overall connection on switched services. In addition, loss measurements are used in conjunction with noise measurements to determine the signal-to-noise ratio.

C-Notched Noise

4.07 A noise measuring test set equipped with a C-notched filter measures the noise in the presence of a signal. This signal, known as a holding tone, is 1004 Hz and is placed on the circuit at data level (−13 dBm0). The test can be a looped or straightaway measurement. In the test for switched services, the holding tone is dial accessed.

4.08 In addition to measuring noise in the presence of a signal, the C-notched noise measurement can also be used to calculate a signal-to-noise ratio. This can be accomplished by subtracting the measurement of noise with tone from a measurement of the same tone made with the C-notched filter reversed in the noise measuring test set. (Reversing the filter disables it, allowing the 1004-Hz tone to be measured.) A listening (monitor) test for impulse noise or single tone interference should be made wherever practicable. If tone interference is detected, every effort should be made to detect the frequency of the tone. Detection of the interfering tone frequency may assist field forces to determine its source, eg, power line hum.

Impulse Noise

4.09 An impulse noise counter equipped with a C-notched filter counts the number of impulse hits occurring above a set threshold in the presence of a 1004-Hz holding tone. As in the case of C-notched noise, the impulse noise test can be a looped or straightaway measurement. In the test for switched services, the holding tone is dial accessed.

4.10 The impulse noise measurement is a record of impulse noise peaks that exceed a given threshold in the voice frequency band of interest. The threshold level is adjustable by an attenuator on the test set. Some impulse noise test sets have multiple attenuators providing multiple thresholds.

Phase Jitter

4.11 Phase jitter is measured with a phase jitter test set using a 1004-Hz holding tone. C-notched noise measurements should always be made in conjunction with phase jitter measurements to assure that noise is not the chief contributor to the phase jitter readings.

4.12 A phase jitter measurement indicates the cumulative effect of incidental phase modulation and additive tones or noise on the zero crossings of the holding tone. To reduce the effect of additive noise, the peak-to-peak deviations in zero crossings are detected after being band limited. The standard limiting band is 20 to 300 Hz and referred to as "Bell."

4.13 Phase jitter is also known to occur below 20 Hz. A second limiting band is used to detect phase jitter in the frequency range of 4 to 20 Hz. This is known as "low frequency" (LF). Phase jitter measurements can be made in three ranges:

- Bell

- LF
- Bell plus LF

Bell plus LF has a frequency range of 4 to 300 Hz. Any two of the three measurements may be specified and are considered a valid measurement. The "Bell plus LF" measurement is not provided in SARTS.

Gain Slope

4.14 Gain slope measurements are typically made with a TMS. Straightaway measurements on a PL circuit or switched connection require two TMSs. On switched access circuits, a step generator is dial accessed in place of the far end TMS.

4.15 Gain slope is the differential loss between 404 and 1004 Hz and 1004 and 2804 Hz. The gain slope measurement may be required for access lines and/or end-to-end connections on the PSN. The gain slope measurement is a recommended benchmark measurement used in conjunction with the peak-to-average ratio (P/AR) measurement on PL and SSN circuits.

Peak-to-Average Ratio (P/AR)

4.16 For P/AR measurements, a P/AR transmitter and a P/AR receiver are connected to opposite ends of a voiceband transmission channel. The transmitter sends a precisely controlled complex pulse train of known peak-to-full-wave average ratio (10 dB) through the channel, where each pulse is altered by the distortions it encounters. The P/AR receiver measures the absolute peak and full-wave rectified average values of the pulse train and displays their ratio on a zero-suppressed scale.

4.17 The P/AR system, after having gone through four generations of implementation, has been demonstrated to be an effective tool in uncovering problems in attenuation distortion, envelope delay distortion (EDD), and return loss. It provides a means for rapid evaluation of these three parameters on trunks and connections. It is essentially impervious to other impairments when they are within normal limits.

4.18 Acceptable P/AR together with acceptable gain slope measurements provide a better than 99 percent assurance factor of acceptable attenuation distortion, return loss, and EDD measurements. P/AR alone can provide a 97 percent assurance factor.

4.19 P/AR limits are strongly tied to the types of facilities used in trunk makeup. This is primarily because the filters in channel banks of different facilities are not all alike and hence have different amounts of EDD. Trunk maintenance limits of P/AR for channels using many different kinds of facilities are given in Appendix 1 of this section or in the maintenance sections of the PL, PSN, and SSN layers.

4.20 As of now, no fixed P/AR limits are available for C conditioned private lines. This is mostly due to a lack of measurements on such lines and the difficulties involved in trying to turn such services down for a sample measurement. At present, the best procedure for conditioned lines is after acceptance by an EDD and loss run; a benchmark P/AR reading should be taken and recorded on the history record. Future readings that exceed ±4 P/AR points from the initial reading will indicate trouble in one of the three parameters that P/AR evaluates.

4.21 When the Western Electric 27 series P/AR equipment is considered, the 27F or later models must be used. Previous versions of the 27 series of P/AR equipment should not be used. The errors introduced in the old P/AR system, because of frequency shift or phase intercept distortion on the line, have been eliminated by introduction of frequency shift in the new P/AR transmitter and different signal processing in the new P/AR receiver. Because of these changes, the new and old P/AR equipments are incompatible.

4.22 The "new" P/AR system has been found to be a very effective measure of intersymbol interference. It has found defective elements in trunks that could not be picked up except by complete EDD and attenuation distortion measurements. It should be used as a first order tool in locating data transmission troubles, and it is also recommended as a circuit order requirement for benchmark purposes.

Attenuation Distortion

4.23 Attenuation distortion measurements are typically made with a TMS. Straightaway measurements require two TMSs.

4.24 The attenuation distortion measurement is the differential loss between 1004 Hz and all

other required frequencies within the band of interest. The required frequencies and the band of interest can be found in the appropriate sections listing the requirements for PL and SSN services. This measurement is not a required measurement on access lines and end-to-end connections on the PSN. Attenuation distortion is not the same as the gain slope measurement discussed in paragraphs 4.14 and 4.15.

Intermodulation Distortion

4.25 The term intermodulation distortion is preferred to the term nonlinear distortion. In addition, the intermodulation distortion measurement replaces the harmonic distortion measurement.

4.26 Since some nonlinear elements are frequency sensitive, this method is being replaced with the multitone intermodulation distortion test. This test is accomplished by transmitting four equal, level tones arranged in two "pairs." One pair called A is located at about 860 Hz, and the other pair called B is located at 1380 Hz. The receiver takes the power average of A+B and B−A products to determine second order distortion and displays the ratio, R2, of the fundamental power to second order power. It also measures the ratio of fundamental to some third order products, R3, located at 2B-A.

4.27 This measurement technique has been recommended because the amplitude distribution of the test signal closely approximates a typical high speed data signal. In addition, the multitone technique provides a more stable measurement of the channel nonlinearities which are frequency dependent and time variable. Harmonic distortion is evaluated by transmitting a 700-Hz tone and measuring the received second and third harmonics. For several sources of nonlinearities in tandem, complete cancellation of a harmonic can occur which is not possible with intermodulation distortion.

Hits and Dropouts

4.28 There are several test sets available which accurately measure these parameters. Some are phase jitter test sets, pen recorders, the combination of phase jitter test sets and hit monitors, and vector scope techniques. Hit and dropout measurements are not provided in SARTS.

4.29 Hit and dropout measurements are a means of recording the number of hits or dropouts that exceed a predetermined threshold. The threshold for gain hits and dropouts is measured in dB, while the threshold for phase hits is measured in degrees.

Return Loss

4.30 The return loss measurement indicates the presence or absence of an echo caused by an impedance mismatch or discontinuity in the channel. This mismatch, and resulting echo, can be controlled by proper balancing. Echo occurs when a signal passes from 4-wire to 2-wire portions of the circuit or connection. If impedances are not matched or balanced, part of the signal energy travels back toward the source in the form of talker echo. If the talker echo is reflected by a similar imbalance at the transmit end, the effect is listener echo. Both talker and listener echo are detected by the return loss measuring set or singing point test set. Only talker echo can be measured by SARTS.

4.31 Return loss measurements are required whenever 4-wire to 2-wire conversions are in the transmission path. These tests insure that a given data set receiver will not receive any transmitted signal above an interfering level more than once (listener echo). To operate satisfactorily, the level of echo must be 12 dB or more below the level of the original received signal. The return loss measurement is especially important when data service is provided over tandem networks, PBX-CO trunks, and the PSN.

Single Frequency Interference

4.32 A listening test or the use of a monitor during the C-notched noise test is normally sufficient for the detection of single frequency interference. However, to identify the frequency of a specific interfering tone, a spectrum analyzer or frequency selective voltmeter is required.

Frequency Offset

4.33 The frequency offset measurement is generally made with two frequency counters. ***A looped test is not valid as the offsets can cancel.*** These measurements are only required on the carrier channel portions of the circuit and should not normally include metallic facilities.

4.34 To measure frequency offset, a frequency counter is used at both ends of the carrier por-

tion of a channel to compare the frequency of tone which is transmitted from one end to the other.

4.35 Frequency offsets that return to zero by as much as 100 Hz have been observed. These offsets can last from a few milliseconds to 5 seconds. A frequency meter and phase jitter test set may be helpful in detecting this problem. An electronic frequency counter cannot detect this type of problem.

Envelope Delay Distortion (EDD)

4.36 Envelope delay distortion measurements are typically made with voiceband gain and delay sets. The SARTS system does not measure EDD. The EDD measurement must be made with two test sets as the looped measurement is not a valid test. The EDD measurement must be made only after the channel has been brought into attenuation distortion specifications.

4.37 The EDD measurement determines the difference between the delay at any frequency in the band of interest and the delay of a reference frequency. The reference frequency is generally around 1800 Hz.

4.38 Once delay equalization is correctly applied to a data circuit, EDD has proven to be the least critical parameter when a trouble arises. Some data sets provide adaptive equalizers. Acceptable P/AR measurements are accurate indicators of acceptable EDD.

5. TEST EQUIPMENT

5.01 Test equipment mentioned in this section is given as a general type only and is not meant to suggest any model(s) or manufacturer(s) unless specifically stated.

5.02 A listing of AT&T evaluated general trade test equipment is located in the Product Evaluation Report (PER) No. 117. Copies of the PER are maintained by the general trade advisors at headquarters locations of Long Lines and each Bell Operating company.

6. ESTIMATION OF TRANSMISSION PERFORMANCE

6.01 This part provides examples of the estimation of end-to-end transmission performance based on sectional measurements. The sectional measurements can be parts of 2-point PL, end links and middle links of multipoint PL, or access lines and trunks of end-to-end connections on the PSN and SSN. All the methods of combining discussed here apply to one direction of transmission. In general, the results of these methods are approximations. Therefore, if the results are out of limits, an actual end-to-end measurement must be made.

A. Attenuation Distortion

6.02 The sectional loss with respect to 1004-Hz measurements should be added algebraically for each frequency.

Example:

LOSS WITH RESPECT TO 1004 HZ (dB)

FREQUENCY* (HZ)	LINK A	LINK B	OVERALL
304	1.0	-0.3	0.7
504	0.8	-0.2	0.6
604	0.4	-0.2	0.2
804	0.2	-0.1	0.1
1004	0	0	0
1204	-0.1	-0.1	-0.2
1404	-0.1	0.1	0
1604	-0.2	0.2	0
1804	-0.1	0.2	0.1
2004	0	0.2	0.2
2204	0.1	0.1	0.2
2404	0.2	0	0.2
2504	0.3	0.1	0.4
2604	0.3	0.2	0.5
2704	0.5	0.4	0.9
2804	0.9	0.7	1.6
3004	1.3	1.4	2.7

* Refer to the maintenance requirements sections for the required measuring frequencies.

If the overall measurement must be compared to the C2 conditioning specification, perform the following steps:

The minimum loss with respect to 1004 Hz between 504 to 2804 Hz = −0.1 dB

The maximum loss with respect to 1004 Hz between 504 to 2804 Hz = 1.6 dB

The minimum loss with respect to 1004 Hz between 304 to 3004 Hz = −0.2 dB

The maximum loss with respect to 1004 Hz between 304 to 3004 Hz = 2.7 dB

The overall attenuation distortion then is:

504 to 2804 Hz: −0.1 to +1.6 dB

304 to 3004 Hz: −0.2 to +2.7 dB

If comparing with conditioning other than C2, use appropriate bandwidths for comparison.

B. Envelope Delay Distortion

6.03 The sectional EDD measurements should be added algebraically for each frequency.

Example:

ENVELOPE DELAY (MICROSECONDS)

FREQUENCY (HZ)	LINK A	LINK B	OVERALL
504	410	380	790
604	320	270	590
804	180	170	350
1004	130	100	230
1204	80	50	130
1404	40	20	60
1604	20	0	20
1804	0	-30	-30
2004	15	-10	+5
2204	30	5	35
2404	70	30	100
2504	110	70	180
2604	160	120	280
2704	220	180	400
2804	290	260	550

If the overall measurements must be compared to the C2 conditioning specification, perform the following steps:

The minimum envelope delay between 1004 and 2604 Hz = −30 μsec

The maximum envelope delay between 1004 and 2604 Hz = 280 μsec

The minimum envelope delay between 604 and 2604 Hz = −30 μsec

The maximum envelope delay between 604 and 2604 Hz = 590 μsec

The minimum envelope delay between 504 and 2804 Hz = −30 μsec

The maximum envelope delay between 504 and 2804 Hz = 790 μsec

The overall envelope delay distortion between 1004 and 2604 Hz = 280−(−30) = 310 μsec

The overall envelope delay distortion between 604 and 2604 Hz = 590−(−30) = 620 μsec

The overall envelope delay distortion between 504 and 2804 Hz = 790−(−30) = 820 μsec

If comparing with conditioning other than C2, use appropriate bandwidths for comparison.

C. C-Notched Noise and Single Frequency Interference

6.04 Combine the sectional measurements on a power basis using Table B (or on a voltage basis using Table C as required).

Example of C-Notched Noise Estimation:

Line A S/N = 28 dB

Line B S/N = 27 dB

Difference between quantities = 28 − 27 = 1 dB

From Table A combining term = 2.5 dB

Subtract combining term from the lower S/N figure: 27 dB − 2.5 = 24.5 dB

The overall S/N ratio (rounded off) is 25 dB.

If the C-notched noise measurement is dominated by third order harmonic distortion (commonly found on some short-haul carrier systems), then the tone measurements will add on a voltage basis and Table C should be used. An overall intermodulation distortion measurement is therefore recommended and should be made in conjunction with C-notched noise measurements.

D. Intermodulation Distortion

6.05 Combining intermodulation distortion measurements is not recommended.

E. Phase Jitter

6.06 Combine phase jitter measurements expressed in degrees using Table D.

Example:

Link A = 3°

Link B = 5°

From Table D the overall phase jitter would be expected to approximate 7°.

F. Impulse Noise

6.07 Use an impulse noise threshold setting of 71 dBrnc0 on each link or section. Algebraically add the number of impulses recorded in 15 minutes on each section to obtain the overall counts.

Example:

Link A = 5 counts

Link B = 2 counts

Overall = 7 counts

G. Frequency Shift

6.08 Add the frequency shift for each section algebraically. Note whether the shift for each link is + or − with respect to the source.

Example:

Link A = +1 Hz

Link B = −2 Hz

Overall = −1 Hz

7. GUIDELINES FOR INSTALLATION, ROUTINE, AND TROUBLE TESTING

7.01 The prioritized list of data parameters that may cause trouble is given in Table E. In addition, the table provides a list of what measurements should be made at circuit installation, on a routine basis, and during the investigation of a trouble report.

TABLE B

COMBINING POWERS

DIFFERENCE IN dB BETWEEN TWO QUANTITIES	COMBINING TERM IN dB	DIFFERENCE IN dB BETWEEN TWO QUANTITIES	COMBINING TERM IN dB	DIFFERENCE IN dB BETWEEN TWO QUANTITIES	COMBINING TERM IN dB
0—0.1	3.0	2.2—2.4	2.0	5.7—6.1	1.0
0.2—0.3	2.9	2.5—2.7	1.9	6.2—6.6	0.9
0.4—0.5	2.8	2.8—3.0	1.8	6.7—7.2	0.8
0.6—0.7	2.7	3.1—3.3	1.7	7.3—7.9	0.7
0.8—0.9	2.6	3.4—3.6	1.6	8.0—8.6	0.6
1.0—1.2	2.5	3.7—4.0	1.5	8.7—9.6	0.5
1.3—1.4	2.4	4.1—4.3	1.4	9.7—10.7	0.4
1.5—1.6	2.3	4.4—4.7	1.3	10.8—12.2	0.3
1.7—1.9	2.2	4.8—5.1	1.2	12.3—14.5	0.2
2.0—2.1	2.1	5.2—5.6	1.1	14.6—19.3	0.1
				19.4—Up	0

TABLE C

COMBINING VOLTAGES

DIFFERENCE IN dB BETWEEN TWO QUANTITIES	COMBINING TERM IN dB	DIFFERENCE IN dB BETWEEN TWO QUANTITIES	COMBINING TERM IN dB	DIFFERENCE IN dB BETWEEN TWO QUANTITIES	COMBINING TERM IN dB
0—0.1	6.0	4.6—4.7	4.0	11.5—11.9	2.0
0.2—0.3	5.9	4.8—5.0	3.9	12.0—12.5	1.9
0.4—0.5	5.8	5.1—5.3	3.8	12.6—13.0	1.8
0.6—0.7	5.7	5.4—5.6	3.7	13.1—13.5	1.7
0.8—0.9	5.6	5.7—5.9	3.6	13.6—14.1	1.6
1.0—1.1	5.5	6.0—6.2	3.5	14.2—14.8	1.5
1.2—1.3	5.4	6.3—6.5	3.4	14.9—15.4	1.4
1.4—1.6	5.3	6.6—6.8	3.3	15.5—16.1	1.3
1.7—1.8	5.2	6.9—7.1	3.2	16.2—16.9	1.2
1.9—2.0	5.1	7.2—7.4	3.1	17.0—17.8	1.1
2.1—2.2	5.0	7.5—7.7	3.0	17.9—18.7	1.0
2.3—2.5	4.9	7.8—8.1	2.9	18.8—19.7	0.9
2.6—2.7	4.8	8.2—8.5	2.8	19.8—20.9	0.8
2.8—2.9	4.7	8.6—8.9	2.7	21.0—22.2	0.7
3.0—3.2	4.6	9.0—9.3	2.6	22.3—23.6	0.6
3.3—3.4	4.5	9.4—9.7	2.5	23.7—25.4	0.5
3.5—3.7	4.4	9.8—10.1	2.4	25.5—27.6	0.4
3.8—3.9	4.3	10.2—10.5	2.3	27.7—30.7	0.3
4.0—4.2	4.2	10.6—11.0	2.2	30.8—35.1	0.2
4.3—4.5	4.1	11.1—11.4	2.1	35.2—44.9	0.1

TABLE D

COMBINING TWO PHASE JITTER MEASUREMENTS EXPRESSED IN DEGREES PEAK-TO-PEAK

LINK B \ LINK A	1	2	3	4	5	6	7	8	9	10
1	2	3	4	4	5	6	7	8	9	10
2	3	3	4	5	6	7	8	9	10	11
3	4	4	5	6	7	8	9	10	11	12
4	4	5	6	7	8	8	9	10	11	12
5	5	6	7	8	8	9	10	11	12	13
6	6	7	8	8	9	10	11	12	13	14
7	7	8	9	9	10	11	12	13	13	14
8	8	9	10	10	11	12	13	13	14	15
9	9	10	11	11	12	13	13	14	15	16
10	10	11	12	12	13	14	14	15	16	17

7.02 During the investigation of a trouble report, the highest ranked parameter should be measured first. The exception to this rule is the P/AR measurement. If P/AR is found out of limits, the following tests should be performed:

(a) A complete attenuation distortion measurement

(b) Return loss

(c) Envelope delay distortion

(d) Intermodulation distortion.

7.03 By installation, it is meant those tests should be performed on a data channel as a result of a service order for new or additional service. Some companies have categorized these as preinstallation tests.

7.04 All switched private line data services shall be maintained in accordance with Table E.

TABLE E

RECOMMENDED ORDER OF TESTS TO BE PERFORMED DURING INSTALLATION, ROUTINE, AND TROUBLE REPORTS

RECOMMENDED ORDER OF TESTS	INSTALLATION	ROUTINE (SWITCHED)	TROUBLE REPORT
1. Continuity	*	*	*
2. Loss	*	*	*
3. "C" Notched Noise	*	*	*
4. Impulse Noise			*
5. Phase Jitter	(5)		*
6. Gain Slope (3 tone)	(6)	*	*
7. P/AR	(1) (7)		(1)
8. Attenuation Distortion (Complete)	(3)		*
9. Intermodulation Distortion	(2)		*
10. Hits, Dropouts			*
11. Return Loss	(4)	*	*
12. Single Freq. Interf.			*
13. Frequency Offset			*
14. Envelope Delay Dist	(3)		*

Notes:

1. If P/AR fails, skip immediately to measuring attenuation distortion, return loss, and envelope delay distortion.
2. Required on all "D" conditioned circuits.
3. Required on all "C" conditioned circuits.
4. Required on all data channels with 2/4-wire sections or 2-wire data terminals.
5. Two of three phase jitter measurements required (4-20, 20-300, or 4-300 Hz).
6. Required on all circuits that have access to the switched network if P/AR tests are not made.
7. Basic Channel (Voiceband) — P/AR may be used in place of attenuation distortion and EDD if done on overall basis for 2-point circuit and on end link, mid link basis for multipoint circuit. P/AR should be made on a loopback (benchwork) basis for "C" conditioned circuits after all tests have been made and all requirements met.

* Tests to be done.

7.05 Routine measurement of private line channels shall be made in accordance with Table E under Routine (Switched). An agreement should be made with the customer before the circuit may be taken out of service. Measurements of channel parameters on working circuits are currently under investigation.

8. PROBABLE SOURCES OF IDENTIFIED TRANSMISSION IMPAIRMENTS

8.01 Bell System personnel responsible for clearing impairments to voiceband analog data transmission services are being provided with more sophisticated testing tools which can identify specific transmission impairments. Many sophisticated customers who use Bell System facilities for data transmission have the ability to report specific transmission impairments. Table F is designed to assist in sectionalization and troubleshooting if the parameter (phase jitter, return loss, etc) causing the poor data performance is known. Transmission parameters which can affect data set performance are listed on the top of the matrix, and the various Western Electric Company facilities or equipment which could be used on the connection are shown on the left.

8.02 A probability is listed for each facility/equipment for each parameter where information is available. The probabilities assume that the circuit loss is correct, and they are abbreviated as h (high), m (medium), l (low), and a — (dash) to indicate no probability. A blank entry indicates insufficient data at this time to estimate a probability. In some instances, numbered notes indicate a known trouble condition, which, if present, would cause the probability to be medium or high. To a large extent, the probability associated with the note indicates the probability that the condition of the note will occur.

8.03 Properly selected and installed facilities, which are appropriate for a given type of data modem will not cause problems. Table F is to be used when something has gone wrong. The table can be used to minimize trouble location time for a given impairment by selecting the facility with the highest probability to be tested first or, conversely, by not testing facilities which could not cause the impairment (T-Carrier cannot produce phase modulation, for example).

8.04 It is ***not*** the function of this matrix to:

(a) List other than transmission impairments (ie, no signaling or echo suppressor characteristics which could affect data set start-up).

(b) Provide guidance on which parameters should be tested first.

(c) Provide a cross-reference between data set speed and transmission impairments.

(d) Provide installation testing strategies.

8.05 Subsequent issues of this table will be modified based on actual field experience with its use. Notes will be added as new failure modes are identified, and notes deleted as field modifications to eliminate trouble conditions are complete.

8.06 Several abbreviations defining impairments are used in Table F. They are as follows:

ABBREVIATION	DESCRIPTION
LEVEL vs. T	Level variation with time. Obvious level fluctuations observable on a standard level measuring set within 15 seconds observation.
LEVEL vs. L	Variations in circuit loss with the level of the input signal, such as level tracking and compandor tracking.
LEVEL vs. f	Level variations versus test tone frequency variation, such as attenuation distortion.
G-S (GAIN-SLOPE)	Level measurements made at 404 Hz, 1004 Hz, and 2804 Hz. A special case of LEVEL vs. f.
EDD	Envelope delay distortion.
RL	Return loss as measured with three standard bands of random noise.
P/AR	A complex pulse train is measured to produce a single number weighting (P/AR) of a facility for intersymbol interference, which is caused by the

simultaneous effects of envelope delay distortion, attenuation distortion, and poor return loss.

CN (C-NOTCH) C-Notch noise measured with a holding tone on the circuit.

NOISE SFI Single frequency interference is present if a single tone, other than a harmonic of a holding tone (if present), is the primary contributor to the measured noise.

JITTER

--0 Phase jitter on a facility as measured with a 20- to 300-Hz bandwidth around a holding tone of 1 kHz.

lf0 Phase jitter in the band below 20 Hz around a 1 kHz holding tone.

fSh Frequency shift.

TRANSIENTS

Imp Impulse noise is large excursions on the received signal which are higher than the normal peaks of message circuit noise.

0H Phase hits are changes in the nominal phase of the circuit which exceed a preselected threshold for at least 4 milliseconds.

GH Gain hits are changes in the nominal loss of the circuit which exceed a preselected threshold for at least 4 milliseconds.

Do A dropout is a negative gain hit of at least 12 dB.

TABLE F

PROBABLE SOURCES OF IDENTIFIED TRANSMISSION IMPAIRMENTS

	IMPAIRMENTS																		
	Level							Noise		Intermodulation		Jitter			Modulation		Transients			
FACILITY/EQUIPMENT	vsT	vsL	vsF	G-S	EDD	RL	PAR	CN	SFI	2nd	3rd	Φ	1fΦ	Amp	Φ	fSh	Imp	ΦH	GH	Do
LOOP PLANT																				
Cable with sealing current	—	—	m	m	m	m	l	l	l	—	—	—	—	—	—	—	m	—	—	—
Cable without sealing current	l	—	m	m	m	m	l	m^{1}	l	—	—	—	—	—	—	—	m^{1}	—	m^{1}	h^{1}
Data Aux. Sets 828.829	—	—	l^{2}	l	l	l	l	l	l	l	l	—	—	—	—	—	l	—	—	—
Subscriber Loop Carrier																				
SLC™ 8	—	h^{3}	m^{4}	l	m^{4}	l	l	l	l	m	l	—	—	—	—	—	l	—	l	—
SLC™ 40	l	m	l	l	l	l	l	h^{12}	m	m	m	l	l	m	—	—	m	l	l	l^{5}
SLC™ 96	m^{6}	l	l	l	l	l	l	m	l	l	l	l	l	l	—	—	m	l	l	l^{5}
TERMINATING EQUIPMENT																				
Repeaters																				
E6, E7	—	—	l^{7}	l^{7}	l	l^{7}	l	l	l	l	l	—	—	—	—	—	l	—	—	—
44 V4	—	—	l	l	l	—	l	l	—	l	l	—	—	—	—	—	l	—	—	—
44 MFT	—	—	l	l	l	—	m	l	—	l	m	—	—	—	—	—	l	—	—	—
22, 24 V4*	—	—	l	l	l	l	l	l	—	l	l	—	—	—	—	—	l	—	—	—
22, 24 MFT*	—	—	l	l	l	l	l	l	—	l	m	—	—	—	—	—	l	—	—	—
Hybrid	—	—	m^{8}	l^{8}	m^{8}	l^{8}	m^{8}	—	—	—	—	—	—	—	—	—	—	—	—	—
SF (260 Hz) SIGNALING*																				
E	—	l	l^{9}	l^{9}	l^{9}	m^{11}	l^{9}	l	l	m^{10}	m^{10}	—	—	—	—	—	l	—	—	l
F	—	—	m^{9}	l^{9}	l^{9}	—	l^{9}	l	l	l	l	—	—	—	—	—	l	—	—	l
G	—	—	l^{9}	l^{9}	l^{9}	—	l^{9}	l	l	l	l	—	—	—	—	—	l	—	—	l
ANALOG CARRIER*																				
1ON	m	h^{3}	h^{19}	h^{14}	m	—	m	h^{13}	l	m	m	l	l	l	l	l	m	l	l	l
N1	m	h^{3}	h^{14}	h^{14}	m	—	m	h^{14}	m	h^{15}	l	m	l	m	—	h^{13}	l	l	l	
N2	m	h^{3}	m	m	l	—	l	m	l	m	l	l	l	l	l	—	m	l	l	l
N3	m	h^{3}	l	l	m	—	m	l^{16}	m^{17}	m	m	m^{18}	m^{18}	l	m^{18}	m	m	m^{18}	l	l
N4	l	h^{3}	l	l	l	—	l	m	m^{17}	m	l	l	l	l	l	m	l	l	l	l
Channel Banks																				
A4	l	l	m	l	l	l	l	l	l	l	l	m	m	l	l	l	l^{19}	h^{19}	l	l
A5	l	l	m^{20}	l	l	l	l^{20}	l	l	l^{20}	l	l	m	l	l	l	l^{19}	h^{19}	l	l
A6/DFSG	l	l	m	l	l	l	l	l	l	l	l	l	l	l	l	l	m^{19}	h^{19}	l	l
LMX-MMX	l	l	m^{4}	l	m^{4}	—	l^{4}	l^{21}	m^{22}	m^{23}	m^{23}	m^{24}	m^{24}	l	m^{24}	m^{30}	m^{19}	m^{24}	m^{26}	m^{26}
Microwave Radio	h^{27}	m^{27}	—	—	—	—	—	m^{27}	m^{27}	m^{27}	m^{27}	m^{27}	—	—	—	—	h^{28}	h^{28}	h^{28}	^{25}
LT-1	m^{6}	l	l	l	l	—	l	m	m	l	l	l	l	l	m	l	m^{29}	l	l	l^{30}

TABLE F (Contd)

PROBABLE SOURCES OF IDENTIFIED TRANSMISSION IMPAIRMENTS

FACILITY/EQUIPMENT	IMPAIRMENTS																		
	Level							Noise		Intermodulation		Jitter		Modulation			Transients			
	γsT	vsL	vsF	G-S	EDD	RL	PAR	CN	SF1	2nd	3rd	Φ	]fΦ	Amp	Φ	fSh	Imp	ΦH	GH	Do
DIGITAL CARRIER*																				
D1A, D1B, D1C	m[6]	m	l	l	l	—	l	h[32]	m	h[31]	m	l	l	l	—	—	m[29]	l	l	]5
D1D, hardened	m[6]	l	l	l	l	—	l	m	l	l	l	l	l	l	—	—	m[29]	l	l	]5
D2	h[6]	m	l	l	l	—	l	m	l	l	l	l	l	l	—	—	m[29]	l	l	]5
D3, D4	m[6]	l	l	l	l	—	l	m	l	l	l	l	l	l	—	—	m[29]	l	l	]5
PBX																				
SXS 701	—	—	—	—	—	—	—	h[34]	—	—	—	—	—	—	—	—	h[34]	—	—	—
DIMENSION® 100or 400	—	—	m	l	l	l	l	]36	l	l	l	l	—	l	l	—	l	—	—	l
" 2000 or Custom	m[35]	—	m	l	l	l	l	]36	l	l	l	l	m[35]	l	l	—	l	—	—	l
HORIZON®	—	l	m	l	l	l	l	l	—	l	l	l	—	—	—	l	l	—	—	—
ECHO SUPPRESSORS																				
Analog 3A, 4A	—	—	—	—	—	—	—	l	—	l	l	—	—	—	—	—	—	—	—	]37
Digital	—	—	—	—	—	—	—	l	—	l	l	—	—	—	—	—	—	—	—	]37
TASI*																				
A	m[6]	m[38]	]38	]38	m[38]	—	m	m[38]	m	m	m	—	—	—	—	—	h[33]	l	m	m
B	]39	]38	]38	]38	]38	—	l	h[38]	m	m	m	—	—	—	—	—	m	l	l	l
E	m[6]	]38	]38	]38	]38	—	l	m[41]		m	m	l	l	l	—	—	m[28]	l	l	]5
SATELLITE																				
COMSTAR	l	l	l	l	m[40]	m[40]	m	l	l	l	l	]24	]24	l	]24	m	l	m	m	m
HYBRID	—	—	m	l	m	l	m	—	—	—	—	—	—	—	—	—	—	—	—	—
SWITCHING EQUIPMENT																				
SXS	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	h[42]	—	]42	]42
Crossbar	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	m	—	—	—
1ESS, 2-Wire	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	l	—	—	—
1ESS, 4W HiLo	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	m[44]	—	—	—
2ESS, 3ESS, 4ESS	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	l	—	—	—
4ESS with VIU's	m[6]	l	l	l	l	l	l	m		l	l	l	l	l	—	—	l	]43	l	]5

LEGEND

Probabilities h= high m = medium l = low — = no

PROBABLE SOURCES OF IDENTIFIED TRANSMISSION IMPAIRMENTS

TABLE F (Contd)

NOTES

* See also the Hybrid row for 2-4 wire conversion.

1. Oxidized cable splices, half of which can be fixed with the application of sealing current. See EL 4504, 3/17/76.
2. Misadjusted equalizers on installation.
3. Syllabic compandors.
4. Edge channels only.
5. 25 to 50 msec dropout on reframing; lightning, for example.
6. Will exhibit level fluctuations at test frequencies which are integral submultiplex of the 8000 Hz sampling rate.
7. Equalizers not properly adjusted at installation.
8. Precision balance networks improperly set on installation.
9. 2600 Hz band rejection notch improperly impressed on channel after cut-through.
10. E-type SF signaling units typically do not meet D-1 intermodulation distortion requirements.
11. If the condition of Note 9 occurs for E-type SF units, the return loss is poor even in the 4-wire case.
12. Adaptive delta modulation gives poor (25 dB) S/N ratio for data signals with high frequency components.
13. If engineerred for the earlier longer span between repeaters.
14. Aging of vacuum tubes. Tubes should be replaced with hybrid integrated networks (HINs).
15. Facility immediate action limits are only R2 = 26 dB, R3 = 30 dB.
16. If the N3 Compandor Applique for operator service trunks is applied to long haul facilties.
17. 4000 Hz carrier.
18. Faulty Frequency Corrector Unit as described in EL 2497, 8/9/73.
19. Switching transient effects in adjacent channels of LMX-2.
20. Ferrte slug in the 561K filter comes unglued, causing loss bumps, or channel banks in the A5 Channel Bank Reuse Program.
21. When LMX channels 6 and 7 are used for program, the Program Blocking Filter roll-off is not sufficient to stop interference in channels 5 and 8.
22. Intermodulation products from hot tones in other channels.
23. On some LMX-2 channels.
24. LMX-1 Primary Frequency Converter with 4 kHz and 128 kHz feeds from different Primary Frequency Supplies or low frequency variations in power feeds to LMX or MMX bays.
25. 30 msec dropout due to protection switch on microwave facility caused by instantaneous loss of signal rather than fading.
26. 228D, 231D or 231E amplifiers sensitive to battery voltage transients.
27. During periods of fading on the microwave links.
28. Protection switching on microwave channels.
29. Strikes on a T-Carrier link.
30. Loss of synchronization by the PFS2-Type Primary Frequency Supply.
31. High intermodulation distortion caused by high level signals in adjacent channels.
32. Immediate action limit for S/N is only 24 dB.
33. Needs routining for adjacent channel crosstalk.
34. The 701 PBX requires special grounding, quiet battery and shielded wire to control noise and impulse noise.
35. Clock differences between modules cause beating (3 Hz maximum rate) when single tones are used for testing, rising from 0.1 dB at 1 kHz to 1 dB at 3.2 kHz.
36. Two or more trunks terminated withthe LC11 and LC11B vintage 1 circuit packs can have high crosstalk.
37. Occasionally, high impulse noise or high longitudinal noise causes false suppressor operation.
38. TASI is energy-actuated, so test tones must be continuous.
39. Will exhibit level fluctuations at test tones which are integral submultiples of the 10 kHz sampling frequency.
40. Long 300 msec echo delays aggravate hybrid unbalance problems.
41. Noise matching circuits may put on noise when disconnected which matches noise level of power line hum when connected.
42. Mechanical shaking of SXS switch due to release of adjacent SXS switches. See EL 4205, 1/16/76.
43. Phase hits occurring at periodic intervals as a result of clock slippage between 4ESS and downstream T-Carriers.
44. 3-wire equivalent of 4-wire circuit: crosstalk spikes caused by False Cross and Ground Checks.

TRUNK REQUIRMENTS

P/AR MEASUREMENTS

VOICEBAND DATA TRANSMISSION PARAMETERS

1. GENERAL

1.01 Peak-to-average ratio (P/AR) maintenance and immediate action limits are given upper and lower bounds. The value of P/AR is that characteristic of a trunk's or facility's ability to handle data with a single number. The typical value is really the mean of many P/AR measurements taken on trunks with particular facilities. The maximum and maintenance limits represent values two standard deviations above and below the typical value. A maximum value for the maintenance limit is given because it is well known that echos with certain delay times can enhance the P/AR reading, thus giving misleading results. The setting of upper and lower bounds is similar to what is done for the slope requirements. The lower bound immediate action limits are established by reducing the maintenance limit by 1 for a single facility, 2 for 2-facility, and 3 for 3-facility trunks. The upper bound immediate action limits are established by increasing the maximum limit by 1 for single facility, 2 for 2-facility and 3 for 3-facility trunks. Table A provides the typical values for various facilities and combination of facilities. In addition, maintenance and maximum limits are provided. Maintenance limits are the minimum acceptable P/AR values while the maximum limits are the highest acceptable P/AR values.

1.02 The P/AR maintenance limits for cable are provided in Tables B and C. Only the minimum P/AR values are given.

NOTICE
Not for use or disclosure outside the
Bell System except under written agreement

TABLE A

P/AR VALUES FOR SINGLE AND MULTI-FACILITY CHANNELS

TYPE	MAXIMUM	MAINTENANCE LIMIT	TYPICAL VALUE
0, ON, N3	94	86	90
N1	98	86	92
L or Radio	99	87	93
N2	101	93	97
T1	102	93	97
2T1	97	88	92
2N3	93	83	88
2N2	96	88	92
2N1	93	85	89
T1 + N3	95	87	91
T1 + N2	96	88	92
N1 + N3	97	87	92
ON + T1	96	87	91
ON + A	93	83	88
ON + N3	93	83	88
ON + N2	96	88	92
ON + N1	96	88	92
2 ON	91	83	87
T1 + N1	96	87	91
N2 + N3	97	87	92
N1 + N2	95	87	91
2 "A" Type	92	82	87
A + T1	95	86	90
A + N3	91	83	87

TABLE A (Contd)

P/AR VALUES FOR SINGLE AND MULTI-FACILITY CHANNELS

TYPE	MAXIMUM	MAINTENANCE LIMIT	TYPICAL VALUE
A + N2	96	86	91
A + N1	96	86	92
3A	83	74	78

In No. 4 ESS with analog trunking, single facility, use values for T1+ facility under consideration. For No. 4 ESS with T1 carrier interfacing via a digroup terminal, use T1 values.

TABLE B

P/AR VALUES FOR NONREPEATERED CABLE

TYPE	LENGTH	MAINTENANCE LIMIT
Nonloaded	0-18 Kft.	97
H88	0-18 Kft.	94

TABLE C

P/AR VALUES FOR REPEATERED CABLE

TYPE	LENGTH	MAINTENANCE LIMIT
Nonloaded	0-18 Kft.	90
H88	0-36 Kft.	90
H88	>36 Kft.	80

NOTES

DATA GENERAL

DATA SERVICES SUPPORT

DIGITAL AND ANALOG DATA TRANSMISSION SERVICES

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A. Switched Services on the PSN . . 2

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5. REFERENCES 4

1. GENERAL

1.01 This section provides an overview of the support provided for voiceband data services on private line (PL), the Public Switched Network (PSN), and private Switched Services Networks (SSN). The various categories of service arrangements and the criteria used to define the support of data services provided by Bell operating companies (BOC) are described. Data services on PL, the PSN, and SSN involve different support terminology and definitions, so the applications are treated separately.

1.02 Whenever this section is reissued, the reason(s) for reissue will be given in this paragraph.

1.03 Data services on facilities offered to other common carriers (OCC) are covered by different sections and tariffs. Operations information on these service arrangements is given in Sections 471-110-020 and 314-300-ZZZ.

1.04 Data services provided on the Digital Data System (DDS) are not covered in this section. Operations information covering DDS can be found in Sections 314-900-100 and 314-900-300.

1.05 Local area data channels (LADC) are not covered in this section. The LADC is covered in Section 314-410-312.

1.06 Special applications such as DATAPHONE® Select-A-Station (DSAS) and Telemetry/Alarm Bridging Service are not covered in this section. Operational informaton or DSAS is covered in Section 314-410-550 and Telemetry/Alarm Bridging Service is covered in Section 314-410-560.

2. DEFINITION OF SUPPORT

2.01 Support is an assurance that published performance standards will be maintained. The Bell System specifies these standards for a PL circuit, an end-to-end connection on the PSN, and an end-to-end connection on SSN where there is no intervening customer provided equipment or facilities. This part describes the standards specified for data transmission.

2.02 All services offered by the Bell System are supported for a minimum quality level, recognizing that some services are supported to a higher degree than others. For instance, a 2-point PL 3002 channel (data communication system), as described in this section, is supported for data in terms of transmission parameters and error performance. Whereas an arrangement such as foreign exchange (FX) circuit when used for data transmission to locations beyond the radius of 200 airline miles from the dial tone office is supported for voice only. The Bell System has an obligation

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to insure its customers that all services meet their ***designed*** specifications, even though the circuits are not being used for their designed purpose.

3. PRIVATE LINE DATA SERVICES

3.01 Data services on PL are available as 2-point [Fig. 1(c) and (d)] or multipoint arrangements. The customer must specify the desired conditioning at the time of ordering the service, usually as recommended by the manufacturer of the terminal equipment (data set). The service and support definitions for private line data services are characterized as either ***Systems or Assemblies.***

3.02 Voice-grade only parameters apply to PL circuits ordered for voice communication. Voice-only PL circuits apply to any circuit administered by the Bell System Practice (BSP) 310 division and not ordered for data transmission. It is recognized that some customers may use these arrangements for data transmission and satisfactory service may result.

3.03 Data-grade parameters apply to PL circuits administered by Section 314-410-ZZZ. The controlled parameters for C- and D-type conditioning are specified in FCC Tariff 260.

A. Systems

3.04 Systems are PL channels that are designed for data transmission and are used within their designed capabilities. The telephone company (TELCO) has no control over the customer's choice of data set [TELCO or customer-provided equipment (CPE)]. (A TELCO is any telephone company, BOC or independent, that provides service and equipment to customers in its franchised area.) More significantly, the TELCO has no control over how often the customer may change between TELCO and CPE data sets. Because the customer may order a channel equipped with TELCO data sets and later may change to CPE without TELCO knowledge, systems are further defined as follows:

- ***Data Transmission System:*** The TELCO provides a channel only. The service, in terms of transmission parameters only, is provided between the channel interface units (CIU). Typically, the CIU is a data auxiliary set (DAS) 829.

- ***Data Communication Systems:*** The TELCO provides the channel and data sets. The channel must be ordered with the recommended channel conditions (C- and/or D-type). In addition to the transmission parameters, as specified for data transmission systems, an error performance is also specified as covered in the various data set documentation.

B. Assemblies

3.05 Assemblies are PL channels or arrangements of channels that were not normally intended or designed for data transmission. (Assemblies could be a channel designed and intended for data transmission but not designed to the specifications recommended by the modem supplier.) However, these arrangements will not be improved beyond their designed specifications. Channels are supported as ordered, and it is understood data services ***may*** perform satisfactorily. The TELCO has not specified and does not support assemblies for error performance.

4. SWITCHED DATA SERVICES

4.01 Switched data services may provide a large number of possible tandem arrangements of equipment and facilities on successive calls between two specific locations. It would be impractical to attempt to specify transmission requirements for every arrangement and to maintain each arrangement to its separate requirement. Therefore, networks are designed so that regardless of the routing, the characteristics of each transmission path are bounded.

A. Switched Services on the PSN

4.02 There are several ways in which to gain access to or from the PSN with each type having its own transmission design limitations. The access lines design limitations are critical in determining the support of an end-to-end connection. Accesses to the PSN may be obtained through:

(1) Normal business or residence lines (loops)

(2) FX lines

(3) Wide Area Telecommunication Service (WATS)

(4) 800 Service

(5) Remote Exchange (RX) Lines

(6) PBX extensions (either on-premises or off-premises) which access the PSN by:

- PBX-CO trunks
- WATS trunks
- FX trunks.

In a given connection, the terminating access may be similar to the originating access line or any of the others.

4.03 Additional considerations used to determine the support of data transmission on the PSN are interpositioning and interconnection. The various methods that are used to terminate station equipment, including the above, are covered in Section 314-010-103.

4.04 Supported data service over the PSN is defined in paragraph 4.05. It is recognized that customers may use other arrangements for data transmission and satisfactory service may result. For these arrangements, voice-grade only parameters for each telephone company provided element will be assured. Examples of unsupported data arrangements are as follows:

- Data transmission between a station on an FX line to a station on the PSN located more than 200 airline miles from the serving (FX dial tone) office regardless of the length of the FX line.
- Data transmission originating and terminating in two FX lines.
- Data transmission from any station to any other station through customer provided facilities or equipment (includes digital performance through CPE modems or PBXs). See Section 314-010-103.
- Data transmission on PSN from any SSN using off-net access lines.
- Switched data transmission to any countries other than the 50 states and Canada.
- Switched data transmission provided by an office or PBX with features, such as call-waiting, executive override, bridged stations without the exclusion feature, etc. (These arrangements are not recommended and will most likely not work for data.)
- Data transmission using acoustically or inductively coupled stations [Fig. 1(b)].

Note: At the present time, data sets behind PBXs cannot be installed to operate with an output level exceeding -9 dBm. Therefore, there may be cases where the PBX extension and trunk losses will cause the data signal level at the serving CO to be below -12 dBm. Support for this service is therefore limited to voice-grade parameters. In order to support high speed data, it is necessary for the customer to order a direct CO line (loop) with a data jack.

4.05 Data service is fully supported for direct access PSN connections using data jacks (or grandfathered data sets). Grandfathered equipment and registered jacks are covered in Section 314-010-103. Fully supported data service on the PSN implies an objective of satisfactory data performance for 85 percent of connections.

4.06 For the PSN, satisfactory data performance is defined in terms of data-grade parameters for an end-to-end connection, called minimum acceptable performance (MAP) [Fig. 1(a)]. The MAP program is given in Section 314-205-503. In complaint cases, this level of performance may require treatment of the access lines. The overall objective is that at least 85 percent of the calls will meet or exceed the end-to-end (jack-to-jack) MAP criteria. These measurements are made as a last resort and require the guidance or assistance of data technical (DATEC) support personnel. The MAP program is applied only when access to the PSN is made, as outlined in Section 314-205-501, for the following lines:

- Subscriber
- FX (for connections to stations within 200 miles from the FX dial tone office)
- PBX (from PBX-CO trunk)
- WATS.

4.07 An error rate may be assured by the TELCO on end-to-end connections where the MAP

program applies and TELCO data sets are used. See Fig. 1(a).

B. Private Switched Services Networks

4.08 There are four types of SSN. They are:

- Tandem Tie Trunk Network (TTTN)
- Electronic Tandem Networks (ETN)

Note: TTTN and ETN are not sold as a pure network; they are a switching capability where the customer has some power to define his own network.

- Common control switching arrangements (CCSA)
- Enhanced private switched communication service (EPSCS).

Each has different design guidelines and operation procedures. The SSNs are covered in Sections 309-YYY-ZZZ.

4.09 In general, SSN offers PL channels for use as a small switched network. Although most channels are defined in PL tariffs, support definitions are similar to those for data services on the PSN. All SSNs offer off-net access, allowing the interconnection of two separate networks. While this arrangement is useable for voice communication, it is not intended for data services and therefore is not supported.

4.10 ***Tandem Tie Trunk Networks (TTTNs):*** These are switched PL network arrangements that provide voice service, and in some cases data transmission, to business customers with a number of locations to be served: When used for data transmission, a voiceband connection is established by normal dialing and then connecting data sets and terminals at each end. Support of data transmission is based, among other criteria, on the number of tie trunks used to complete the connection.

4.11 ***Common Control Switching Arrangements (CCSA):*** These provide for the interconnection of customer locations via dedicated access lines and intermachine trunks and shared common control switching. The CCSA networks are terminated at the customer's location by telephone sets, data sets, key telephone systems, or main PBXs/centrexes. Data transmission on CCSA networks provides a similar quality of service as that of the PSN.

4.12 ***Electronic Tandem Networks (ETN):*** These provide for the interconnection of customer locations via access tie trunks, intertandem tie trunks, and switching provided by either DIMENSION® 2000 PBXs or No. 1 ESS centrex. Data service is offered as two options, both of which are based on the number of trunks used to complete the connection and the speed of the data transmitted.

4.13 ***Enhanced Private Switched Communication Service (EPSCS):*** This service provides voice grade service between customer locations by means of intermachine trunks and access lines. The intermachine trunks and access lines are designed to permit data transmission at speeds up to 4800 b/s.

4.14 Switched Service Networks provide for both voice and data services. However, support for data differs from one type of network to the next. For this reason, support for data is covered as part of each type of network in Sections 309-YYY-ZZZ.

4.15 The data conditioning requirements associated with SSN are C3, C7, C8, and/or D3. These parameters are specially applicable to the following:

- TTTN trunks
- CCSA trunks
- EPSCS trunks [Fig. 1(f)] and access lines
- ETN trunks [Fig. 1(e)] and off-premises station (OPS) lines.

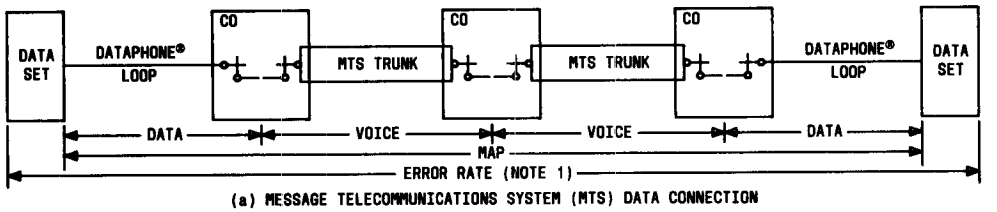
The parameters are also covered in Sections 309-YYY-ZZZ.

5. REFERENCES

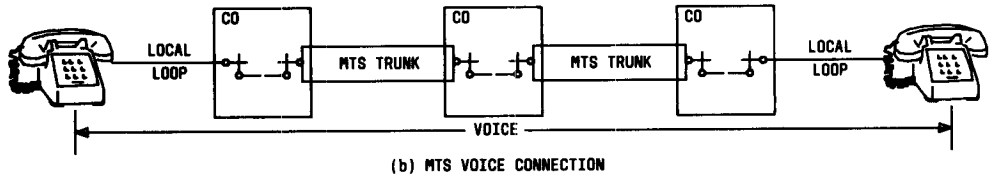
5.01 The following sections provide additional information on data services support of voiceband analog data transmission:

310-300-300	Two-point Private Line Circuits—Voice Only—Tests Requirements and Objectives

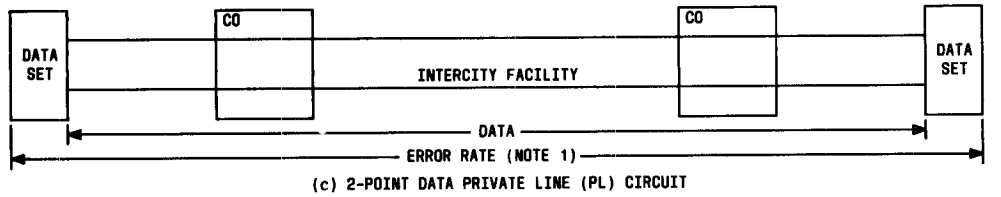
314-010-100	Data General—Transmission Parameters
314-010-103	Data General—Interconnection/ Interpositioning
314-305-300	Data Systems—DATAPHONE® Service—Overall Maintenance Procedures
314-205-500	Data Systems—DATAPHONE® Service—Overall Data Transmission Test Limits
314-305-501	Data Systems—DATAPHONE® Service—Test Requirements
314-205-503	Data Systems—DATAPHONE® Service—Minimum Acceptable Performance (MAP)
314-410-100	Private Line Circuits—Voice Bandwidth—Description
314-410-500	Private Line Circuits—Voice Bandwidth—Requirements
471-110-020	Special Services—Voice Grade and Voice Grade Data Facilities Provided to Other Common Carriers
471-200-001	Special Services—Other Common Carriers—Installation and Repair Responsibilities for Facilities Furnished to Other Common Carriers



(a) MESSAGE TELECOMMUNICATIONS SYSTEM (MTS) DATA CONNECTION



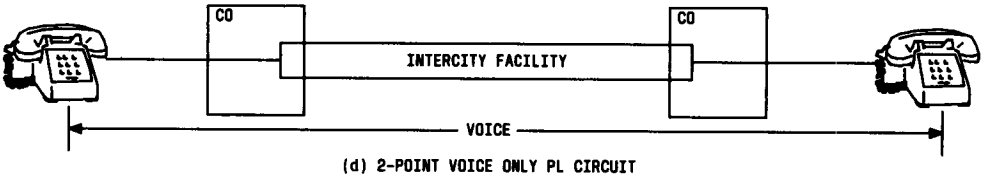
(b) MTS VOICE CONNECTION



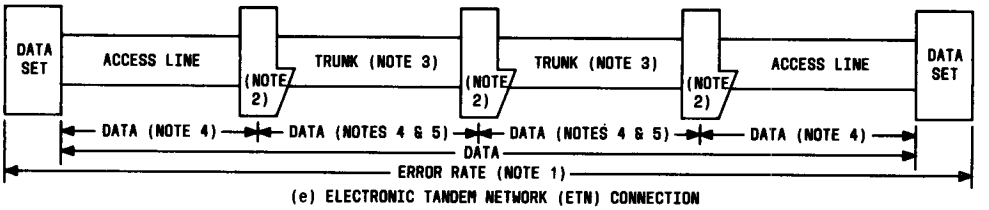
(c) 2-POINT DATA PRIVATE LINE (PL) CIRCUIT

NOTES:
1. SPECIFIED ONLY WHEN BELL SYSTEM DATA SETS ARE USED [MAY INCLUDE INDEPENDENT COMPANY (ICO) DATA SET IF TERMINATED IN ICO TERRITORY]
2. DIMENSION® PBX.
3. CENTRAL OFFICES NOT SHOWN.

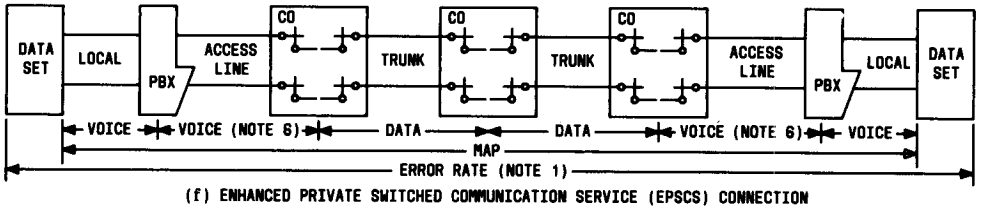
Fig. 1—Examples of Voice Only and Data Supported Services (Sheet 1 of 2)



(d) 2-POINT VOICE ONLY PL CIRCUIT



(e) ELECTRONIC TANDEM NETWORK (ETN) CONNECTION



(f) ENHANCED PRIVATE SWITCHED COMMUNICATION SERVICE (EPSCS) CONNECTION

NOTES (CONTD)

4. MUST BE ORDERED BY THE CUSTOMER, OTHERWISE VOICE ONLY.
5. MAXIMUM 2 OR 3 IN TANDEM, DEPENDING ON DESIRED SPEED OF TRANSMISSION (SEE SECTION 309-400-300).
6. MAY BE DATA IF ORDERED BY CUSTOMER FOR HIGHER SPEED OF TRANSMSSION.

Fig. 1—Examples of Voice Only and Data Supported Services (Sheet 2 of 2)

NOTES

DATA GENERAL

INTERCONNECTION/INTERPOSITIONING

DIGITAL AND ANALOG DATA TRANSMISSION SYSTEMS

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1. GENERAL

1.01 This section provides information for the interconnection and interpositioning of customer-provided equipment (CPE) to 3002-type private line voiceband data channels, to the Message Telecommunication System (MTS), and to Switched Services Networks (SSN). Examples and definitions of interconnection, interpositioning, and associated applications and terms are provided for quick reference.

1.02 When this section is reissued, the reason for reissue will be given in this paragraph.

1.03 This section contains required information for the use of Bell operating company (BOC) personnel. It is important that BOC personnel understand the difference between interconnection and interpositioning and when one is applicable and the other is not. This section specifically addresses these and associated terms as they pertain to the maintenance and installation of data services on private line (PL) service, MTS, and SSN. This section supplements Sections 309-XXX-YYY, 314-205-XXX, and 314-410-XXX.

2. INTERCONNECTION

2.01 Interconnection is the connection of CPE to Bell System facilities or terminal equipment for either PL service or MTS. The connection could be independent facilities if in independent company (ICO) territory. The Federal Communication Commission (FCC) requires all station terminal equipment connected to the MTS to be either grandfathered or registered, or if not, the equipment must be connected via a grandfathered or registered protective circuitry (eg, a protective connecting arrangement [PCA]).

2.02 ***Registered Equipment:*** Registered equipment complies with Part 68 of the FCC rules and regulations and has been granted a registration number.

2.03 ***Grandfathered Equipment:*** Grandfathered equipment is nonregistered equipment that was either directly connected to telecommunications facilities without a telephone company (TELCO)-provided PCA or data access arrangement (DAA) as of October 17, 1977 (grandfathered eligibility date for telephone, data, and ancillary equipment). Grandfathered equipment is also "of a type" that was directly connected as of the grandfathered eligibility date ***and*** has been directly connected for the first time between the grandfathered

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eligibility date and July 1, 1979 (register-only date). These connections must have been legal connections in accordance with the then current tariffs (Bell or independent).

2.04 Any piece of nonregistered equipment, even though identical to a grandfathered device, which was not connected to TELCO facilities by the register-only date, can only be connected through either customer-provided grandfathered or registered protective circuitry.

2.05 Data services that include interconnection may be classified as either systems or assemblies. The specific responsibilities and requirements associated with systems or assemblies are given in Section 314-010-102.

3. INTERPOSITIONING

3.01 Interpositioning is where BOC terminal equipment accesses BOC facilities [eg, exchange CO, wide area telecommunications service (WATS), PL services, SSN] through CPE. Typical applications involve customer-provided data sets interpositioned between Bell-provided DATASPEED® terminals and Bell facilities and customer-provided patch panels or diagnostic units interpositioned between Bell-provided data sets and Bell facilities (Fig. 1).

3.02 It is the Bell System policy to satisfy service needs involving interpositioning of terminal equipment when all of the following conditions are met:

- The interconnection of Bell-provided facilities and terminal equipment and customer-provided terminal equipment conforms to the FCC registration program rules, or to applicable tariffs.
- Standard interfaces exist for the Bell facilities and Bell and customer-provided terminal equipment to be interconnected.
- Additional costs, if any, incurred by the Bell System in providing such arrangements will be recovered in appropriate rates.

The Bell System has taken the position of being as cooperative as possible. However, our technical involvement is limited to assuring that Bell equipment functions properly.

Interfaces

3.03 One of the key provisions of the interpositioning policy is the requirement that standard interfaces be used to connect BOC facilities with BOC and customer-provided terminal equipment. This means that both the line side and the drop side of interpositioned customer-provided equipment must connect via standard jack and plug interfaces. These interfaces must conform to recognized standards, such as Electronic Industries Association (EIA) RS-232C or RS 449/423 and those found within FCC rules, Part 68 where applicable. An additional category of acceptable standard interfaces are comprised of those published in Bell System technical references which states that the interfaces are of jack and plug design, are uniform in their application to customer-provided and BOC-provided equipment, and describe connections to Bell facilities or equipment. The AT&T Company has approved the 829-type interface to be used to interconnect with 3002-type PL circuits. The FCC rules, Part 68 govern those interfaces used to interconnect with the MTS.

3.04 The data auxiliary set (DAS) 829-type is a channel interface unit. It is designed for use on 3002-type 4-wire PL data channels and can be used in the data only mode, voice alternate mode, and/or dial backup mode (Fig. 2). It is the Bell System's standard interface for use between the BOC facility and the interpositioned CPE. The actual connection is the miniature 50-position ribbon plug and jack. The DAS 829 is described in Section 598-082-100.

3.05 Because there are length limitations on cabling between the DAS 829 and Bell data sets, close coordination between the BOC and the customer is necessary. The total length of the cable on the line and the drop sides of the interpositioned CPE to the DAS 829 and the Bell data set must not exceed the maximum distances given in Section 598-082-200.

3.06 Added cabling is also an important factor that should be considered when interpositioning devices such as patch panels (or other similar equipment) ahead of Bell data sets. It is desirable to arrange the station cabling so that data sets can be plugged directly into the connector of the DAS 829 when the patch panel cables are removed. This enables the BOC or customer to remove the patch panel in the event of trouble so that the

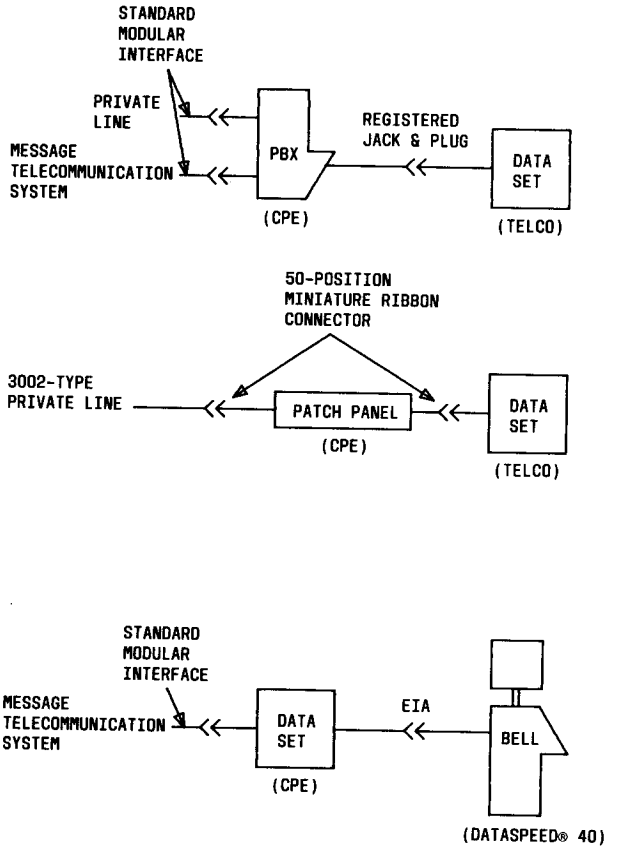


Fig. 1—Examples of Interpositioning

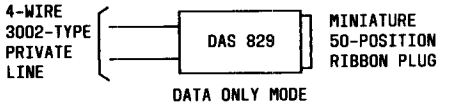
telecommunication facilities and data sets can be tested in the absence of the interposed equipment. This arrangement reduces maintenance time and expense. It also allows the installation of channels and data sets to be completed even if the customer's equipment is not present at the time (Fig. 3).

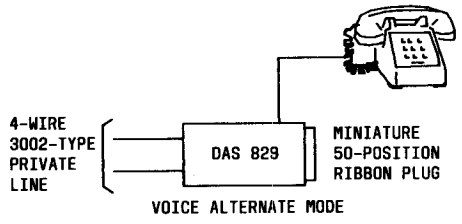
TELCO and Customer Responsibilities

3.07 Interpositioning involves the interconnection of CPE and therefore interpositioning arrangements are classified as either transmission systems or assemblies. It is the responsibility of the customer to ascertain the proper operation of the CPE ***before*** reporting a trouble to TELCO.

3.08 Efficient screening of "interpositioning" trouble reports can do much to improve TELCO productivity. A question and answer technique with the customer reporting the trouble can pinpoint the cause to the CPE without further TELCO involvement.

3.09 Testing through CPE can also be helpful in isolating trouble conditions. Testing through customer-provided patch panels is an obvious case. Obviously, for various technical reasons, BOC personnel will not always be able to test through an interpositioned CPE modem to assure proper Bell terminal operation. If, however, such a through test is possible, and it is done ***with the***





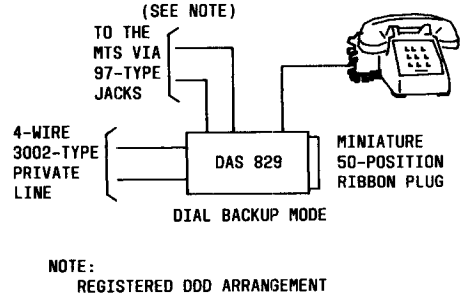


Fig. 2—DAS 829-Type Channel Interface Unit

permission of the customer, the results may determine that the Bell terminal equipment is functioning properly and save a costly craft dispatch. Should the results of a through test indicate a possibility of a Bell terminal problem, craft must be dispatched to verify the trouble condition and repair same. Before such a dispatch, the customer should be given a maintenance of service charge warning. If the craftsperson on site determines that the Bell terminal is in fact functioning properly but there is a customer system problem, eg, protocol or language incompatibility, a maintenance of service charge would be applicable.

3.10 Basically, there is no hard and fast rule that the BOC is or is not required to test through CPE equipment in an interpositioning arrangement. Common sense should be the guide to profitable operating procedures. However, the BOC is required to maintain transmission parameters on BOC-provided facilities up to the first BOC/CPE demarc point only. The BOC equipment behind the second and any successive demarcs are tested in a stand-alone manner to assure proper functioning (Fig. 4).

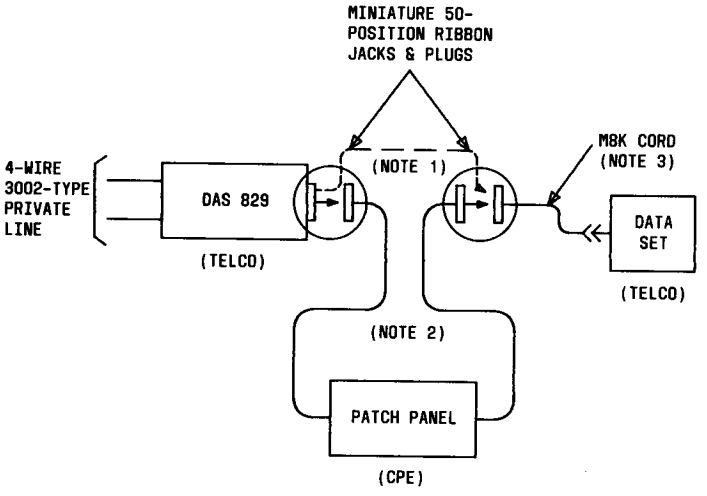
Unique Universal Service Order (USO) and Installation Procedures

3.11 Standard uniform service order codes (USOC) are used with orders involving interpositioning. However, in order to identify the position of each item, the field identifier "CPI" (CUSTOMER PROVIDED-INTERPOSITIONED), appears adjacent to the USOC for the equipment located immediately behind the CPE (Fig. 5).

3.12 Complete information to accommodate the installation of each arrangement is obtained from the customer by marketing. Information having no permanent value, ie, changeable features under the customer's control should be identified on the service order following the field identifier, RMK (REMARK).

3.13 ***All jacks*** associated with the CPE are to be installed prior to the BOC's due date. These jacks are the ***responsibility of the customer*** and ***are installed at their expense.*** Provision of the jack is necessary prior to BOC's visit in order to properly test the telephone company-provided equipment, so that billing may begin coincidental with the installation. All jacks must be of standard design as outlined in paragraph 3.03 and are the customer's responsibility for installation. Customers should be notified that if the appropriate jack is not in place on the agreed upon due date, the date may be changed and renegotiated. However, with customer agreement, the equipment may be installed prior to the customers completing their portion of the installation, and billing would begin immediately. Should a subsequent visit be required by BOC and the BOC-provided equipment is operating properly, a maintenance of service charge is appropriate.

3.14 Where there are limitations on the length of cable between the channel interface unit and data set, as in the case of the DAS 829 and Bell 200-type data set (paragraphs 3.05 and 3.06



NOTES:
1. CABLING SHOULD BE ARRANGED SO THAT DATA SET CABLE CAN BE WITHDRAWN FROM PATCH PANEL CONNECTOR AND PLUGGED DIRECTLY INTO DAS 829 CONNECTOR FOR TELCO TESTS (AS INDICATED BY DOTTED LINE)
2. THE MAXIMUM DISTANCE BETWEEN THE DAS 829 AND THE DATA SET (INCLUDING THE CABLING ASSOCIATED WITH THE INTERPOSITIONED CPE) MUST NOT EXCEED THE FOLLOWING:

DATA SET	MAX LENGTH IN FT
201C-L1	1400
201C-L1D	1400
202D	500
202T	200
208A	1400
209A	1400

3. THE M8K CORD IS SUPPLIED AND USED WITH ALL DATA SETS EXCEPT 202D. USE D50AA-3 IN PLACE OF D6AA-61 SUPPLIED WITH DATA SET 202D

Fig. 3—Recommended Positioning of TELCO and CPE Equipment

and Fig. 3), close coordination is required between the customer and the BOC.

4. INTERPOSITIONING/INTERCONNECTION AND SIMILAR CONFIGURATIONS

4.01 There are several configurations that may be confused with interpositioning/interconnection. (Interpositioning is illustrated in Fig. 6 and 7.) Telephone company and customer-provided wire, stand-alone equipment, and equipment-to-equipment configurations are discussed and illustrated to remove any confusion.

Stand-alone Equipment

4.02 The policy does not include stand-alone Bell equipment, ie, Bell terminal equipment connected to computers, other common carrier (OCC) services, or private microwave systems without connection to the Bell System network or private line services. OCC services also include

those Bell facilities which provide access to OCC services. Figure 8 illustrates stand-alone equipment and similar interpositioning configurations.

TELCO and Customer-provided Wire

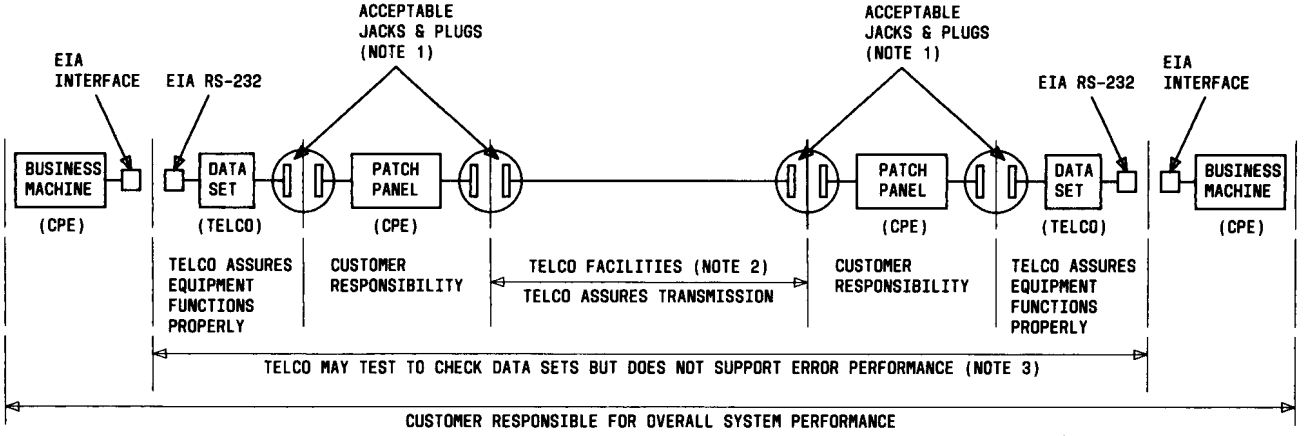
4.03 Customers are required to provide the premises wiring in accordance with FCC rules, Part 68 associated with their PBX and key telephone systems. Bell System procedures presently require that whoever (the Bell System or customer) provides the PBX or key system must also provide the system premises wiring and interfaces behind that system. It is not contemplated at this time that Bell System equipment will be connected in arrangements where the customer provides wiring other than system premise wiring. Figure 9 illustrates BOC and customer-provided wire situations as compared to an interpositioning configuration.

Equipment-to-Equipment

4.04 An equipment-to-equipment connection is the connection of a "secondary" piece of terminal gear to the MTS or to a 3002-type PL channel through a "host" piece of terminal equipment involving leads in addition to or in place of the standard leads outlined in Part 68 of the FCC rules (Fig. 10). For an MTS connection, the standard leads are the T and R, and in some cases the A and A1 leads. Most equipment-to-equipment data connections are made via the standard EIA interface (RS-232C or RS 449/443).

4.05 In most cases the "secondary" piece of terminal equipment must be registered. (The "host" piece of terminal equipment must be either grandfathered or registered or connected through a registered connecting device.)

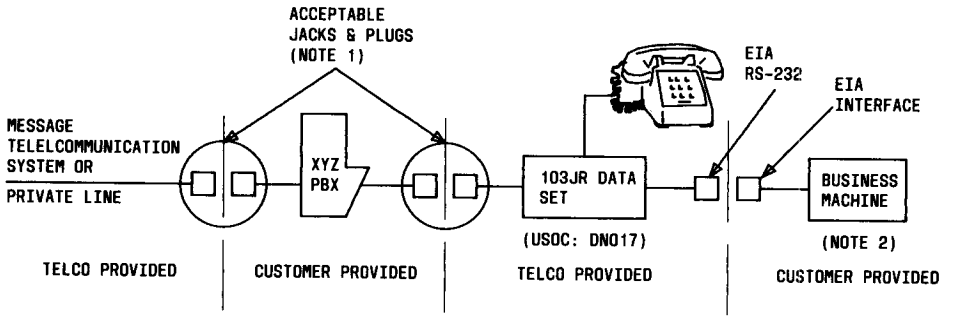
4.06 Where equipment-to-equipment and interpositioning arrangements are combined, both arrangements must meet their respective requirements.

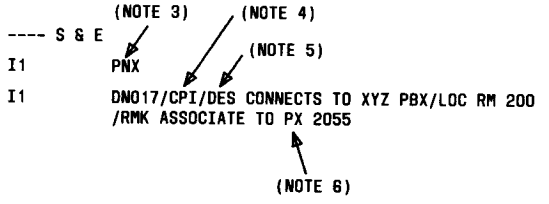


NOTES:
1. ACCEPTABLE PER FCC RULES, PART 68 FOR CONNECTION TO THE MESSAGE TELECOMMUNCIATIONS SYSTEM OR, ACCEPTABLE PER BELL SYSTEM STANDARD FOR CONNECTION TO 3002-TYPE PRIVATE LINE CIRCUIT.
2. FOR 3002-TYPE PRIVATE LINE, INCLUDES DAS 829 INTERFACE
3. MADE ONLY WITH CUSTOMER APPROVAL.

Fig. 4—TELCO and Customer Responsibilities

NOTES





NOTES:

1. ACCEPTABLE PER FCC RULES, PART 68 FOR CONNECTION TO THE MTS OR, ACCEPTABLE PER BELL SYSTEM STANDARD FOR CONNECTION TO PL CIRCUIT.
2. THE CPE DATA TERMINAL IS NOT REQUIRED TO APPEAR ON THE SERVICE ORDER.
3. THE PNX USOC IS SHOWN FOR REPORTS PURPOSES. IT SHOULD BE TALLIED AS A PBX STATION.
4. CPI APPEARS WITH USOC FOR BELL DATA SET. ("CPI" INDICATES THE BELL DATA SET IS IMMEDIATELY BEHIND THE INTERPOSITIONED PBX.)
5. THE DES ENTRY IDENTIFIES THE CPE PBX WITH WHICH THE DATA SET IS CONNECTED AND THE LOC ENTRY PROVIDES LOCATION INFORMATION FOR INSTALLATION AND MAINTENANCE.
6. THE LINE NUMBER TO WHICH THE DATA SET IS ASSOCIATED IS SHOWN IN AN UNRETAINED RMK (REMARK) ENTRY. IT MUST BE RECOGNIZED THAT THE PX NUMBER MAY BE CHANGED BY THE CUSTOMER AT SOME FUTURE DATE, THEREFORE HAS NO PERMANENT VALUE.

Fig. 5—Uniform Service Order Codes (USOC) Associated with Interpositioning

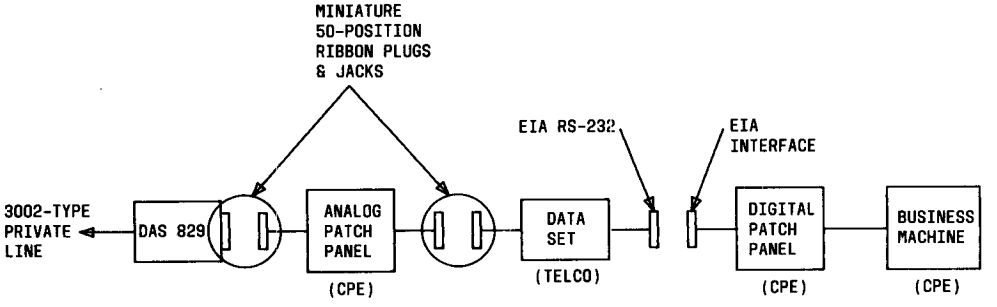


Fig. 6—Interpositioning of 3002-Type Private Line Channel

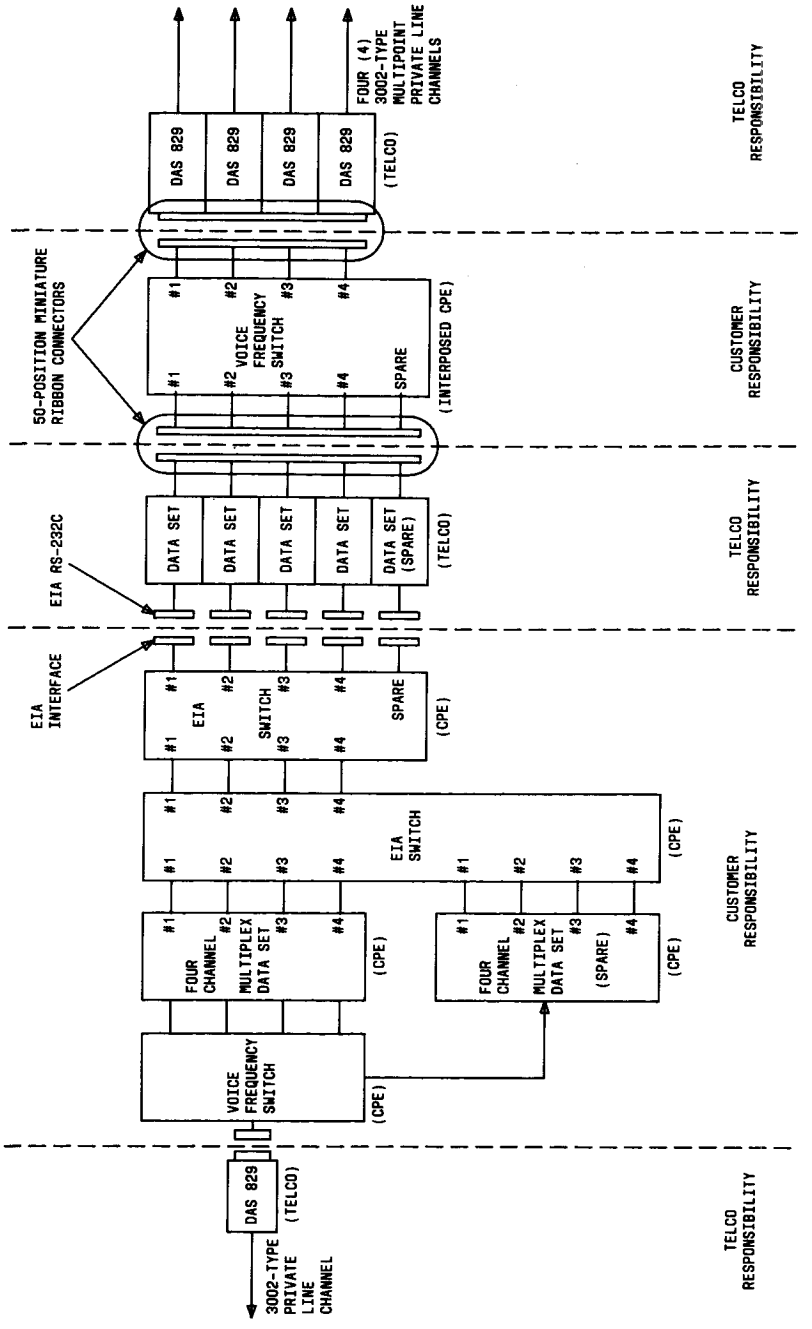


Fig. 7—Interpositioning on Multiple 3002-Type Private Line Channel Arrangement

NOTES

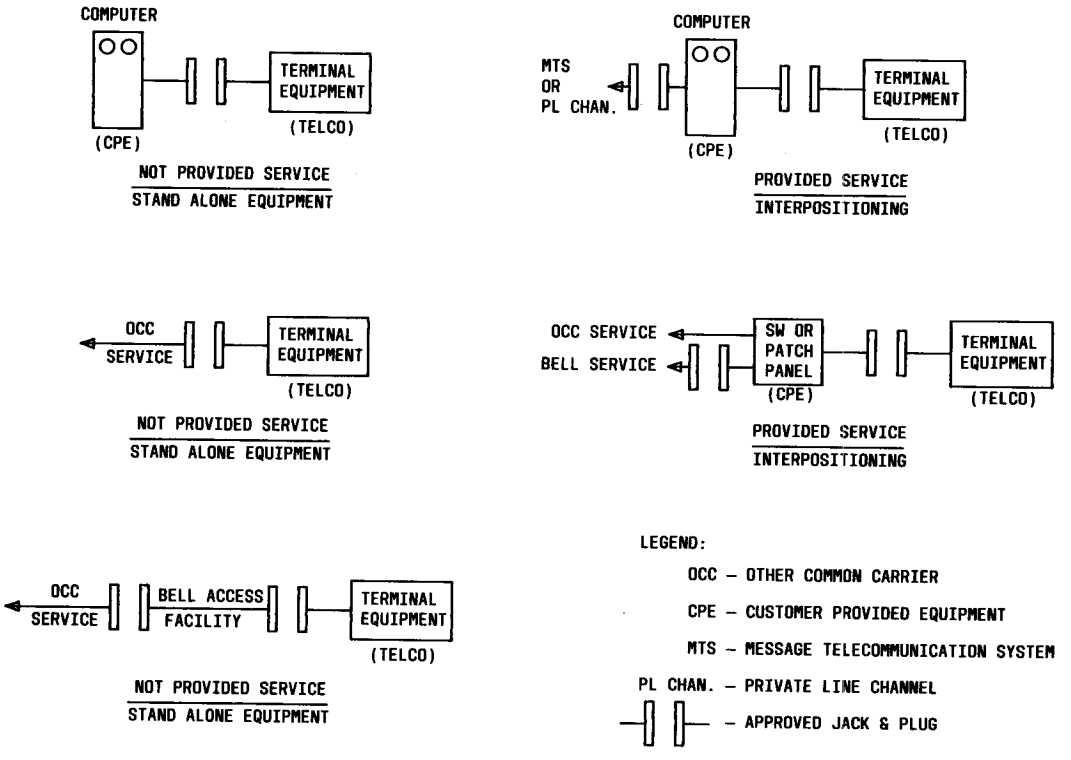
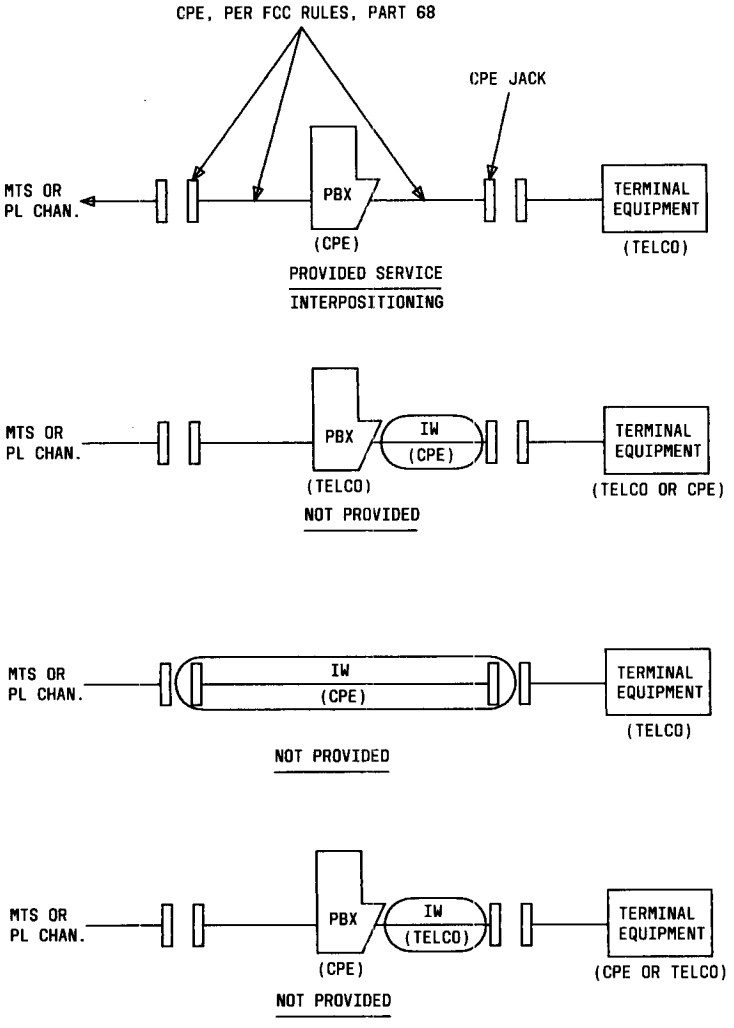


Fig. 8—Stand-alone Equipment vs Interpositioning



LEGEND:
PBX – PRIVATE BRANCH EXCHANGE
IW – INSIDE WIRING
CPE – CUSTOMER PROVIDED EQUIPMENT
MTS – MESSAGE TELECOMMUNICATION SYSTEM
PL CHAN. – PRIVATE LINE CHANNEL

Fig. 9—TELCO and Customer-Provided Inside Wire

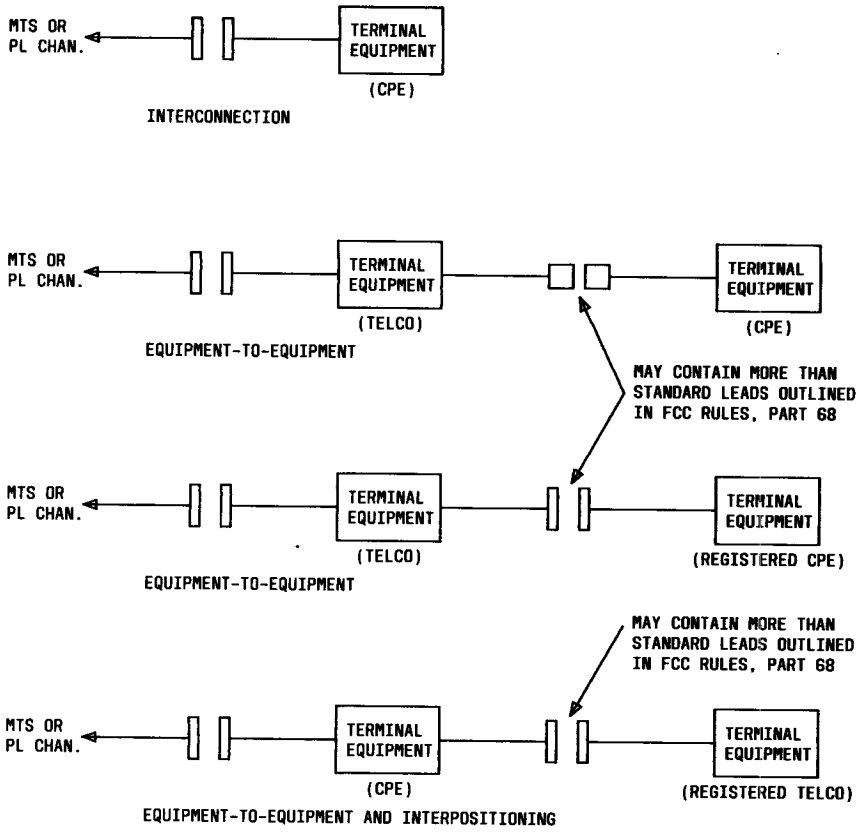


Fig. 10—Examples of Equipment-to-Equipment Connections

NOTES

PART II

SWITCHED DATA SERVICES

SWITCHED SERVICE NETWORKS
ELECTRONIC TANDEM NETWORK (ETN)
SERVICE MAINTENANCE

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APPENDIX

NOTICE
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Bell System except under written agreement

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1. GENERAL

1.01 This section defines the Network Routing Guide and maintenance features and specifies the preservice (installation) and maintenance (trouble and routine) test descriptions, procedures, and requirements for the Electronic Tandem Network (ETN).

1.02 Whenever this section is reissued, the reason(s) for reissue will be given in this paragraph.

1.03 The objectives of the tests and procedures covered in this section are to ensure that calls will be properly completed and that satisfactory voice and/or data transmission will be achieved. These tests, switchboard to switchboard (overall or end-to-end), are part of the network test plan for ETN.

1.04 To perform ETN tests, attention must be given to ensure that the following items have been completed:

(a) Testboard-to-testboard transmission tests

(b) Drop test at both ends

(c) All cross connects and necessary plug-in equipment installation at tandem location.

2. RESPONSIBILITIES

2.01 The responsibilities of the various offices associated with ETNs are covered in section 309-400-001. For the purpose of this section, the office designated as the Plant Control Office (PCO) is responsible for the scheduling and performance of circuit order and annual routine maintenance tests. Other work centers are responsible for trouble testing as required.

2.02 The PCO will also do the following:

(a) Delegate the performance of tests to another office (eg, subcontrol office on central office to central office trunks) when necessary.

(b) Maintain a permanent record of circuit order and routine maintenance test results. Trouble reports and associated test results will be documented on trouble logs or Special Service System (SSS) trouble tickets as appropriate.

(c) Assume full end-to-end testing responsibilities of a circuit comprised entirely of telephone company (TELCO) facilities and equipment.

2.03 When a circuit includes customer-provided facilities or terminates in customer-provided equipment (CPE), the TELCOs are responsible for testing to the TELCO/CPE interface only. The TELCO is not responsible for testing CPE. When a circuit includes other common carriers (OCCs), refer to Section 471-200-001.

3. ETN IMPLEMENTATION

A. Service Considerations

3.01 The high visibility of ETN circuit status, as well as the customer records for out-of-service credit, requires strict adherence to procedures for releases, response to automatic detected trouble, and ticketing of trouble reports.

3.02 Customers rely heavily on their communication service in the operation of their business. For this reason, it is important that:

(a) Service dates be met

(b) Outage time be kept to a minimum

(c) Status of circuits be known at all times

(d) Circuit maintenance be of the highest quality

(e) Network operation be as designed and expectations of the customer be met.

3.03 Initial circuit order tests must be of the highest quality and should be started in time to allow for clearing of any problems or troubles that may be encountered before cutover. The same applies to rearrangements, changes, additions, and deletions which are covered in the ETN Plan for Coordination.

3.04 Circuit releases for maintenance activities will usually be obtained by the PCO. In any event, the PCO must be informed of all releases and plant activities on circuits for which it is designated control.

B. Circuit Order Tests

3.05 Circuit order tests must be performed before a circuit is placed in service. If the requirements are not met, the circuit must not be turned up without the concurrence of the appropriate engineering forces.

3.06 Circuits that must be installed using equipment or facilities other than those specified by the circuit layout record (CLR) should be turned up for service only after engineering approval has been received. In these cases, the CLR should be corrected locally and a new corrected CLR must be issued by the engineering forces as soon as possible.

3.07 Circuit order tests are to be performed on initial installation and whenever any subsequent changes or rearrangements are made that might affect the operation or transmission characteristics of the circuit. Circuit order tests often prove to be valuable tools during trouble locating procedures. For this reason, the circuit order test results should be recorded and filed with the CLR or at some other readily accessible location for reference.

4. ETN VERIFICATION TESTS

4.01 A brief summary of each of the network tests, the organizations involved, the documentation required, and the means of verification is given in the following paragraphs. For DIMENSION Feature Package 8 (FP8) PBXs, references to test methods are also provided with each description. A summary of this information is provided in Table A.

A. Hardware Acceptance Tests

4.02 The ETN test activity begins with the installation and acceptance testing of the hardware for the Customer Administration Center System (CACS) and the station message detail record (SMDR) tape unit, as well as the FP8. The organization which installs these units also performs the associated standard tests. These tests ensure that the units are fully operational and that the PBX features are working properly. The CACS hardware is used during the CACS test and in the call-through. The SMDR tape unit is also used during the call-through. In the case of DIMENSION FP8 tandems, the PBX is used during the remaining tests and the call-through.

B. Transmission/Maintenance Tests

4.03 There are two sets of tests designed for transmission: testboard-to-testboard and switchboard-to-switchboard (end-to-end). The testboard-to-testboard tests measure the transmission levels between offices for all circuits. These tests are verified during the switchboard-to-switchboard tests. The switchboard tests measure the transmission levels from trunk to trunk between tandems, from tandem to main PBXs, and from trunk to serving office for off-net circuits. The standard switchboard tests are augmented on each circuit with a station-to-station measurement which verifies pad switching as well as the transmission levels and signaling compatibility.

4.04 Switchboard-to-switchboard tests (end to end tests) check the facilities from each tandem to all other main PBX/CTXs or tandems which are directly connected to it. These tests are performed after the cross connects are made and the testboard and drop tests completed. A standard sequence for transmission/maintenance tests and section references is listed below for DIMENSION FP8 tandems.

(1) 1000 Hz Loss—Section 311-300-500

(2) Frequency Response—Section 311-300-500

(3) Message Circuit Noise—Section 311-300-500

(4) Balance (Echo Return Loss and Singing Point)—Sections 311-350-100 and 311-350-500

(5) Pulsing—Sections 333-126-500 and 311-300-500.

4.05 Form ETN-1 (Fig. 1) for recording FP8 test results are completed with the actual measurements obtained. The PCO is responsible for assuring and documenting these tests, although the measurements are performed at the tandem location by other work center personnel.

4.06 The switchboard tests for each circuit in a group are considered complete after a station-to-station call and level measurements have been made. A call in both directions verifies continuity and provides a subjective check of the quality of transmission of each circuit. A measurement is made to verify the previous transmission test levels as well as to demonstrate that the switched pads are switching properly. In the case of FP8,

TABLE A

ETN TESTS

TESTS	PREREQUISITES	RESPONSIBLE ORGANIZATION	METHOD OF TESTING	DOCUMENTATION REQUIRED
Hardware Acceptance (PBX, SMDR, CACS)	Installation Complete	WECo or PBX craft	Section 554-111-300 (DIMENSION) 554-010-122 (SMDR) 554-010-140 (CACS)	See Method of Testing
Testboard-to-Testboard	All circuits installed	PCO (SSC/STC)	Standard procedures	Measurements obtained on forms.
Switchboard-to-Switchboard (Transmission)	PBX installed TB-TB drop tests cross-connects complete	PCO (SSC/STC)	Tested by PBX craft from trunk side. Levels given in Cut-over Guide	Measurements obtained to complete form.
Switchpad (Overall)	SWB-SWB complete on circuit	PCO (SSC/STC)	Measure levels from line-side through loop-around test trunk	Measurement on same form as switchboard results
Trunk Group	SWB-SWB complete on one circuit	PCO (SSC/STC)	List of calls to be placed between PBXs	Checklist included with switchboard results
PBX Acceptance	Installation complete. Final reuse tape installed	PBX craft	Check station features and translations	COD initialed. Section 554-111-302 Section 554-111-303
Network Translations Routing Guide/ COD comparison	Final reuse tape installed	Business Services	Cross-check of routing and ACA	COD initialed. ACA Forms 3 & 4 completed for sample routes. Forms will be sent to PBX craft for verification.
COD/Machine translation compairson	RG/COD complete	PBX craft	Check translations via MAAP panel	Form 3 & 4 from Bus. Svcs completed. Returned to Cutover Chairman
CACS	1. Installation complete 2. RMATS ports installed	PBX craft	Check connection to switches	Printout sent to Cutover Chairman
Network Initialization	Performed prior to call-through and cutover	PBX craft Business Services	Synchronize all clocks, activate ACA, SMDR, and CACS. Initialize	Checklist initialed. Returned to Cutover Chairman
Call-through	All other tests completed	NCO, PCO, PBX craft, Business Services	Call analysis via SMDR tape and data matrix	Call-through Analysis Matrix

the test can be made by placing calls through the loop-around test line in the distant DIMENSION PBX and taking measurements on the tones received. The PBX craft person performs this test and records the results of the measurements. Form ETN-1 (Fig. 1) is used to record end-to-end trunk tests for FP8.

4.07 For off-net groups, comparable transmission tests are performed per existing sections between the tandem PBX and the Serving Test Center (STC) or serving office at the far end. A call to verify continuity, depending on the type of facility, may be made in only one direction.

4.08 For each on-net group, after one circuit has been tested, a set of calls is placed to verify signaling compatibility as well as to test certain aspects of automatic alternate routing (AAR) (eg, programmed pause, overflow to off-net, and calls to a satellite PBX, a station, or an attendant). See form ETN-2 (Fig. 2) for FP8.

C. Translations

4.09 The transmission tests are augmented by a series of calls designed to verify certain features. These calls are made on a trunk group basis and test the translations that may permit a call to complete off-net through a tandem or PBX. The ability to call an extension, an attendant, or a satellite PBX is also verified by these tests. For FP8, station features and station translations are tested and verified during PBX acceptance testing. The remaining translations for automatic circuit assurance (ACA) and AAR/ARS (automatic route selection) are tested and verified by two mechanisms. Forms 3 and 4 (Fig. 3 and 4) are used for recording the test results.

4.10 The first mechanism for verification involves a detailed comparison between the routing guide (see Appendix 1) and the customer order document (COD). This is done by the Business Services organization. The second, used to determine that the COD matches the actual PBX software as shown via the maintenance and administration panel (MAAP), is made only on a sample of the translations.

D. Data Acquisition

4.11 Data acquisition via the SMDR unit is tested during the hardware acceptance tests and verified during call-through. The CACS data acquisition capabilities are tested during the CACS test and initialization. The purpose of the test is to ensure that the data collection mechanisms are set up correctly and to perform minor data validity checks. This test is verified through the use of the CACS during the call-through.

5. AUTOMATIC CIRCUIT ASSURANCE (ACA)

5.01 The ACA feature, available with DIMENSION FP8, assists the customer in identifying possible trunk malfunctions. The FP8 PBX monitors and keeps track of holding times associated with calls on each circuit (ie, tie, foreign exchange [FX], Wide Area Telecommunications Service [WATS], and central office [CO] trunks). When circuits exhibit unusual holding-time characteristics (very short or very long holding times), a call is initiated to the PBX attendant identifying the potential short or long holding-time circuit. ACA for No.1/1A ESS is not presently provided.

5.02 While one long holding time will alert the attendant, short holding times are accumulated. When a predetermined number of short holding-time conditions have occurred (usually 24), the attendant will be alerted. The attendant console will display the trunk group and trunk number that has the holding-time problem.

5.03 When alerted by ACA, the attendant will verify the condition of the suspect circuit by using the Trunk Verification by Station (TVS) feature, which is available with DIMENSION FP8. This is done by dialing the trunk test access number, trunk group number, and trunk number displayed on the console. If a defective trunk is found and if it is a 1-way outgoing trunk, the customer can put it in a maintenance busy condition. The customer must then notify the PCO of the trunk in trouble.

5.04 Another form of circuit assurance in the DIMENSION FP8 is detection of circuits which cannot be seized. Each trunk circuit pack has different voltage levels during call progress. If the DIMENSION PBX does not see an expected voltage or if a circuit times out, call processing will cease and the suspect trunk is placed in a quarantine state. The DIMENSION PBX then tests the circuit every 20 milliseconds; and if the circuit is still suspect after fifteen minutes, a minor alarm will be generated in the DIMENSION PBX alarm panel and the attendant console. The customer

should advise the Repair Service Bureau (RSB) of the alarm. The RSB may enlist the aid of the Remote Maintenance Administration and Traffic System (RMATS), if available, or dispatch repair forces to locate the problem using the MAAP. Although the trouble may clear itself and the circuit may be automatically restored to service, the alarm must be cleared manually.

6. REMOTE MAINTENANCE STATION (RMS)

6.01 If using DIMENSION FP8 tandems, a station is extended to the PCO to facilitate network maintenance and is called an RMS. The RMS provides the same basic function as the TVS features. The difference between TVS for the customer and RMS for the PCO is the capability with RMS to busy out both 1-way outgoing trunks and the outgoing portion of 2-way trunks. The TVS feature allows a busy to be placed only on 1-way outgoing trunks.

6.02 When RMS is used to busy out the outgoing portion of a 2-way trunk, the distant end must be made busy also. Failure to busy out the distant end will result in "high and dry" problems on the incoming portion of that trunk.

6.03 The RMS feature provides the following:

(a) Permits the PCO to dial and determine whether individually selected trunks terminating on the PBX are working (ie, the trunk can be selected and checked to see if it meets transmission objectives).

(b) Provides an override option when the trunk under test is busy (1-way incoming trunks may be checked with RMS only when they are in the busy condition).

(c) Provides a trunk maintenance busy routine when trouble is verified on a given trunk.

6.04 With this feature, all trunks terminated at the PBX can be tested. This includes CO, FX, WATS, direct inward dialing (DID), tie, and release-link trunks (RLTs) for centralized attendant service. Special trunks, such as recorded dictation, code call, and paging cannot be accessed with this feature.

6.05 With the RMS, both busy and idle trunks can be tested. When a trunk under test is idle, a normal test call placed over that trunk will provide adequate verification. When a trunk circuit selected for testing is busy, a per trunk group option to override the busy call is provided. This override option directs an executive override tone (2 to 4 seconds of steady tone) to both parties on the active call and then establishes a 3-way connection (bridge-on). The bridge-on option is not provided on RLTs or trunk-to-trunk connections.

6.06 DID and other 1-way incoming type trunks (other than incoming RLTs) can be accessed with the RMS only when the trunk is busy. Incoming trunks ***cannot*** be selectively seized and tested when idle.

TRUNK TESTING FROM THE RMS

6.07 Three access codes are provided with the RMS. One access code is provided for trunk testing, one for making a trunk maintenance busy, and one for making a trunk maintenance unbusy. When the selected trunk is made maintenance busy, any calls in progress are terminated.

A. Trunk Testing Through the DIMENSION FP8 PBX

6.08 Chart 1 shows procedures for trunk testing within a local PBX.

CHART 1

TRUNK TESTING THROUGH THE DIMENSION FP8 PBX

STEP	PROCEDURE
1	Initiate a test call by establishing an off-hook condition at the RMS. ***Note:*** PBX dial tone should be heard.

CHART 1 (Contd)

STEP	PROCEDURE
2	Dial the trunk test access code.
	Note: Second dial tone should be heard.
3	Dial the desired trunk group access code followed by the trunk number to be tested.
4	Determine that call has not been intercepted.
	Note: Intercept tone will be heard if an invalid code is dialed during call process.
5	Listen for one of the following responses.
	(a) CO dial tone (Outgoing trunk under test is not busy.)
	Note: Tester can now dial a test number through RMS, establish a connection, and evaluate the quality of transmission. (It may be necessary to dial a valid single digit traveling class mark (TCM) after the test number if the call progresses through another DIMENSION FP8 PBX).
	(b) Conversation (Trunk under test is busy; RMS bridged to trunk after a 2 to 4 second warning tone to both parties on active call.) The testers should identify themselves and indicate that a trouble test is in progress.
	Note: If unable to evaluate the quality of transmission, further testing should be delayed until circuit is idle and positive transmission tests are performed.
	(c) Centralized attendant services (CAS) attendant (Trunk under test is an idle RLT.)
	Note: Use RMS to evaluate quality of transmission with CAS attendant.
	(d) Busy tone
	Note: Busy tone is returned for one of the following reasons:
	Trunk under test has bridge-on restriction
	Trunk under test in process of call setup
	Trunk under test on 3-way call
	RLT under test is busy
	Call on trunk under test is data restricted
	Call on trunk under test is trunk-to-trunk call.
	(e) Continuous recall (stutter) dial tone (Trunk under test is maintenance-busy.)

B. Maintenance Busy/Unbusy Routine

6.09 The maintenance busy or maintenance unbusy routine is an option of the RMS. When a 2-way trunk or 1-way outgoing trunk under test results in an incomplete connection or poor transmission, the outgoing portion can be made maintenance busy and unavailable for service. The maintenance unbusy routing is used to make a defective trunk available after repairs have been made. Chart 2 shows the procedure required for placing a trunk on maintenance busy or for removing it.

CHART 2

TRUNK TEST FOR MAINTENANCE BUSY/UNBUSY ROUTINE

STEP	PROCEDURE
1	Initiate a test call by establishing an off-hook condition at the RMS.
	Note: PBX dial tone should be heard.
2	Dial the maintenance busy or unbusy code.
	Note: Second dial tone should be heard.
3	Dial the desired trunk group access code followed by the trunk number to be tested.
4	Determine that call has not been intercepted.
	Note: Intercept tone will be returned if an invalid code is dialed or the trunk is not of the type that can be put on maintenance busy.
5	Determine that trunk is on or off maintenance busy.
	Note: Three bursts of confirmation tone are returned to the RMS to verify that the trunk is on or off maintenance busy.

7. PBX TEST TONES AND LOOP-AROUNDS

7.01 Test tones and loop-arounds are provided with the DIMENSION FP8 PBX. Both test tone and loop-around numbers are assigned separate station numbers associated with the DIMENSION FP8 PBX.

7.02 Test tones and loop-arounds use two different ports in the test line equipment. The loop-around can only be dialed while the test tone call is going through its cycle. Two different circuits must be used to obtain a loop-around (see Fig. 5). After the test tone number has been dialed on circuit "0", the loop-around number is dialed on circuit "1", connecting both circuits "0" and "1" in a loop-around mode. Since only one call at a time can be placed by the RMS, the call on "0" circuit must be held up by artificial means in order for the RMS to dial the loop-around number.

7.03 The use of the loop-around feature enables the RMS to make the near to far-end transmission measurement by applying tone to "1" circuit and subtracting the far to near reading from the loop-around measurement.

7.04 The following occurs when port "0" is called:

(a) Answers automatically in 0.67 seconds

(b) Quiet termination for 300 milliseconds

(c) 1004 Hz at 0 dBm for 9 seconds (tone coupled thru port "0" to time division bus)

(d) Quiet for 1 second

(e) 404 Hz at 0 dBm for 9 seconds

(f) Quiet for 1 second

(g) 2804 Hz at 0 dBm for 9 seconds

(h) Quiet for 33 seconds

(i) Disconnects automatically (port "0" goes on-hook).

7.05 The following occurs when port "1" is called:

(a) Answers automatically in 0.67 seconds

(b) Quiet termination for 30 seconds (port "1" terminated in 600Ω input impedance of the amplifier)

(c) Disconnects automatically (port "1" goes on-hook).

7.06 The following occurs when port "0" is called first and then Port "1:"

(a) Port "0" (which is generating the tone sequence) immediately terminates generation of tones and remains off-hook.

(b) Port "1" answers in 0.67 seconds.

(c) Port "1" is linked to port "0" via 0 dB amplifier (one way) for 90 seconds.

(d) Port "1" disconnects.

(e) Port "0" continues off-hook and quiet for 30 seconds before hanging up.

7.07 The ability of an RMS to dial the RMS at the far end of a tie trunk enables the testers to make transmission and noise measurements without using the test tone and loop-around features. When using this method however, the testers must allow for the excess level deviations of the RMS test circuitry at each end of the connection.

8. NETWORK ACCEPTANCE TESTS

8.01 The COD must be compared and verified with the routing guide and verified with the project memo for all features. All tests must be documented by the PCO (Fig. 1 through 4). Copies of the documentation forms should be sent to the National Cutover Chairman. The general tests are shown in Charts 3 through 9.

CHART 3

SWITCHBOARD-TO-SWITCHBOARD TESTS

STEP	PROCEDURE
1	Use LC-11 test jacks on DIMENSION PBXs for transmission measurements. ***Note:*** Trunk to station loss must be allowed to equal 2.3 dB on DIMENSION PBXs and the requirement on the circuit order layout record for other type PBXs.
2	After transmission lineup tests from LC-11 jacks, dial up a test call from a station at the tandem switch to a station at the distant location.

CHART 3 (Contd)

STEP	PROCEDURE
	Note: After call is established, again check transmission (1010 Hz) to assure proper overall loss and switch pad operation.
3	Place a test call from the distant end to the test station at the tandem switch.
	Note 1: Pulsing tests from the DIMENSION PBX to subtending dial pulse locations are required.
	Note 2: The MAAP may be used to temporarily convert the signaling mode for tests at the DIMENSION PBX.
4	Use RMS to dial distant station (RNX-XXXX).
5	Use TVS to dial distant attendant (RNX-0111).
6	Place call from distant location to tandem attendant (RNX-0111).
7	If a satellite or tributary PBX is involved, place a test call (station to station) in both directions from the tandem to the satellite/tributary.
8	If off-net calling is provided through a subtending PBX, place an off-net call from the tandem through that PBX.
	Note 1: Steps 4 through 8 required on a trunk group basis only.
	Note 2: See Fig. 1 and 2 for sample test forms.

CHART 4

SMDR TESTS

STEP	PROCEDURE
1	Verify SMDR operation by using a printer and special circuit pack LC375. This provides a hard copy of an SMDR printout for pre-cutover testing.
	Note 1: The SMDR must be accepted prior to turnover with the tape printout.
	Note 2: On call-through tests, the first half of the test will use the printer and the second half of the test will use the regular SMDR magnetic tape.
	Note 3: Separate SMDR tapes should be ordered for call-through tests.

CHART 5

CACS NETWORK TESTS

STEP	PROCEDURE
1	Initialize CACS to customer-provided parameters. This includes verification of: (a) Polling frequency (b) Threshold values.
2	Test CACS connection capability to each tandem.

CHART 6

AUTOMATIC CIRCUIT ASSURANCE

STEP	PROCEDURE
1	Initialize ACA and verify: (a) Trunks equipped (b) ACA thresholds for each trunk group. ***Note 1:*** Check COD for factory settings ***Note 2:*** See Fig. 3 for sample test form for ACA.

CHART 7

CALLS TO PBXs AND OTHER TANDEMS (AAR)

STEP	PROCEDURE
1	Verify RNX-XXXX call (completed with switchboard-to-switchboard tests).
2	Verify operator (RNX-0111) call (completed on switchboard-to-switchboard tests).
3	Verify direct access calls via TVS and RMS (completed on switchboard-to-switchboard tests).

CHART 7 (Contd)

STEP	PROCEDURE
4	For overflow (on/off net): (a) Verify RNX (on-net) to listed directory number (off-net) translations. (b) Verify off-net translations to operator.
5	Verify main satellite/tributary calls (completed on switchboard-to-switchboard tests).
6	Verify incoming calls (completed on switchboard-to-switchboard tests).
	Note: See Fig. 2 and 4 for sample test form.

CHART 8

AUTHORIZATION CODES/FACILITY RESTRICTION LEVELS (FRLs)

STEP	PROCEDURE
1	Obtain a test authorization code with the highest FRL for TELCO testing and maintenance.
	Note: This is a separate authorization code than that used for call-through tests.
2	Verify FRLs by comparing the routing guide with the COD by Business Services prior to turnover.

CHART 9

AUTOMATIC ROUTE SELECTION (ARS)

STEP	PROCEDURE
1	Verify off-net calls via main PBXs (completed on switchboard-to-switchboard tests).
2	Verify all head-end and tail-end hop-off patterns.
3	Check sample sequences for all head-end and tail-end hop-off patterns via MAAP.

CHART 9 (Contd)

STEP	PROCEDURE
	Note: See Fig. 4 for sample form.
9.	**QUEUEING**

CHART 10

TEST REQUIREMENTS FOR NETWORK QUEUEING

STEP	PROCEDURE
	A. Local Test at Each Tandem
1	Test proper queueing on tandem switcher originating call.
	(a) Tandem users queue in nonpriority queue (when provided).
	(b) Users receive proper tones.
	(c) Queues time out as required.
	(d) Calls overflow on time out as required (if applicable).
	(e) Traffic registers assigned and pegged properly.
	(f) Message detail created properly.
	Note 1: Trunk calls can be tested later.
	Note 2: See Fig. 6 for test procedure.
	B. Network Tests
2	Test queueing on calls from subtending switches.
	(a) Subtending users queue in priority queue (when provided)
	(b) Users receive proper tones.
	(c) Queues time out as required.
	(d) Calls overflow on time-out as required (if applicable).

CHART 10 (Contd)

STEP	PROCEDURE
	(e) Traffic registers assigned and pegged properly.
	(f) Message detail created properly.
	(g) Service protection is operational. (See Fig. 7 for test procedures.)
3	Test network queueing with access tie trunk queues (when provided). (See Fig. 8 for test procedures.)
	(a) Test queue at original tandem.
	(b) Test access tie trunk queue.
4	Test network queueing in mixed DIMENSION/ESS ETN on DIMENSION/ESS groups. (See Fig. 9 for test procedures.)
	(a) Verify that call-in-queue at DIMENSION PBX seizes trunk after call at ESS releases.
	(b) Verify that call-in-queue at ESS seizes trunk after call at DIMENSION releases.
5	Test CACS controls and data by suspending or reinstating a queue and network queue. (See Fig. 10 for test procedures.)
	(a) Check individual tandem queueing.
	(b) Check network queueing.
	(c) Verify that CACS data reflects queueing.
	Note: CACS data reflects queues and queue seizures.
6	Test Customer Administration Panel/Customer Administration Terminal (CAP/CAT) controls and data by suspending or reinstating a queue. (See Fig. 11 for test procedures.)
	Note: CAP/CAT reads data on queues.

10. ETN DATA TRANSMISSION

A. Data Considerations

10.1 Voiceband analog data transmission on ETN is supported under two service provisioning options. The availability of these two new conditioning offerings provide a simplified data transmission plan for ETN. This plan provides basic (no conditioning) and enhanced (new tie trunk conditioning) data service.

10.2 Basic data service is supported (permitted and maintained) for higher data speeds (to the extent specified in Section 851-300-100) between on-premises stations of PBX/CTX tandem switches and main PBXs/CTXs. With no conditioning, data at speeds of 300 b/s or less will be supported over

connections with five or fewer tie trunks in tandem, 2400 b/s for two trunks in tandem, and 4800 b/s for one trunk.

10.3 Enhanced data service provides two new conditioning options, C7 and C8. These options will allow support for higher speed data transmission over more complex connections of tandem tie trunks. The C7 and C8 conditioning limits are:

ATTENUATION DISTORTION (Relative to 1000 Hz) (400 to 2800 Hz)	ENVELOPE DELAY DISTORTION (1000 to 2600 Hz)
Variation (dB)	Variation (μsec)
C7 -1, 4.5	550
C8 -1, 3.0	125

See Sections 314-410-300 and 314-410-500 for test procedures.

10.4 Tie trunks for an ETN configuration are installed following standard tie trunk designs and cannot be expected to support data beyond the basic level without special treatment. Enhanced data service on connections with up to three tandem tie trunks, for data speeds up to 4800 b/s, is available when conditioning is applied. Data support is defined in the following paragraphs with the appropriate conditioning requirements.

B. Data Support

10.5 High speed data transmission support should not be offered and C7 and C8 conditioning should not be applied when the following facility conditions are encountered in a trunk:

(a) O, ON, or N1 carrier is present

(b) More than one T1/D1A, B facility is present

(c) More than five carrier facilities (any type) are present.

10.6 All trunks between data locations, with the exception of those listed in paragraph 10.2 above, must be conditioned or special routing must be provided to access a conditioned subgroup for data calls.

10.7 Data support for data speeds greater than 300 b/s is defined for tandem connections of C7- or C8-conditioned tie trunks in ETN and other tie trunk configurations as follows:

(a) Up to 2400 b/s—Three tie trunks, any combination of C7 or C8 conditioning

(b) Up to 4800 b/s—Two tie trunks, C7 conditioning; three tie trunks, at least one C8 conditioning and two C7 conditioning.

10.8 The C8 conditioning may be applied on any one of the three tandem tie trunk groups, although the intertandem trunks will normally be preferred in ETN configurations. Separate voice and data trunk groups can be established between two electronic tandem switching (ETS) locations using special RNX codes to select the data trunks. In this case, only the data trunk group rquires conditioning. The data RNX precludes the possibility of alternate routing. This procedure reduces the required number of trunks to be C8 conditioned. Wihout special routing, the entire voice circuit group would require conditioning.

10.9 Data transmission support on ETN and other tie trunk configurations is based on providing a grade of service (GOS) comparable to the Message Telecommunications System (MTS) network. Data GOS is defined as the percent of dialed connections meeting error rate limits for Bell System provided data sets or transmission parameter limits for CPE data sets. Data support consists of a GOS of at least 85 percent of dialed connections meeting the error rate or transmission criteria.

10.10 Error rate limits for determining data GOS with Bell System provided data sets are a bit error rate of 10^{-5} or better for asynchronous data sets and a 1000-bit block error rate of 10^{-2} or better for synchronous data sets.

10.11 The determination of GOS for higher speed data support, using CPE data sets, is based on the end-to-end requirements in Table B. The end-to-end limits apply over the number of tandem connections supported for the given data speed and conditioning purchased, eg, with C7 conditioning only, the end-to-end limits for 2400 b/s apply over three trunks and the limits for 4800 b/s apply over only two trunks.

TABLE B

PARAMETER REQUIREMENTS FOR SUPPORTED DATA TRANSMISSION

(END-TO-END)

PARAMETER/UNITS	>300, ≤2400 BPS	>2400, ≤ 4800 BPS
EDD (μsec) (1004 to 2604 Hz)	≤1500	≤1100
Slope (dB) (404, 2804 Hz)	≤14	≤14
R2* (dB)	≥27	≥27
R3* (dB)	≥32	≥32
Signal/Noise † (dB)	≥24	≥24
Phase Jitter (Deg [20 to 300 Hz])	≤10	≤10
P/AR ‡	>50	>10
Impulse Noise/counts in 15 min — 6 dB below Received 1004 Hz tone	≤15	≤15

* R2 and R3 are 2nd and 3rd order intermodulation distortion, respectively.

† C-Notch noise at least 24 dB below received 1004 Hz holding tone level.

‡ Not required if EDD and slope are measured.

C. Data Service Arrangement

10.12 Data service arrangements which propose the use of off-premises PBX station lines are not recommended. However, data will be supported on an off-premises station (OPS) as specified for enhanced service if the OPS line is C7 conditioned and if it is counted as a trunk toward the maximum number of trunks allowed in a data connection.

10.13 When facilities and/or switches provided by OCCs or customers are utilized in an overall arrangement that include ETS switches, no statement of data support can be made over connections involving the OCC or CPE facilities or switches. Data transmission is not recommended or supported and no error rate can be specified when the MTS network is accessed via an ETN configuration (ie, an off-net connection).

11. REFERENCES

11.01 The following sections contain additional information.

SECTION	TITLE
309-001-011	Switched Services Network—ETL
309-400-000	ETN—General Description
309-400-001	ETN—Procedures and Responsibilities
309-400-002	CACS/CAP/CAT
309-400-004	ETN—Trouble Reporting
309-400-005	ETN—Network Analysis
309-400-007	ETN—Network Identification
311-100-500	Circuit Order and Trunk Order Transmission Tests
311-100-501	1000 Hz and Noise Measurements
311-300-500	PBX—Tests and Adjustment
471-2YY-ZZZ	Other Common Carrier (OCC)

SECTION	TITLE	SECTION	TITLE
554-010-122	SMDR—Maintenance and Test	554-191-208	SMDR—Feature Document
554-111-110	DIMENSION—Maintenance and System Administrative	554-191-3ZZ	DIMENSION—Troubles and Special Orders
554-111-300	DIMENSION—Installation and Test	660-225-1ZZ	Special Service System
554-111-3ZZ	DIMENSION—Feature Translation	795-402-100	Common Language Service Codes

ETN 1
12/8/78

End to End ETN Trunk Tests

Circuit _____ Customer _____

Location(A) (Tandem) _____ Distant End (Z) _____
RNX(A) _____ Trunk Group DAC(Z) _____
Authorization Code _____ Station(Z) # of Digits Outpulsed _____

1. Switchboard to Switchboard Tests
   A. Transmission Test
      1) Net Loss EML _____
         BSP 311-300-500 (Table L)

		Loss Readings (For Dimensions allow 2.3 dB trunk to station loss) A→→Z	Z→→A
2) Frequency Response			
BSP 311-300-500 (Table M)	1004N		
	404N		
	2804N		
3) Message Circuit Noise Required _____			
BSP 311-300-500 (Table N)			

		Required	Actual
4) ERL and S.P.			
BSP 311-350-100 311-350-500 Terminating	ERL		
851-300-100	SP		
Through	ERL		
	SP		

		Actual	(A→→Z)	(Z→→A)
5) Pulsing				
BSP 311-300-500 333-126-500	Max 12PPS			
	Min 12PPS			
	Max 8PPS			
	Min 8PPS			

   B. Switchpad Test
      Tandem Sta →→ Distant Sta (Overall loss and SW Pad Verification)
      Use TVS Test Station
      AML (1004H)

A→→Z	Z→→A

      (Dial test code + dial access code + TK # + station #).
      Note: If distant end is equipped, test tones may be used for this test.

   C. Operations Test Call
      Distant END →→ tandem test station
      (Network access code + RNX + tandem test station number) (+ Auth code if required).

      Call Completed OK _____

      Signature _____
      Date _____

Copy to National Cutover Chair

Date _____

Fig. 1—Sample ETN Test Form 1

ETN-2
12/8/78

TRUNK GROUP TESTS

Customer _____
Tandem Location (A) _____
RNX(A) _____
TEST AUTHORIZATION CODE _____

Trk Grp # _____
Distant Location (Z) _____
DAC(Z) _____
RNX Z: _____
Attentant RNX(Z) _____

1. Use TEST STATION to dial Distant Station
   8 + RNX + STATION
   Call Completed and SMDR Verified _____

2. Use test station to dial Distant Attendant
   8 + RNX + 0111
   Test Completed OK _____

3. If Satellite or Tributary is involved.
   Test Call A →→ Sat/Trib Station
   Dial 8 + RNX + Sat/Trib Sta XXXX
   Call Completed and SMDR Verified _____
   Tributary RNX _____

4. If "Off Net" calling is provided via a subtending PBX.
   (a) Call an OFF Net number through the subtending PBX
   Call Completed and SMDR Verified _____
   Test NR _____

5. AAR Verification of "ON Network" to "OFF Network" translations.
   (Call from Tandem Station to distant station).

   Note: Busy out all "on net" primary and alternate routes that could be accessed.

   (a) Call Distant Station (8+RNX+XXXX)
   1. If distant end had DID, the call should complete to the station via DDD.

   2. If distant end doesn't have DID the call should complete to the distant attendant on the LDN.

   Call Completed and SMDR Verified _____

   (b) Call Distant Attendant (8+RNX+0111) if DID. Attendant
   1. The call should complete to the distant attendant.

   Call Completed and SMDR Verified _____

Signature _____

Date _____

Note: On all of the above tests an authorization code may be required.

Form Forwarded To National Cutover Chair:

Date: _____

Fig. 2—Sample ETN Test Form 2

ETN-3a
Page____ of____

CUSTOMER_____

TANDEM LOCATION_____

AUTOMATIC CIRCUIT ASSURANCE TEST

(ACA TEST)

Business Service personnel should complete all sections labeled "Bus Svce" using the Routing Guide (sections "Group Attributes" and "Misc. Information") and the COD.

The field personnel verify the above results by performing the MAAP procedures given, and complete the rest of the form with the results as shown on the MAAP. A copy of the completed form should be sent to:

Cutover Chairman

_____

_____

Note: The Cutover Chairman should be notified on any discrepancies of results. He will coordinate their resolution with Business Services.

1. ACA enable:

_____ (Bus Svce)

_____ (MAAP 285, field 4)

(0 = off, 1 = on)

2. Console referred to and whether activated or not.

Console #	_____	(Bus Svce)
	_____	(MAAP 286, field 3)
Active	_____	(MAAP 286, field 1)
On/Off	_____	(MAAP 286, field 2)

Completed by (Bus Svce)_____ Date_____

Verified by (field personnel)_____ Date_____

Fig. 3—Sample ETN Test Form 3 (Sheet 1 of 2)

ETN-3b
Page ____ of _____

CUSTOMER _____

TANDEM LOCATION _____

ACA TEST
(continued)

3. Trunk group and thresholds assigned

DAC (BUS SVCE)	TRUNK GROUP # (BUS SVCE)	SHORT CALL (BUS SVCE)	THRESHOLD (MAAP 120)	LONG CALL (BUS SVCE)	LIMIT (MAAP 12)

Completed by (Bus Svce) _____ Date _____

Verified by (field personnel) _____ Date _____

Note: The Cutover Chairman should be notified on any discrepancies of results. He will coordinate their resolution with Business Services.

Fig. 3—Sample ETN Test Form 3 (Sheet 2 of 2)

ETN-4a
Page____of____

Customer: _____

Tandem Location: _____

AAR/ARS Routing Tests

Business Service personnel should complete all items labelled "Bus Svce" using the Routing Guide and the COD.

The field personnel verify the above results by performing the MAAP procedures given and completing the rest of the form with the results as shown on the MAAP.
A copy of the completed forms should be sent to: Cutover Chairman

_____

_____

NOTE: The Cutover Chairman should be notified of any discrepancies on this form. It is his responsibility to resolve them via coordination with Business Services.

A. AAR

1. A list of network RNX's and the AAR pattern they route to.

Routing Guide (Bus Svce — RNX Code Patterns)		(MAAP 320, word 4)
RNX (Location Code)	Pattern #	Pattern #
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

Completed by (Bus Svce): _____ Date: _____

Verified by (field personnel): _____ Date: _____

Fig. 4—Sample ETN Test Form 4(Sheet 1 of 5)

ETN-4b
Page ___ of ___

Customer: _____

Tandem Location: _____

AAR/ARS Routing Tests
(continued)

A. AAR (continued)

2. The trunk group number and other information for each of the preferences in the routing patterns listed in part A.1. above.

Routing Guide
Bus Svce — ARS Routing Patterns)

Pattern #	Preference	DAC/Trunk Group #	FRL	Warning Tone	Offnet
1	1				
	2				
	3				
	4				
2	1				
	2				
	3				
	4				
3	1				
	2				
	3				
	4				
4	1				
	2				
	3				
	4				

(MAAP 320, word 1)

Trunk Group #	FRL	Warning Tone	Offnet

Completed by (Bus Svce): _____ Date: _____

Verified by (field personnel): _____ Date: _____

Fig. 4—Sample ETN Test Form 4 (Sheet 2 of 5)

ETN-4c
Page___ of___

Customer:_____

Tandem Location:_____

AAR/ARS Routing Tests
(continued)

B. ARS

1. A list of routing patterns (for three plans) for 3-digit translated foreign NPAs.

	Routing Guide (Bus Svce — FNPA 3-D Service Codes)			(MAAP 311, word 2)		
NPA	Plan 1 Pattern #	Plan 2 Pattern #	Plan 3 Pattern #	Plan 1 Pattern #	Plan 2 Pattern #	Plan 3 Pattern #

2. List of office codes (NNXs) and corresponding patterns for the home NPA.

Routing Guide (Bus Svce — HNPA NNX List)		(MAAP 311, word 1)
NNX (Office Code)	Pattern #	Pattern #

Completed by (Bus Svce): _____ Date: _____

Verified by (field personnel): _____ Date: _____

Fig. 4—Sample ETN Test Form 4 (Sheet 3 of 5)

ETN-4d
Page___ of__

Customer: _____

Tandem Location: _____

AAR/ARS Routing Tests
(continued)

B. ARS (continued)

3. List of routing patterns for 6-digit translated foreign NPAs.

Routing Guide (Bus Svce — FNPA 6-D NNX Translation List)			(MAAP 311, word 3)
NPA	NNX (Office Code)	Pattern #	Pattern #

Completed by (Bus Svce): _____ Date: _____

Verified by (field personnel): _____ Date: _____

Fig. 4—Sample ETN Test Form 4 (Sheet 4 of 5)

ETN-4e
Page ____ of ____

AAR/ARS Routing Tests
(continued)

Customer: _____

Tandem Location: _____

B. ARS (continued)

4. The trunk group number, FRL, warning tone for each of the preferences (for each plan) for the ARS patterns listed in A.1, 2, 3 above.

Routing Guide (Bus Svce — ARS Routing Patterns)							(MAAP 310, word 1)			
Plan	Pattern #	Preference	DAC/Trunk Group #	FRL	Warning Tone	Trunk Group #	FRL	Warning Tone		
			/							
			/							
			/				

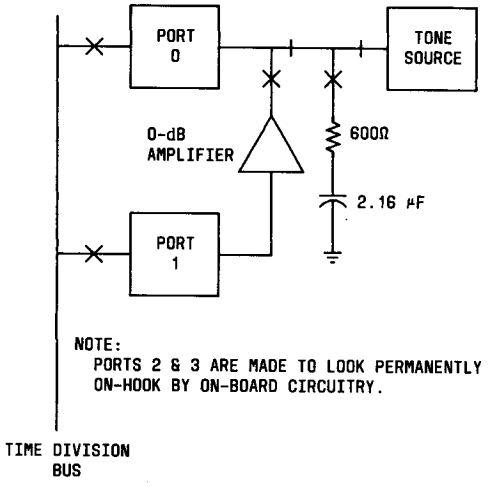

Fig. 5—DIMENSION Test Tones and Loop-Around Test

1. BUSY OUT ALL TRUNKS ON GROUP TO BE TESTED AND ALL ALTERNATE ROUTES (IF APPLICABLE).

2. INITIATE A CALL. NOTE TONES AS CALL QUEUES.

3. USE RMATS OR MAAP TO MONITOR PEG COUNTS ON NONPRIORITY QUEUE.

   (a) NOTE IF CALL CAUSES PEG INCREMENT.

   (b) NOTE ALL TRAFFIC REGISTER CONTENTS ON NO. 1/1A.

   (c) USE CAT TO MONITOR NONPRIORITY QUEUE AS ABOVE.

   (d) MONITOR PRIORITY QUEUE (WHEN PROVIDED).

4. OPEN FIRST ALTERNATE ROUTE; MONITOR TRAFFIC REGISTERS FOR THAT ROUTE (ONLY APPLICABLE TO ARS OR DDD OVERFLOW).

5. CALL IS ALLOWED TO TIME OUT.

6. TERMINATE CALL AFTER TIME-OUT, AND NOTE TERMINATION TIME AND ANY TONES.

7. MONITOR MESSAGE DETAIL RECORD CONFIRMING THAT CALL QUEUED FOR X SECONDS ALLOWED FOR TIME-OUT AND COMPLETED OVER ALTERNATE ROUTE WITH UPGRADED FRL (IF APPLICABLE) OR WENT TO REORDER.

8. REPEAT STEPS 1 THROUGH 7 FOR EACH FRL AND DOCUMENT TEST RESULTS.

Fig. 6—Recommended Procedures for Local Test at Each Tandem in Support of Network Queueing Installations

1. BUSY OUT ALL TRUNKS ON GROUP TO BE TESTED AND ALL ALTERNATE ROUTES (IF APPLICABLE).

2. USE TEST ACCESS TO SIMULATE CALL FROM MAIN/SATELLITE/TRIBUTARY ON ACCESS TIE TRUNK.

3. USE RMATS OR MAAP TO MONITOR PEG COUNTS ON NONPRIORITY QUEUE (WHEN PROVIDED).

   (a) NOTE IF CALL CAUSES PEG INCREMENT.

   (b) NOTE ALL TRAFFIC REGISTER CONTENTS ON NO. 1/1A.

   (c) USE CAT TO MONITOR NONPRIORITY QUEUE AS ABOVE.

   (d) MONITOR PRIORITY QUEUE (WHEN PROVIDED).

4. OPEN FIRST ALTERNATE ROUTE; MONITOR TRAFFIC REGISTERS FOR THAT ROUTE (ONLY APPLICABLE TO ARS OR DDD OVERFLOW).

5. CALL IS ALLOWED TO TIME OUT.

6. TERMINATE CALL AFTER TIME-OUT, AND NOTE TERMINATION TIME AND ANY TONES.

7. MONITOR MESSAGE DETAIL RECORD CONFIRMING THAT CALL QUEUED FOR X SECONDS ALLOWED FOR TIME-OUT AND COMPLETED OVER ALTERNATE ROUTE WITH UPGRADED FRL (IF APPLICABLE) OR WENT TO REORDER.

8. REPEAT STEPS 1 THROUGH 7 FOR EACH FRL AND DOCUMENT TEST RESULTS.

Fig. 7—Recommended Procedures for Network Queueing Test

1. BUSY OUT ALL TRUNKS ON GROUP TO BE TESTED AND ALL ALTERNATE ROUTES (IF APPLICABLE).

2. AT DISTANT TANDEM, BUSY OUT ALL TRUNKS IN ACCESS TIE TRUNK GROUP WITH QUEUES INSTALLED.

3. INITIATE TANDEM CALL TO PBX (SERVED BY DISTANT TANDEM) ON ACCESS TIE TRUNK GROUP IN STEP 2.

4. OPEN TRUNK IN DIRECT ROUTE-ON. CALL SHOULD COMPLETE TO DISTANT TANDEM AND QUEUE.

5. AT DISTANT TANDEM, OPEN TRUNK IN ACCESS TIE TRUNK GROUP. CALL SHOULD COMPLETE.

6. MONITOR MESSAGE DETAIL RECORD AT ORIGINATING TANDEM FOR PROPER DATA AND NOTE.

7. AT DISTANT TANDEM, MONITOR MESSAGE DETAIL RECORD AT TERMINATING TANDEM FOR PROPER DATA AND NOTE.

8. REPEAT STEPS 1 THROUGH 7 FOR EACH COMBINATION OF INTERMACHINE TRUNK QUEUES AND ACCESS TIE TRUNK QUEUES.

Fig. 8—Recommended Procedures for Network Queueing Test With Access Tie Trunk Queues

1. BUSY OUT ALL BUT ONE TRUNK IN "DIMENSION"/ESS TRUNK GROUP AND ALL ALTERNATE ROUTES AT EACH OF THE TANDEMS.

2. INITIATE TWO CALLS FROM ESS TANDEM TO "DIMENSION" TANDEM.

3. INITIATE TWO CALLS FROM "DIMENSION" TANDEM TO ESS TANDEM.

4. VERIFY THAT FIRST ESS CALL IS RELEASED -- "DIMENSION" CALL SHOULD SEIZE TRUNK.

5. HOLD "DIMENSION" CALL FOR 1 MINUTE -- THEN RELEASE -- ESS CALL SHOULD SEIZE TRUNK.

6. HOLD ESS CALL FOR 1 MINUTE -- THEN RELEASE.

7. MONITOR MESSAGE DETAIL DATA TO DETERMINE IF TRUNK GROUP IS PROPERLY SHARED.

Fig. 9—Recommended Procedures for Testing Network Queueing a Mixed DIMENSION/ESS ETN Configuration

1. BUSY OUT ALL TRUNK GROUPS AT A TANDEM.
2. INITIATE TEST CALLS TO VERIFY THAT QUEUES AT TANDEM ARE ACTIVE. ASSUME TANDEM AND NETWORK TESTS HAVE BEEN COMPLETED.
3. USE CACS TERMINAL TO SUSPEND EACH QUEUE AT TANDEM.
4. INITIATE CALLS TO TEST QUEUE SUSPENSION.
5. USE CACS TERMINAL TO REINSTATE EACH QUEUE AT TANDEM.
6. INITIATE CALLS TO TEST THAT QUEUES ARE ACTIVE.
7. REPEAT STEPS 1 THROUGH 6 FOR EACH TANDEM.
8. WITH ALL TRUNKS BUSY, USE CACS TERMINAL TO SUSPEND QUEUES ON A NETWORK BASIS.
9. INITIATE CALLS TO TEST QUEUES SUSPENSION.
10. USE CACS TERMINAL TO REINSTATE QUEUES ON NETWORK BASIS.
11. INITIATE CALLS TO TEST IF QUEUES ARE ACTIVE.
12. PUT ALL TRUNKS BACK INTO SERVICE.
13. DURING TESTING, MONITOR CACS TRAFFIC DATA REPORTS TO ENSURE QUEUES AND QUEUE SIZES ARE PROPERLY REFLECTED IN CACS MASK.

Fig. 10—Recommended Procedures for Testing CACS Network Queueing Installations

1. BUSY OUT ALL TRUNKS GROUPS TO BE TESTED FOR QUEUEING.

2. INITIATE CALLS TO ENSURE QUEUES ARE ACTIVE.

3. USE CAP TO CANCEL QUEUEING (NO. 1/1A TANDEMS USE CAT).

4. INITIATE CALLS TO TEST QUEUE SUSPENSION.

5. USE CAP/CAT TO REINSTATE QUEUE.

6. INITIATE CALLS TO ENSURE QUEUE IS ACTIVE.

7. DURING TESTS, USE CAP/CAT TO READ TRAFFIC REGISTERS.

8. REPEAT STEPS 1 THROUGH 6 FOR EACH QUEUE AT EACH TANDEM.

Fig. 11—Recommended Procedures for Testing CAP/CAT Network Queueing Installations

NOTES

SWITCHED SERVICE NETWORK

ELECTRONIC TANDEM NETWORKS (ETN)

EXAMPLES OF NETWORK ROUTING GUIDES FOR "DIMENSION®" FEATURE PACKAGE 8 TANDEMS

1.01 This appendix shows the Network Routing Guides (NRGs) used on the Electronic Tandem Network (ETN) for DIMENSION Feature Package 8 (FP8). It provides an easy reference to the NRG when more detailed information may be required.

1.02 The NRG defines the switching machine assignments and routing of network service. The NRGs are important references and are used by various work centers. Information contained in the routing guide is listed below:

- Network and Tandem Diagrams
- Facility Restriction Levels
- Automatic Alternate Routing (AAR) Codes and Location Record
- RNX Code Assignments
- RNX Code Patterns
- AAR Group Attributes
- AAR Routing Patterns
- Automatic Route Selection (ARS) Routing Record
- NPA 3-Digit Pattern List
- NPA 6-Digit NXX Translation List
- HNPA NXX List
- NPA 6-Digit NXX Local Call List
- ARS Group Attributes
- ARS Routing Patterns
- ARS Special/Service Codes
- Intertandem Trunking Record
- Intertandem Group Attributes
- Intertandem Routing Patterns
- Miscellaneous Information
- Master DAC/Pattern Assignments and Trunk Group Restrictions
- Master 6-Digit Local Call List Assignments
- Test/Administrative Codes

1.03 ***Network and Tandem Diagrams:*** Figure 1 shows the network configuration with all tandem locations. Figure 2 shows subtending locations and facilities for each tandem switch.

1.04 ***Facility Restriction Levels (FRLs):*** There is a maximum of eight FRLs. They are 0 through 7 and are used to deny certain users access to specific groups of circuits and stations served from a tandem switch. An FRL is assigned to all circuit groups. The customer can upgrade or downgrade station and originating access tie trunk FRLs as required. An example of FRL use is a Level 3 calling certain NPAs. Levels of a lesser value would be denied (Fig. 3). Another example would be that a Level 3 FRL could be assigned for daytime use but be downgraded by the customer to a lower FRL after normal working hours.

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1.05 ***AAR Codes and Location Record:*** A form which is used for record keeping purposes at the tandem switch and which lists the location, Message Telecommunication System (MTS) number, dial access code (DAC) assigned, TOUCH-TONE® or dial pulse signaling, originating (default) FRL, outpulsing required, network attendant number, if applicable, and the type of equipment used (Fig. 4).

1.06 ***RNX Code Assignments:*** An RNX code is a unique 3-digit code to access a given network location and is an integral part of the uniform numbering system. The special first digit restriction (R) is due to the reservation of any digits 4 through 9. Each switch at every location (Fig. 5) is assigned a unique block of RNX codes, an associated routing pattern, and a DAC.

1.07 ***RNX Code Patterns:*** Each RNX is assigned a unique routing pattern number which provides the switcher with information on call routing. Figure 6 shows how RNX codes and routing pattern numbers are assigned. This form indicates every RNX routing pattern in the ETN.

1.08 ***AAR Group Attributes:*** Items unique to the group of circuits being addressed are identified as AAR group attributes. A form (Fig. 7) is used to show these items. The DAC column on this form shows the assignment of the trunk group in the tandem. The authorization code (AC) column indicates if ACs are required on all calls. (A 0 indicates that an AC is not required on all calls, and a 1 indicates that it is required.) The trunk reservation (Trk. Res.) column indicates the quantity of trunks in the group reserved for special application. The access AAR/ARS column indicates if the trunk group has access to both on-net (AAR) and off-net (ARS) circuits. (A 0 indicates access denied to both on-net and off-net while 1 indicates access to both.) The automatic circuit assurance (ACA) column indicates the thresholds for short holding time (SHT) in seconds and long holding time (LHT) in hours.

1.09 ***AAR Routing Patterns:*** Routing patterns for each RNX are assigned 2-digit or 3-digit numbers. Pattern 01 is usually reserved for intercept. AAR routing pattern forms (Fig. 8) show the following:

(a) ***Dial Access Codes:*** Three-digit codes assigned by Business Services to each circuit group. (See dial access code record.)

(b) ***Term FRL:*** The facility restriction level assigned to the terminating group.

(c) ***Warning Tone:*** A warning tone can be provided to the calling party indicating a less than economical route has been accessed, for example, an on-net call overflowing to MTS on a more expensive route would be indicated by a 1. An economically acceptable route would be indicated by a 0 and no warning tone would be generated.

(d) ***Off Net:*** If routine pattern is equal to 1, call is destined for off-net via a main PBX and must be controlled by the switcher. Subnetwork trunking must be completed. An on-net call is indicated by 0.

(e) ***Precision Dial Tone (PDT):*** The PDT will be received as a 1 from all subnetwork links in a specific route. Zero indicates some portion or links in the route are not PDT.

(f) ***Digits to Delete:*** Indicates to the terminating switcher the number of digits to delete in order to complete the call. For example, a PBX with 3-digit station codes would require the switch to delete four digits.

(g) ***Subnetwork Trunking:*** Required if a call is destined to go via a main PBX to a tributary, etc, or if the on-net dialed call overflows to off-net for completion.

(1) Digits to insert indicates to the switcher those digits necessary to insert for off-net calls.

(2) Groups 1, 2, and 3 indicate call progression through the network. The subitems are:

(a) TOUCH-TONE (TT) — Indicated by 1. Dial pulse is indicated by 0.

(b) Pause Length — The maximum seconds to wait before outpulsing.

(c) Digits Outpulsed — The number of digits to outpulse (maximum of 7).

1.10 ***ARS Routing Record:*** The ARS routing record lists the various off-network routes being served by a specified switch by NPA and NXX or NPA only. Figure 9 is an example of an

ARS routing record. The routing record contains the following information:

(a) ***NPA:*** The 3-digit numbering plan area of the served area.

(b) ***Remarks:*** Indicates miscellaneous information on call routing.

(c) ***FX Terminating Central Office (CO):*** Lists the 3-digit NXX of the terminating CO if an FX is involved.

(d) ***Route On:*** Indicates how calls to a given NPA are routed. In Fig. 9, calls to NPA 214 route on the 214 NPA and calls to NPA 817 route on both the NPA and the NXX.

(e) ***First Route, Second Route, etc:*** Off-net (ten digit) dialed calls have various routes to complete by. These columns reflect the first choice and the available overflow routes (eg, first choice—Wide Area Telecommunications Service—(WATS) full band 5, second choice—WATS measured time band 5, third choice—DDD, etc), up to a maximum of ten routes.

1.11 ***NPA 3-Digit Pattern List:*** This form, Fig. 10, identifies the pattern number of translated NPAs with the exception of the HNPA. The time of day route (maximum of 3) is indicated in hours, minutes (given in military time). The T.O.D. sequence column goes into effect as indicated by the hours and minutes columns. When the horizontal columns intersect the vertical columns, a 2-digit pattern number is inserted to tell the switch which route this NPA is to be routed on. For example, (20X) from the horizontal column combined with (XX1) from the vertical column equals NPA (201). If tail-end-hop-off (TEHO) is utilized, a pattern number for intermachine trunks is indicated.

1.12 ***NPA 6-Digit NXX Translation List:*** This list, Fig. 11, is used to provide the necessary information for 6-digit translation related to foreign numbering plan areas. It supplements the 3-digit pattern list and includes the following information.

(a) ***NPA:*** Lists the NPA that is 6-digit translated. There is a separate sheet for each NPA.

(b) ***Pattern Columns:*** Each NPA can have a maximum of four groups terminated in it. The number of groups is indicated by a 2-digit route pattern number shown as Default or FX List 1 through 4.

(c) ***NXX Code:*** All the NXXs in an NPA must be routed. The NXX is listed by FX list number and corresponds to the FX pattern number which, when translated, will route to the specified pattern. If an NXX is not listed under any pattern, the program automatically defaults to NPA FX Pattern I.

1.13 If Fig. 11 is used as an example of the NPA 6-Digit NXX translation list, it can be determined that NPA 817 when translated will route to patterns 06 and 04. At this point, it can be determined that there are 10 NXXs to be routed to the FX ARS pattern 04. All other NXXs (not listed) within the 817 NPA will automatically default to pattern 06.

1.14 ***HNPA NXX List:*** Figure 12 shows a sample list for a (home) HNPA NXX list. It is similar to the form listing the NPA 6-Digit NXX translation list except that it lists the HNPA. In this list, the actual pattern number is listed for each NXX routed.

1.15 ***NPA 6-Digit NXX Local Call List:*** Figure 13 shows a sample 6-Digit NXX local call list. It indicates calls that are local to an FX calling area or calls that do not have a digit 1 prefix to them. The pattern number relates to the pattern number on the top of the NPA 6-Digit NXX translation list (Fig. 11). The local call list is assigned by Business Services and can be between 02 and 99. All NXXs not requiring a prefix of digit 1 are indicated by a check (✓).

1.16 ***ARS Group Attributes:*** This form (Fig. 14) is used for an overview of the ARS routes in a given switch. The DAC column on this form shows the assignment of the trunk group in the tandem. The serving NPA column shows the NPA serving the far-end or open-end. The # of ckts. column shows the quantity of circuits used. The Trk. Res. column indicates the quantity of trunks in the group that are reserved for special application. The ACA column indicates the thresholds for short holding time in seconds and long holding time in hours.

1.17 ***ARS Routing Patterns:*** These patterns provide information related to off-net routing arrangements (Fig. 15). They are identical to the on-net routing patterns with the following exceptions:

(a) Subnetwork trunking is used for off-net calls via subtending locations.

(b) Only four digits are inserted.

(c) There are a maximum of ten routes associated with each pattern rather than four.

(d) Time of day sequence (T.O.D. Seq.) is available. If the customer subscribes to time variable off-network routing, each T.O.D. Seq. is indicated with a 1, 2, or 3. The time of day is in military time, hours and minutes. Each sequence uses the same pattern number.

1.18 The following is a description of the columns on the ARS routing pattern form.

(a) ***Pattern Number:*** A 2-digit arbitrarily assigned number from 02 to 99.

(b) ***DAC:*** An arbitrarily assigned 3-digit trunk or group identification code from 100 to 199.

(c) ***Term FRL:*** The facility restriction level assigned to the terminating group.

(d) ***Warning Tone:*** A warning tone can be provided to the calling party indicating a less than economical route has been accessed. For example, if a warning tone is provided, an on-net call overflowing on a more expensive route would be indicated by a 1. If the call accesses an economically acceptable route, no warning tone would be generated and a 0 would be shown.

(e) ***Distant NPA:*** The terminating or distant NPA of the WATS or FX facility.

(f) ***Dial 1 for Toll:*** If 0, only local calls are allowed to be completed. A 1 indicates the digit 1 or barrier code is required for a 10-digit toll call only. A 2 indicates the digit 1 is required for both 7- and 10-digit toll calls.

(g) ***Local List Number:*** This column lists the NPA 6-digit NXX local call list number (see paragraph 1.15).

1.19 ***ARS Special/Service Codes:*** This form (Fig. 16) is used to route all special codes and/or service code requirements of the customer. The actual patterns these codes are to be routed to are inserted in the space provided. Blank spaces indicate routing to intercept.

1.20 ***Intertandem Trunking Record:*** This form (Fig. 17) is a written description of the intertandem tie trunk routes to distant tandem locations. The first alternate route is the first choice trunk group. The alternate indicates the first through the third alternate in tandem routes.

1.21 ***Intertandem Group Attributes:*** Figure 18 shows the intertandem group attributes which give an overview of intertandem routes for a given tandem. The following columns are shown:

(a) ***DAC:*** The assignment of the trunk group in the tandem.

(b) ***# Of Ckts:*** Indicates the quantity of circuits to be used.

(c) ***Trk. Res:*** Indicates the quantity of trunks in the group that are reserved for special application.

(d) ***ACA:*** Indicates the thresholds for short holding time (SHT) in seconds and long holding time (LHT) in hours.

1.22 ***Intertandem Routing Patterns:*** This form (Fig. 19) is used to record intertandem routing patterns. The following columns are shown:

(a) ***Pattern Number:*** A 2- or 3-digit arbitrarily assigned number, excluding 00 and 01.

(b) ***DAC:*** An arbitrarily assigned 3-digit trunk or group identification code.

(c) ***Term FRL:*** The facility restriction level assigned to the terminating group.

(d) ***Warning Tone:*** A warning tone can be provided to the calling party indicating a less than economical route has been accessed. For example, if a warning tone is provided, an on-net call overflowing to MTS on a more expensive route would be indicated by 1. If an economically acceptable route is accessed, no

warning tone would be generated and a 0 would be shown.

(e) ***Off Net:*** If routing pattern is equal to a 1, call is destined for off-net via a main PBX and must be controlled by the switcher. Subnetwork trunking must be completed. An on-net call is indicated by 0.

(f) ***Precision Dial Tone (PDT):*** The PDT will be received as a 1 from all subnetwork links in a specific route. A zero indicates some portion or links in the route are not PDT.

(g) ***Digits to Delete:*** Indicates to the terminating switcher the number of digits to delete in order to complete the call. For example, a PBX with 3-digit station codes would require the switch to delete four digits.

(h) ***Subnetwork Trunking:*** Required if a call is destined to go via a main PBX to a tributary, etc, or if the on-net dialed call overflows to off-net for completion.

1.23 ***Miscellaneous Information:*** This form (Fig. 20) is used to record miscellaneous information common to the tandem switch. The following information is included:

(a) ***Authorization Codes:*** The number of authorization codes the customer has (9000 maximum) is listed. The length of the code (4 to 7 digits) and the number of seed digits (3 or 4) are included.

(b) ***Customer Administration Center FRL:*** List the FRL of the Customer Administration Center (CAC), usually 7. The Dialing Plan is the number of station digits (3 or 4) or number of RNX digits (2 or 3).

(c) ***Station Message Detail Recording (SMDR)***

(1) Ineffective attempts on printout requires a yes or no response.

(2) Length of Account Codes is optional, 5 to 9 digits.

(3) Account Code Prefix Digit is the reserved R digit, from 2 through 9.

(4) Reserved Digits are digits reserved for future use.

(5) Group Exceptions (DAC) are those groups for which SMDRs are to be excluded.

(d) ***Attendant Console # (ACA):*** The number associated with the attendant console needed to provide ACA.

(e) ***Attendant Console FRL:*** The FRL associated with the attendant console (usually 7).

(f) ***Network:*** Symmetrical prohibits on-net alternate routing while Hierarchial means alternate routing is permitted.

(g) Access Codes

(1) AAR indicates access digit (usually 8).

(2) ARS indicates access digit (usually 8 or 9).

(3) IDDD indicates an IDDD special cut-through code if applicable.

1.24 ***Master DAC/Pattern Assignments and Trunk Group Restrictions:*** This form (Fig. 21) is a master list by DAC showing the first choice AAR or ARS pattern and the trunk group assigned. The trunk group restriction (TGR) column, if checked, indicates that the associated DAC is restricted from direct access by stations.

1.25 ***Master 6-Digit Local Call List Assignments:*** This form (Fig. 22) is used to list in numerical order all assigned 6-digit NXX local call list numbers and their associated ARS patterns. As these numbers are assigned, they are recorded under the Assigned To column to prevent duplication.

1.26 ***Test and Administrative Codes:*** This form, Fig. 23, provides administrative test code numbers and a test for tie trunks and intermachine tie trunks associated with a given switch. It also provides space to list telephone numbers of involved work centers.

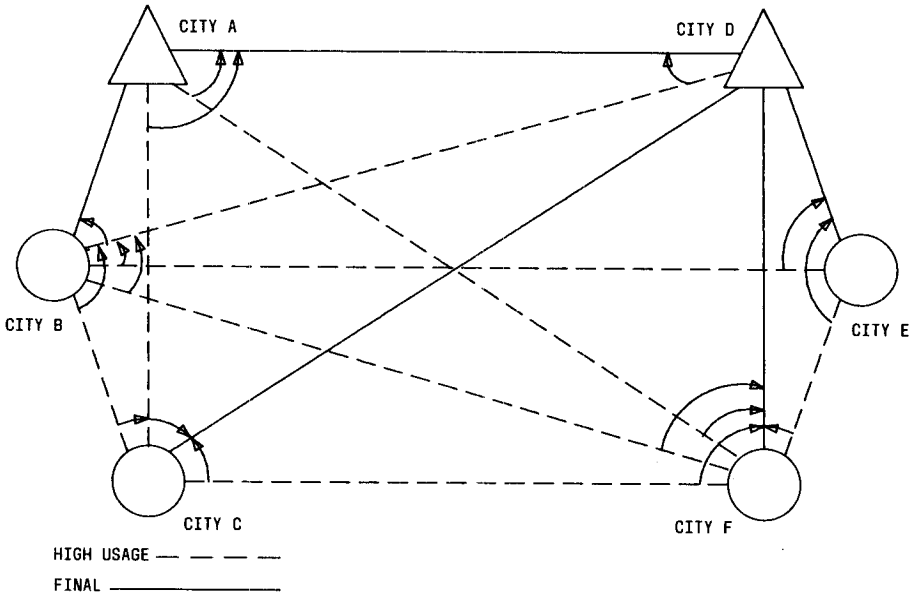

Fig. 1—Example of Network Tandems Configuration

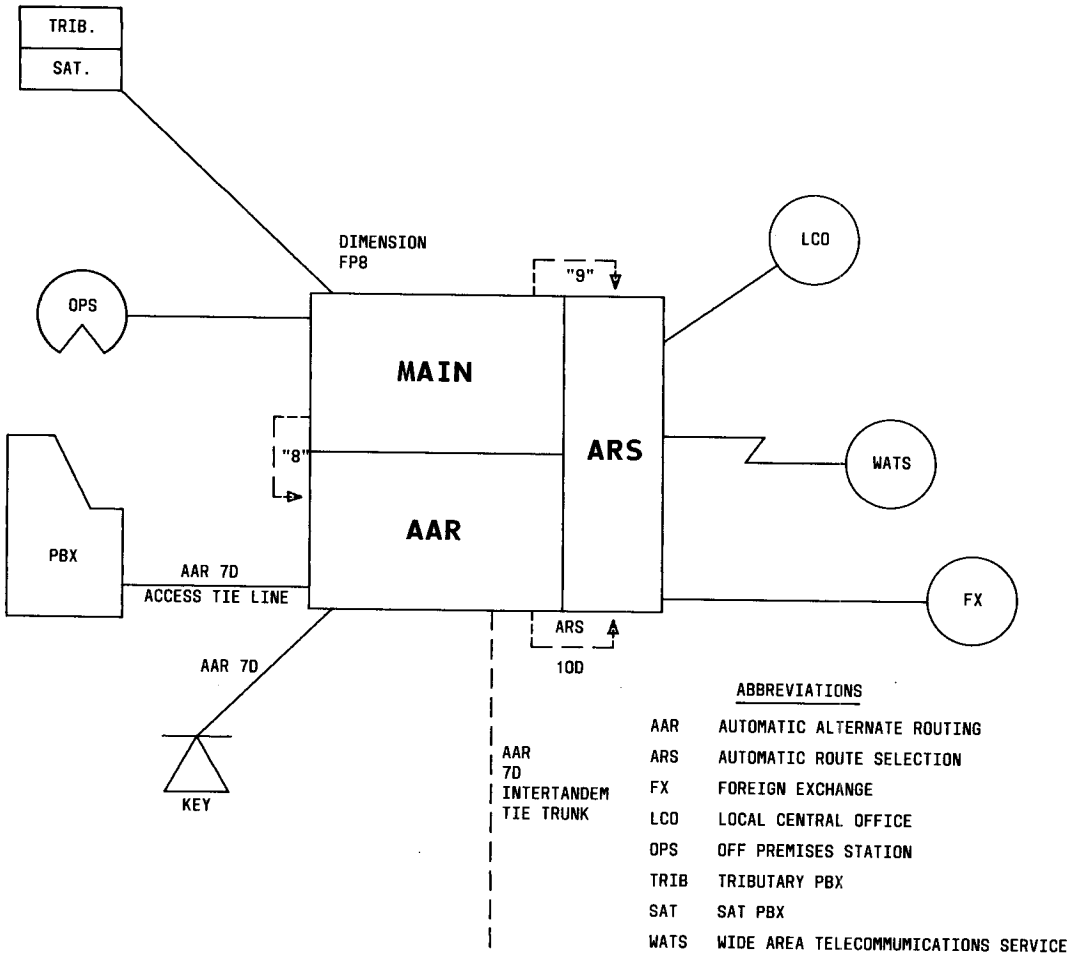

Fig. 2—Example of Tandem Switch Facilities

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FACILITY RESTRICTION LIST

FRL Val.	Description	Alt. FRL
0	INTERCOM	0
1	OPERATOR(011)LOCAL NNX's SERVICE CODES	1
2	FRL 1 AND ON-NETWORK	2
3	FRL 2 AND OFF-NETWORK VIA WATS AND FX	2
4	FRL 3 AND DDD TO CONTINENTAL USA	2
5	FRL 4 AND ALL DDD AND REMOTE ACCESS	2
6	FRL 5 AND ON-NET CALL OVERFLOW TO DDD	2
7	CAC	7

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Fig. 3—Facility Restriction List

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AAR CODES AND LOCATION RECORD

Action	Effective Date	Location (City, State)	RNX	Pattern No.	MTS	DID Y/N	DAC	Signaling In	Signaling Out	DEFLT FRL	Out Pulse	Network ATT DT No.	Type Eqpt.
A	CUT	Dallas, TX 1505 Elm	222	30	214-745-8000	Y	130	TT	TT	2	4	0111	DIM 2000
A	CUT	Dallas, TX 3400 Ill.	251	31	214-333-3211	Y	132	DP	DP	2		0111	OKI
A	CUT	Denver, Co 475 17th St	253	37	303-893-2780	Y	150	TT	TT	0			Key

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Fig. 4—AAR Codes and Location Record

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RNX CODE ASSIGNMENTS

RNX	Effective Date	Route Pattern	DAC
220		— — —	— — —
221		— — —	— — —
222	CUT	1 5 1	1 1 2
223		— — —	— — —
224		— — —	— — —
225		— — —	— — —
226		— — —	— — —
227		— — —	— — —
228		— — —	— — —
229		— — —	— — —
230		— — —	— — —
231		— — —	— — —
232		— — —	— — —
233		— — —	— — —
234	CUT	1 5 2	1 1 3
235	CUT	1 5 3	1 1 4
236	CUT	1 5 4	1 1 5
237		— — —	— — —
238		— — —	— — —
239		— — —	— — —
240		— — —	— — —
241		— — —	— — —
242		— — —	— — —
243		— — —	— — —
244		— — —	— — —
245		— — —	— — —
246		— — —	— — —
247		— — —	— — —
248		— — —	— — —
249		— — —	— — —
250		— — —	— — —
251		— — —	— — —
252		— — —	— — —
253		— — —	— — —
254		— — —	— — —
255		— — —	— — —
256		— — —	— — —
257		— — —	— — —
258		— — —	— — —
259		— — —	— — —

RNX	Effective Date	Route Pattern	DAC
260		— — —	— — —
261		— — —	— — —
262		— — —	— — —
263		— — —	— — —
264		— — —	— — —
265		— — —	— — —
266		— — —	— — —
267		— — —	— — —
268		— — —	— — —
269		— — —	— — —
270		— — —	— — —
271		— — —	— — —
272		— — —	— — —
273		— — —	— — —
274		— — —	— — —
275		— — —	— — —
276		— — —	— — —
277		— — —	— — —
278		— — —	— — —
279		— — —	— — —
280		— — —	— — —
281		— — —	— — —
282		— — —	— — —
283		— — —	— — —
284		— — —	— — —
285		— — —	— — —
286		— — —	— — —
287		— — —	— — —
288		— — —	— — —
289		— — —	— — —
290		— — —	— — —
291		— — —	— — —
292		— — —	— — —
293		— — —	— — —
294		— — —	— — —
295		— — —	— — —
296		— — —	— — —
297		— — —	— — —
298		— — —	— — —
299		— — —	— — —

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Fig. 5—RNX Code Assignments

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RNX CODE PATTERNS

RNX Code (X) (RN)	0	1	2	3	4	5	6	7	8	9
22			151							
23					152	153	154			
24										
25										
26										
27										
28										
29										

RNX Code (X) (RN)	0	1	2	3	4	5	6	7	8	9
32										
33										
34										
35										
36										
37										
38										
39										

RNX Code (X) (RN)	0	1	2	3	4	5	6	7	8	9
42										
43										
44										
45										
46										
47										
48										
49										

RNX Code (X) (RN)	0	1	2	3	4	5	6	7	8	9
52										
53										
54										
55										
56										
57										
58										
59										

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Fig. 6—RNX Code Patterns

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AAR GROUP ATTRIBUTES

DAC	Assignment	# Of Ckts.	A C	Trk. Res.	Access AAR/ ARS	Remarks	ACA SHT	ACA LHT
11 2	1326 Main St., City A	04	0	00	1		30	2
11 3	812 South St., City B	10	0	00	1		30	2
11 4	555 Bow Rd., City C	01	0	00	1		30	2
11 5	19A West Ave; City D	22	1	06	1		30	2

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AAR ROUTING PATTERNS

Action	Effective Date	Pattern Number	DAC	Term FRL	Warning Tone	Off Net	PDT	Dig. To Del.	Subnetwork Trunking: Digits To Insert	Group 1: TT	Group 1: Pause Length	Group 1: Digits Out Pulsed	Group 2: TT	Group 2: Pause Length	Group 2: Digits Out Pulsed	Group 3: TT	Group 3: Pause Length	Group 3: Digits Out Pulsed
A	CUT	151	150	2	0	0	0	3	19197273734									
			105	6	1	0	1	3										
A	CUT	163	150	2	0	0	0	4		1	08	3						
			114	3	0	1	1	7	130362005 00		08	4	1	00	7			

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Fig. 8—AAR Routing Patterns

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ARS ROUTING RECORD

Action	Effective Date	NPA	Remarks	FX Term C.O.	Route On	1st/6th Route	Out Pulse	2nd/7th Route	Out Pulse	3rd/8th Route	Out Pulse	4th/9th Route	Out Pulse	5th/10th Route	Out Pulse
A	CUT	214	222		NPA	WFBO	10D	DDD	7D						
A	CUT	713 512 806	INTRA		NPA	WFBO	10D	DDD	10D						
A	CUT	817	See TRANSLATIONS		NNX	City A	7D	WBFO	10D	DDD	10D				

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Fig. 9—ARS Routing Record

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NPA 3-DIGIT PATTERN LIST

Action	Effective Date	T.O.D. Hr.	T.O.D. Min.	T.O.D. Seq.	A →	XX0	XX1	XX2	XX3	XX4	XX5	XX6	XX7	XX8	XX9
A	CUT	07	30	1	NP	— —	— —	0 6	0 6	0 6	0 6	0 6	0 6	0 6	0 6
					20X	— —	0 —	0 6	0 6	0 7	0 6	0 6	0 6	0 6	0 6
					21X	— —	— —	0 6	0 6	— 6	0 6	0 6	0 6	0 6	0 6
					30X	— —	0 6	0 6	0 6	0 6	0 6	0 6	0 6	0 6	0 6
					31X	— —	— —	0 6	0 6	0 6	0 6	0 6	0 6	0 6	0 6
					40X	— —	0 6	0 6	0 6	0 6	0 6	0 6	0 6	0 6	0 6
					41X	— —	— —	0 6	0 6	0 6	0 6	0 6	0 6	0 6	0 6
					50X	— —	0 6	0 6	0 6	0 6	0 6	0 6	0 6	0 6	0 6
					51X	— —	— —	0 6	0 6	0 6	0 6	0 6	0 6	0 6	0 6
					60X	— —	0 6	0 6	0 6	0 6	0 6	0 6	0 6	0 6	0 6
					61X	— —	— —	0 6	0 6	0 6	0 6	0 6	0 6	0 6	0 6
					70X	— —	0 6	0 6	0 6	0 6	0 6	0 6	0 6	0 6	0 6
					71X	— —	— —	0 6	0 6	0 6	0 6	0 6	0 6	0 6	0 6
					80X	— —	0 6	0 6	0 6	0 6	0 6	0 6	0 6	0 6	0 6
					81X	— —	— —	0 6	0 6	0 6	0 6	0 6	0 6	0 6	0 6
					90X	— —	0 6	0 7	0 6	0 6	0 7	0 6	0 —	0 6	0 6
					91X	— —	— —	0 6	0 6	0 6	0 3	0 6	0 1	0 6	0 6
						Default Pattern #		— —							

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Fig. 10—NPA 3-Digit Pattern List

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NPA 6-DIGIT NXX TRANSLATION LIST

Action	Effective Date	NPA
A	CUT	817

DEFAULT OR FX LIST 1 FX LIST 2 FX LIST 3 FX LIST 4: 0 6 0 4 _ _ _ _

(NX)(X)	NXX-FX List (1-4) 0	1	2	3	4	5	6	7	8	9
20										
21										
22										
23			2				2	2		
24										
25										
26										
27										
28										
29										
30		2				2				
31										
32										
33										
34										
35										
36										
37										
38		2				2				
39										
40					2					
41										
42		2								2
43										
44										
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Fig. 11—NPA 6-Digit NXX Translation List

AT&T OTC Business Services

Customer Sample

ETN Routing Guide

HNPA NXX LIST

Action	Effective Date	HNPA	NXX Code	NXX Code Patterns									
A	CUT	201	(NX)(X)	0	1	2	3	4	5	6	7	8	9
			20										
			21										
			22					05	05				
			23										
			24	05									
			25										
			26										
			27			08							
			28					08			08		
			29										
			30										
			31										
			32										
			33										
			34										
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			49										
			50										
			51										
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			53										
			54										
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Fig. 12—HNPA NXX List

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Customer Sample FP8 Dimension A

ETN Routing Guide

NPA 6-DIGIT NXX LOCAL CALL LIST

Action	Effective Date	NPA	NXX Code	PATTERN NUMBER 04 / LOCAL CALL LIST NUMBER 99									
			(NX)(X)	0	1	2	3	4	5	6	7	8	9
A	CUT	817	20	—	—	—	—	—	—	—	—	—	—
			21	—	—	—	—	—	—	—	—	—	—
			22	—	—	—	—	—	—	—	—	—	—
			23	—	—	✓	—	—	—	✓	—	—	—
			24	—	—	—	—	—	—	—	—	—	—
			25	—	—	—	—	—	—	—	—	—	—
			26	—	—	—	—	—	—	—	—	—	—
			27	—	—	—	—	—	—	—	—	—	—
			28	—	—	—	—	—	—	—	—	—	—
			29	—	—	—	—	—	—	—	—	—	—
			30	—	—	—	—	—	—	—	—	—	—
			31	—	—	—	—	—	—	—	—	—	—
			32	—	—	—	—	—	—	—	—	—	—
			33	—	—	—	—	—	—	—	—	—	—
			34	—	—	—	—	—	—	—	—	—	—
			35	—	—	✓	—	—	✓	—	—	—	—
			36	—	—	—	—	—	—	—	—	—	—
			37	—	—	—	—	—	—	—	—	—	—
			38	—	—	—	—	—	—	—	—	—	—
			39	—	—	—	—	—	—	—	—	—	—
			40	—	—	—	—	—	—	—	—	—	—
			41	—	—	—	—	—	—	—	—	—	—
			42	—	—	—	—	—	—	—	—	—	—
			43	—	—	—	—	—	—	—	—	—	—
			44	—	—	—	—	—	—	—	—	—	—
			45	—	—	—	—	—	—	—	—	—	—
			46	—	—	—	—	—	—	—	—	—	—
			47	—	—	—	✓	—	—	—	—	—	—
			48	—	—	—	—	—	—	—	—	—	—
			49	—	—	—	—	—	—	—	—	—	—
			50	—	—	—	—	—	—	—	—	—	—
			51	—	—	—	—	—	—	—	—	—	—
			52	—	—	—	—	—	—	—	—	—	—
			53	—	—	—	—	—	—	—	—	—	—
			54	—	—	—	—	—	—	—	—	—	—
			55	—	—	—	—	—	—	—	—	—	—
			56	—	—	—	—	—	—	—	—	—	—
			57	—	—	—	—	—	—	—	—	—	—
			58	—	—	—	—	—	—	—	—	—	—
			59	—	—	—	—	—	—	—	—	—	—

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Fig. 13—NPA 6-Digit NXX Local Call List

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Customer Sample FP8 Dimension A

ETN ROUTING GUIDE

ARS GROUP ATTRIBUTES

DAC	Serving NPA	Assignment	# Of Ckts.	Trk. Res.	Remarks	ACA SHT	ACA LHT
130	817	FX TO CITY A	02	00		30	1
131	201	WATS Band 0 (FBD)	20	00		30	1
132							

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Fig. 14—ARS Group Attributes

AT&T OTC Business Services

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Customer Sample FP8 Dimension A

ETN Routing Guide

ARS ROUTING PATTERNS

Action	Effective Date	Pattern Number	T.O.D. Hr.	T.O.D. Min.	T.O.D. Seq.	DAC	Term FRL	Warning Tone	Distant NPA	Dial 1 For Toll	Local List Number	Subnetwork Trunking: Off Net	PDT	Digits to Insert	Group 1: TT	Group 1: Pause Length	Group 1: Dig. Out	Group 2: TT	Group 2: Pause Length	Group 2: Dig. Out
A	CUT	03	07	30	1	110	3	0	817	1	99	1	0	-----	—	—	—	—	—	—
						111	3	0	201	0	—	1	1	-----	—	—	—	—	—	—
						—	—	—	—	—	—	—	—	-----	—	—	—	—	—	—
						—	—	—	—	—	—	—	—	-----	—	—	—	—	—	—
						—	—	—	—	—	—	—	—	-----	—	—	—	—	—	—
						—	—	—	—	—	—	—	—	-----	—	—	—	—	—	—
						—	—	—	—	—	—	—	—	-----	—	—	—	—	—	—
						—	—	—	—	—	—	—	—	-----	—	—	—	—	—	—
						—	—	—	—	—	—	—	—	-----	—	—	—	—	—	—
		—	—	—	—	—	—	—	—	—	—	—	—	-----	—	—	—	—	—	—
						—	—	—	—	—	—	—	—	-----	—	—	—	—	—	—
						—	—	—	—	—	—	—	—	-----	—	—	—	—	—	—
						—	—	—	—	—	—	—	—	-----	—	—	—	—	—	—
						—	—	—	—	—	—	—	—	-----	—	—	—	—	—	—
						—	—	—	—	—	—	—	—	-----	—	—	—	—	—	—
						—	—	—	—	—	—	—	—	-----	—	—	—	—	—	—
						—	—	—	—	—	—	—	—	-----	—	—	—	—	—	—
						—	—	—	—	—	—	—	—	-----	—	—	—	—	—	—
						—	—	—	—	—	—	—	—	-----	—	—	—	—	—	—

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Fig. 15—ARS Routing Patterns

OTC Business Services

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Page

Customer Sample FP8 Dimension A

ETN Routing Guide

ARS SPECIAL/SERVICE CODES

	0/011	110	111	112	113	114	115	116	117	118
Pattern #	0 7									

	119	211	311	411	511	555	611	711	811	911
Pattern #						0 8 0 7				0 7

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Fig. 16—ARS Special/Service Codes

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Customer Sample FP8 Dimension A

ETN Routing Guide

INTERTANDEM TRUNKING RECORD

Distant Tandem	Routes			
	1st	1st Alt.	2nd Alt.	3rd Alt.
Tandem B	IMT Hi-usage Direct	Tandem C	DDD	
Tandem C	IMT Hi-usage	Tandem B	DDD	

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Fig. 17—Intertandem Trunking Record

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Customer Sample FP8 Dimension A

ETN ROUTING GUIDE

INTERTANDEM GROUP ATTRIBUTES

DAC	Assignment	# Of Ckts.	Trk. Res.	Remarks	ACA	
					SHT	LHT
L73	Tandem B	50	10		40	22
L71	Tandem C	26	08		40	22

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Fig. 18—Intertandem Group Attributes

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Customer Sample FP8 Dimension A

ETN Routing Guide

INTERTANDEM ROUTING PATTERNS

Action	Effective Date	Pattern Number	DAC	Term FRL	Warning Tone	Subnetwork Trunking: Off Net	PDT	Dig. To Del.	Digits To Insert	Group 1: TT	Group 1: Pause Length	Group 1: Digits Out Pulsed	Group 2: TT	Group 2: Pause Length	Group 2: Digits Out Pulsed	Group 3: TT	Group 3: Pause Length	Group 3: Digits Out Pulsed
A	CUT	LBL	L73	2	0	0	0	0										
			L77	2	0	0	0	0										
			L05	6	L	L	L	3	1303620050 0									

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Fig. 19—Intertandem Routing Patterns

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ETN Routing Guide

MISCELLANEOUS INFORMATION

Authorization Codes:
- Quantity Total _____
- Length Of Code _____
- Number Of Seed Digits _____

Customer Administration Center FRL
Dialing Plan:
- Number Of Station Digits _____
- Number Of (RNX) Digits _____

Station Message Detail Recording:
- Ineffective Attempts On Printout _____
- Length Of Account Codes _____
- Account Code Prefix Digit _____
- Reserved Digits _____
- Group Exceptions (DAC) _ _ _ _ _ _ _ _ _
_ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Attendant Console #(ACA) _ _
Attendant Console FRL _____
Network – Symmetrical _____
– Hierarchial _____
Access Codes – AAR _____
– ARS _____
– IDDD _____

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Fig. 20—Miscellaneous Information

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Customer Sample FP8 Dimension A

ETN Routing Guide

MASTER DAC/PATTERN ASSIGNMENTS
and TRUNK GROUP RESTRICTIONS

DAC	TGR	Assigned To	AAR Patt	Assigned To	ARS Patt	Assigned To
112		830 Oak St., City A	151			
113		71 Jones Dr., City B	163			
114		Sunset Rd., City C	164			
115		Telco Ave., City D	165			

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Fig. 21—Master DAC/Pattern Assignments and Trunk Group Restrictions

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ETN Routing Guide

MASTER 6-DIGIT LOCAL CALL LIST ASSIGNMENTS

Local List No.	ARS Patt	Assigned To
— —	— —	
— —	— —	
— —	— —	

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ETN Routing Guide

TEST/ADMINISTRATIVE CODES

	Dialing Plan For Test Calls Originating From:	
	Directly Terminated Lines And PBX/CTX Tie Trunks	Intermachine Trunks
Test Codes:		
Balance Termination Test Line		
Toll Test Board Trunk		
Milliwatt		
Supervisory And Signaling Test		
Far End Transmission And Noise Test		
Data Test Line		
Administrative Codes:		
Toll Test Board		
Trouble Reporting		
Switch Contact		

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Fig. 23—Test/Administrative Codes

DATA SYSTEMS—"DATAPHONE®" SERVICE AND OTHER DATA SERVICES ON THE DIRECT DISTANCE DIALING NETWORK OVERALL MAINTENANCE PROCEDURES

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B. Additional Maintenance Considerations Voice Jacks and Data Jacks . . . 2

2. SWITCHED DATA SERVICE—OVERALL MAINTENANCE PLAN 3

CHART 1—Trouble Investigation—Phase 1—Remote Tests 5

CHART 2—Trouble Investigation—Phase II—On-Site Tests 7

A. Trouble Investigation—Phase III—Escalate to Data Technical Support (DATEC) 8

1. GENERAL

1.01 This section describes the overall trouble clearing procedures and analysis of data services, on switched telecommunications or direct distance dialing (DDD) network, hereafter called switched data services. Initially, only telephone company provided data sets were connected to the network and the service was called DATAPHONE service. However, with the advent of interconnection, "other" data equipment or customer provided equipment (CPE) was permitted to directly interconnect using some means of network protection. With the registration program, network protection is intended by having equipment registered and connections made using voice jacks or data jacks. These changes, along with the various methods that customers can use to access the switched network, have complicated the investigation of trouble reports on switched data services. Therefore, changes are required in the overall plan for trouble investigation and maintenance of switched data services in a complex, multivendor environment.

1.02 This section is reissued for the following reasons:

(a) To include information on voice and data jacks

(b) To update testing methods and analysis procedures

(c) To clarify supported switched data services

(d) Provide information for handling data trouble reports envolving satellite trunk connections

(e) To provide information for handling data trouble reports involving international calls.

Since this reissue is a general reissue, no revision arrows have been used to denote significant changes.

1.03 All trouble reports on switched data services will be received by the special service center (SSC). An integral part of the SSC is the data test center (DTC) capability. This practice covers the handling, controlling, and clearing of all trouble reports. The SSC/DTC may often find it necessary and advantageous to request the assistance of other work groups in locating, sectionalizing, and clearing data troubles.

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1.04 To provide a systematic approach to the location and clearing of trouble, the plan is divided into the following phases:

(a) Trouble Investigation—Phase I—Remote Tests

(b) Trouble Investigation—Phase II—On-Site Tests

(c) Trouble Investigation—Phase III—Escalate to Data Technical Support (DATEC)

A. Description of Overall Maintenance Plan

1.05 Switched data services involves the use of local loops, foreign exchange (FX), wide area telecommunications service (WATS), remote exchange (RX), and PBX station lines to access the DDD network. Various publications describe the DDD network to customers and defines those data services that the telephone company supports or does not support.

1.06 The customer is normally the first party to recognize the existence of a trouble condition. It is essential that telephone personnel obtain a clear understanding of the problem at the outset of the investigation through a ***trouble report analysis***. The procedure for performing this analysis is given in Section 668-010-300. From preliminary analysis, it should be possible to determine the type of trouble and the locations experiencing it. If the trouble is properly analyzed, erroneous and/or misdirected reports should be eliminated.

B. Additional Maintenance Considerations Voice Jacks and Data Jacks

1.07 The voice jack and/or data jack provide the means for registered data sets (both TELCO and CPE) to be connected to the DDD network. When a CPE data set is used with these jacks, the error rate performance is not specified nor is the data set to be tested, by the DTC or other TELCO personnel. Descriptive information on the voice and data jacks is given in Section 590-101-103.

Test Requirements

1.08 The customer may have his local access line terminated in either a voice jack or a data jack. Transmission tests are required at installation for FX, RX, and remote WATS lines as indicated in Section 314-205-501. However, for loops and local WATS, installation tests are the same as normal business service, whether terminated in a voice jack or data jack. That is, only a normal line test is required. With a data jack, however, insertion loss is measured as part of the data jack installation.

1.09 In case of problems at installation or during a trouble report, the following parameters should be measured on the access line:

Voice Jack

- Insertion Loss
- C-Notched Noise
- Impulse Noise

Data Jack

- Insertion Loss
- C-Notched Noise
- Impulse Noise
- Slope (404-2804 Hz)

The limits for these various parameters are given in Section 314-205-501. If the limits cannot be met, the circuit should be referred to the circuit provision bureau (CPB) for design on an expedited basis.

Levels of Support

1.10 Since it is not possible to control the transmission parameters that affect data transmission in all possible arrangements, there is a need to define the two levels of support. These terms are defined below.

1.11 Fully supported switched data services are services for which the telephone company has published end-to-end performance standards. End-to-end performance (over a long period of time) is supported on 85 percent of the connections for fully supported services. These performance standards are called minimum acceptable performance (MAP) criteria and are described in Section 314-205-503. When TELCO data sets are used, end-to-end digital error performance is also

supported. Digital error performance criteria are no more than one bit error in 100,000 bits transmitted for asynchronous data transmission, or no more than one-1000 bit block in error out of 100-1000 bit blocks transmitted for synchronous data transmission.

Support to Satisfactory Voice Quality Only

The second level of support is satisfactory voice quality only. A trouble report on this category of service should be handled as a normal voice type trouble report. Each element of the end-to-end connection should meet its standard objectives. Representative examples of this category are:

- Service on an FX line to a station more than 200 miles from the dial tone office
- Service from any station to any other station through OCC, CPE facilities or equipment
- Service from an off-premises PBX station to any station other than on-premises station behind the same PBX
- Service from any private switched network off net to a station on the DDD network
- Acoustically or inductively coupled stations
- Service to any country other than the 50 states and Canada.

Trouble Reports Involving Satellite Trunks

1.13 The planned growth of satellite facilities in the switched network will increase the exposure of switched data services to satellite facilities. While most data systems will operate satisfactorily over satellite trunks, there are some data arrangements which may experience difficulties resulting in trouble reports. The following guidelines for handling these reports are as follows:

(a) If a satellite trouble is suspected, call the local DATEC team and verify that satellite routing between the cities the customer is calling is available. (DATEC advisories are issued as required to update satellite trunk status.) If satellite routing is not possible, normal trouble testing procedures should be followed to clear the trouble.

(b) If the trouble cannot be cleared using normal testing procedures, or if a satellite trouble is confirmed, then escalate the trouble to DATEC.

Trouble Reports Involving International Calls

1.13 If a customer trouble report is received which involves an international data service the following steps should be taken:

(a) Assure that locally provided TELCO facilities are performing satisfactorily

(b) If no trouble is found, immediately refer the report to the appropriate international service coordination center.

These centers and their areas of responsibilities are given in Section 314-205-500.

2. SWITCHED DATA SERVICE—OVERALL MAINTENANCE PLAN

2.01 The overall maintenance plan consists of three different phases. The first two phases presents a suggested procedure for investigating and isolating trouble. The third phase is entered only when the trouble cannot be cleared through normal testing or when a third consecutive trouble report on the same trouble is received within a 30-day period. The phases are arranged to allow performing the easiest tests on the most probable causes first, followed by the more difficult and time consuming on-site tests last (if needed).

2.02 The existence of a complex, multivendor environment requires that trouble investigation be made promptly in order to isolate the trouble cause to either TELCO or CPE. Trouble isolation is quickly made by performing remote test procedures and by using self-test features of the data set(s) if available. Additionally, the multivendor environment requires that CPE be checked to insure proper operation. If the telephone company dispatches repair personnel and the trouble cause is not TELCO equipment, a maintenance of service charge (MSC) may be assessed the customer. Therefore, it is important that unnecessary dispatch of repair personnel be avoided if possible. A dispatch of repair personnel should only be made when it is determined, by the results of remote tests, that TELCO equipment is the trouble cause and a dispatch is necessary. The administration of the MSC is described in Section 660-101-312.

2.03 The procedures given in Phase I consists of those remote tests performed by DTC personnel on the customers local access line and the TELCO data sets. These tests normally are made in response to the first trouble report from the customer. However, they may also be made in response to additional reports on the same service.

Note: When three similar trouble reports on the same service are received within 30 days and have been closed out as "test OK," "came clear," "found OK," "no trouble found," etc, escalate immediately to Phase III when the third report is received.

CHART 1

TROUBLE INVESTIGATING—PHASE I— REMOTE TESTS

APPARATUS:

None required

STEP	PROCEDURE
1	The SSC/DTC receives a trouble report from the customer.
2	The SSC/DTC analyzes the customer trouble report using the questions given for this analysis in Section 668-010-300. This analysis should indicate the probable location of trouble such as near-/far-end, CPE/TELCO, loop/data set, network, etc.
3	If customer report indicates local loop trouble, perform the normal dc tests on the near-end local loop to confirm or eliminate trouble such as opens, shorts, crosses, etc. ***Note:*** If trouble appears to be caused by excessive noise or loss, proceed to Phase II and perform transmission tests on the access line as given in Section 314-205-501.
4	If results of the dc tests are not satisfactory, the SSC/DTC will arrange for repairing or changing the loop.
5	If the customer report indicates TELCO data set trouble, or if the trouble persists and the loop meets test requirements, the SSC will notify the DTC serving the area and instruct them to perform a test of the near-end data set.
6	If the near-end TELCO data set tests defective, dispatch repair personnel to replace the defective data set.
7	If the near-end data sets tests satisfactorily, and the trouble persists, the DTC should test the far-end data set if TELCO supplied.
8	If the far-end data set tests defective, the DTC will inform the SSC of the test results. The SSC will inform the proper repair group for appropriate acton.
9	If the near- and far-end data sets both test OK, the customer will be advised so that they may contact their business machine people and possibly avoid a maintenance of service charge.
10	If the service is restored satisfactorily, the trouble report will be closed. If the customer is not satisfied with the service and there is no evidence of additional trouble on CPE, proceed to Phase II.

2.04 If the source of trouble is not apparent from tests and information obtained in Phase I, further investigation is necessary to identify the section of data system that is malfunctioning. The activities in Phase II are intended to further isolate the source of trouble by dispatching repair personnel to perform dynamic tests on the data sets and, if necessary, perform transmission tests on the access lines. These activities are initiated by the failure of Phase I to isolate the problem.

CHART 2

TROUBLE INVESTIGATION—PHASE II—
ON-SITE TESTS

APPARATUS:

None required

STEP	PROCEDURE
1	If the customer provided equipment tests satisfactorily, and the service is not restored, the SSC will dispatch a data repair person to the customer site. The customer will be advised by the SSC/DTC that a maintenance of service charge may be assessed if no trouble is found in TELCO equipment.
2	The data repair person will perform a dynamic test to the proper DTC, if data set is TELCO supplied. If data set is not TELCO, perform transmission tests on the access line only and go to Step 5.
3	If the results of the dynamic tests are not satisfactory, replace the data set and repeat the dynamic test.
4	If the results of the dynamic tests are satisfactory, and the trouble persists, the data repair person will perform transmission tests on the access line as given in Section 314-205-501.
5	If the results of the transmission tests do not meet the limits given in Section 314-205-501, corrective action should be made by notifying the circuit provision bureau (CPB) for action on an expedited basis.
6	If the results of the transmission tests are satisfactory and the trouble persists, and if the data sets are TELCO provided, the data repair person will perform an end-to-end self test of the data sets if these test capabilities are available.
7	If the end-to-end self tests are unsatisfactory, replace the defective data set.
8	If the end-to-end self tests are satisfactory and the customer is not satisfied with the service and there is no evidence of additional trouble, proceed to Phase III.

A. Trouble Investigation—Phase III—Escalate to Data Technical Support (DATEC)

2.05 There are three levels of data technical support available for assisting field forces on data service problems. The first level of technical support is the DATEC support personnel in an area or division organization. Local DATEC may then contact the second level of technical assistance from DATEC support personnel at the company headquarters or the third level of support from AT&T headquarters.

2.06 Technical escalation of data service problems is appropriate under the following conditions:

(1) The service meets Bell System specifications but does not meet the customer's performance expectations.

(2) The service does not meet Bell System specifications and the problem source cannot be identified.

(3) The service has generated a high incidence of trouble reports.

2.07 When trouble conditions have been escalated to DATEC personnel, they may direct that certain tests be repeated or additional tests be performed. These tests may include the following:

(a) End-to-end transmission (MAP)

(b) End-to-end error performance (if TELCO supplied data set)

(c) Hold and trace.

DATA SYSTEMS—"DATAPHONE®" SERVICE AND OTHER DATA SERVICES ON THE DIRECT DISTANCE DIALING NETWORK OVERALL DATA TRANSMISSION TEST LIMITS

1. GENERAL

1.001 This addendum supplements Section 314-205-500, Issue 4. Place this pink sheet ahead of page 1 of the section.

2. CHANGES TO SECTION

2.001 On page 1, in the BSP title, change the word SYSTEM to SYSTEMS.

2.002 On page 2, revise the Note following paragraph 1.06 as follows:

Note: After July 1, 1979, only registered data sets may be connected to the network; however, apparatus legally connected to the network before this date (grandfathered apparatus) can remain connected for life.

2.003 On page 7, change the last four sentences in paragraph 8.02 as follows:

Table E gives the maintenance and immediate action limits for single and multiple facility trunks. If the P/AR limit is met, it should not be necessary to perform the envelope delay distortion test. Note that the requirements for P/AR has both maximum and minimum limits.

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14. REFERENCES 12

1. GENERAL

1.01 This section describes the overall transmission considerations and test requirements involved in providing data transmission over the switched telecommunications network (DDD) using loops, trunks, and switching equipment as used in voice service. This section applies to both DATAPHONE® service and to data services using customer-provided equipment (CPE) unless otherwise specified. There are no specific requirements for inductively or acoustically coupled data stations. Specific test requirements for access lines [subscriber, foreign exchange (FX), wide area telecommunications service (WATS), and PBX extentions] used for data transmission are given in Section 314-205-501. The overall minimum acceptable performance (MAP) criteria for the network facilities are given in Section 314-205-503.

Note: In this section the term telco applies to all Operating Telephone Companies, Bell System and Independent.

1.02 This section is reissued for the following reasons:

- To update information on customer-provided equipment
- To include voice and data jacks
- To provide information on satellite trunks
- To update test requirements
- To include trunk maintenance and immediate action limits for use in trouble analysis.
- To include information on international data service.

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Since this is a general revision, change arrows ordinarily used to indicate changes have been omitted.

1.03 Data services on switched network are supported to the 50 states and Canada. Other international service is not supported.

1.04 In general, data transmission calls are handled the same as voice telephone calls. The calling party dials the desired number and the called party answers. When the parties are ready to send or receive data, both parties change their mode of operation from voice to data by the operation of pushbuttons or keys either built into or associated with the data set. It is necessary that the data sets on both ends of the connection be of the same type and be compatible in bit rate, frequency, etc. Upon completion of the data transmission, both parties (by previous agreement) either hang up or return to the voice mode. There are exceptions to this procedure; eg, the called station may be unattended. If the called station is unattended, the calling party receives a tone indicating that the distant end data set has answered and is ready to receive (or send) data. At the end of the call, the distant end will disconnect under the control of the far-end business machine equipment. Another exception is in the use of automatic calling units. These units permit a computer or other similar business machine to "dial" the desired number. These systems are usually associated with the unattended service feature described above, and therefore no person is involved at any time during the sequence of operations.

1.05 In order to test DATAPHONE services, that is, data services using telco data sets at both ends, a number of 904-type data test centers (DTC) have been established in various locations in the Bell System and are used in conjunction with local and toll test centers. The 904A, B, C, and D data test centers are arranged for remote testing and monitoring of data sets in DATAPHONE service and in voiceband private line services. The 904G and H are arranged for remote testing and monitoring of data sets of the 101-, 103-, or 105-type. Section 807-460-165 contains a description of all 904-type data test centers and references to other sections with additional information on these test centers. Section 314-205-300 provides information on the overall transmission maintenance procedures.

1.06 The voice or data jacks provide means for registered data sets to be connected to the DDD network. When CPE data set is used with these jacks, neither the error rate performance is specified nor is the data set tested by the DTC or by other telco personnel.

> ***Note:*** After July 1, 1978, only registered data sets may be connected to the network; however, apparatus legally connected to the network before this date (grandfathered apparatus) can remain connected for life.

1.07 An important characteristic of analog transmission systems is that the adjustment of a component made at any one point will have an effect upon adjustments made at other points. Therefore, it is important in clearing transmission difficulties to correct the basic cause of the trouble rather than to make terminal adjustments to eliminate the symptoms.

2. TRANSMISSION ASPECTS OF DATA SERVICES

2.01 The data subscriber line should meet the objectives given in Section 314-205-501.

2.02 There are a number of transmission considerations which may affect data transmission over the DDD network. They are as follows:

(a) Maximum transmitting level and overall circuit loss

(b) Attenuation frequency distortion (slope)

(c) Return Loss

(d) C-notched noise ratio

(e) Impulse noise

(f) Peak-to-average signal ratio (P/AR)

(g) Envelope delay distortion

(h) Frequency shift

(i) Nonlinearities (Interdemodulation distortion)

(j) Phase jitter

(k) Hits—gain and phase

(l) Dropouts.

These items are covered in more detail in Parts 3 through 11 of this section.

2.03 Several of the parameters listed above are primarily controlled by voice requirements. These include overall circuit loss, return loss, slope, and noise. Of the remaining parameters, data requirements are usually controlling.

2.04 The performance of a data set generally deteriorates after the operating limits are exceeded; a small change may degrade the performance from good to intolerable. Maintenance and adjustment of data transmission equipment and facilities should be as close to the optimum point as possible. Proper adjustments to each section in the overall connection will increase the reliability of the service.

3. MAXIMUM TRANSMITTING LEVEL AND OVERALL CIRCUIT LOSS

3.01 The maximum practical transmitting level of data sets is limited primarily by the maximum level that a steady tone or combination of tones which may be applied to a carrier terminal unit without overloading. Most DATAPHONE data sets have been designed so that the maximum transmitting level will not exceed one milliwatt into 900 ohms. Data jacks provide a means to limit, when necessary, the signal power delivered by a data set. In connection with initial installation tests (see Section 314-205-501), the loop insertion loss is measured and recorded. The maximum sending level for any data set is adjusted so as not to exceed -12 dBm at the main frame appearance of the subscriber line at the dial tone office. This will correspond to a maximum data signaling power of -13 dBm0 on toll carrier facilities. The transmit level can be verified by dialing the milliwatt supply from the customer's premises and subtracting the transmission measuring set reading from -12 dBm. Some types of DATAPHONE data sets such as the 400 series, transmit more than one tone simultaneously. The total power of all tones transmitted simultaneously must not be greater than -12 dBm. In order to keep receiving levels within requirements, the data set level should be set so it will be received at the dial tone office as close to the -12 dBm level as possible without exceeding it. Information on the transmit level options is found in the BSP installation section of that particular data set.

4. ATTENUATION FREQUENCY DISTORTION

4.01 Excessive attenuation frequency distortion (also called slope) on voice-frequency data transmission increases the error rate by degrading the signal as it traverses the facility. For the entire station-to-station connection through the DDD network, the attenuation frequency (slope) should not exceed 14 dB between 1004 and 2804 Hz or between 400 and 1004 Hz for satisfactory operation of data sets.

4.02 Table A gives maintenance and immediate action limits for single facility trunks.

5. RETURN LOSS REQUIREMENTS

5.01 Return loss requirements are important for data services. Listener echo is critical for some data sets because the receiving data set on a connection will interpret the data received through the echo path as interference. Talker echo is not critical on terrestial circuits, but on satillite circuits it may be a problem.

6. SIGNAL TO C-NOTCHED NOISE RATIO

6.01 Quantizing noise in digital carrier systems and the effect of compandors in digital and some analog systems result in signal dependent noise. Signal to C-notched noise ratio is a measure of noise with a signal present.

6.02 Noise will not be a problem to data if a 24-dB signal-to-C-notched noise ratio is maintained throughout the connection. Single and multiple facility maintenance and immediate action limits are given in Tables B and C.

7. IMPULSE NOISE

7.01 Impulse noise hits are a primary source of errors in data transmission. A 6-type impulse noise counter is used to measure impulse noise on a facility. Information involving the use of the 6-type impulse counter can be found in the 103-6YY-ZZZ series of practices. The magnitude and frequency of the occurrence of the impulse noise voltages are used to specify the impulse noise objective. The objective is expressed as a threshold (referred to the zero transmission level point) which will be exceeded no more than a specified number of times per 15 minutes for individual circuit measurements.

TABLE A

ATTENUATION FREQUENCY
DISTORTION (SLOPE) LIMITS

FACILITY	LOSS IN DB RELATIVE TO 1004					
	MAINTENANCE LIMITS		IMMEDIATE ACTION LIMITS		TYPICAL	
	400 Hz	2800 Hz	400 Hz	2800 Hz	400 Hz	2800 Hz
OA, OB, OC, OD	−1.0, +2.5	−1.5, +2.5	−2.0, +4.0	−2.0, +4.0	±0.8	±1.0
ON	−1.0, +2.0	−1.0, +2.5	−2.0, +4.0	−2.0, +4.0	±0.8	±1.1
N1	−1.0, +2.0	−1.0, +2.5	−2.0, +4.0	−2.0, +4.0	±0.8	±2.3
N2	−1.0, +1.6	−1.0, +2.0	−2.0, +3.0	−2.0, +3.0	±0.7	±1.2
N3	−1.0, +1.5	−1.0, +1.5	−2.0, +3.0	−2.0, +3.0	±0.8	±0.6
NR	−1.0, +1.6	−1.0, +1.0	−2.0, +3.0	−2.0, +3.0	±0.8	±0.9
R, LR, L	−1.0, +1.5	−1.0, +1.0	−2.0, +3.0	−2.0, +3.0	±1.0	±0.6
T1 (Toll)	−1.0, +1.0	−1.0, +1.0	−2.0, +3.0	−2.0, +3.0	±0.5	±0.5
T1 (Non-Toll)	−1.0, +2.1	−1.0, +2.0	−2.0, +3.0	−2.0, +3.0	±2.3	±2.2
Metallic (Non-Repeatered)	−1.0, +2.0	−1.0, +3.0	−2.0, +3.5	−3.0, +4.0	±0.5	±0.5
Metallic (Repeatered)	−1.0, +3.0	−1.0, +4.5	−2.0, +4.5	−2.0, +5.5	±0.5	±2.0

7.02 Impulse noise exhibits some level variation with the time of day; however, it is permissible to make these measurements any time during the normal business day. Measurements resulting from data transmission service trouble reports should be made during periods when the customer is experiencing trouble, if possible.

7.03 The impulse noise objectives for trunks and facilities are given in Table D. The maintenance limit is five counts in 5 minutes and the immediate action limit is ten counts in 5 minutes.

7.04 When measuring impulse noise, a -13 dBm0 holding tone is used. This stabilizes the expandor loss at 9.0 dB and activates quantizers in digital systems.

7.05 Impulse noise objectives will be met if, throughout the connection, fewer than 15 counts in 15 minutes occur at a threshold 5 dB below the data signal.

8. ENVELOPE DELAY DISTORTION AND P/AR

8.01 Envelope delay distortion (EDD) can seriously affect data transmission on the DDD network. Different frequencies undergo different amounts of delay as they are transmitted over the message network, which will cause the data signal to be distorted. The amount of envelope delay distortion on a voice-frequency trunk depends upon the type of facility and, in the case of cable, the length of the facility. Carrier system EDD is affected by the type of carrier and the multiplex arrangement.

TABLE B

C-NOTCH NOISE LIMITS IN d B r n c O*

FACILITY	HOLDING TONE LEVEL IN dBmO	CIRCUIT LENGTH (MILES)						
		0 – 100	101 – 200	201 – 400	401 – 1000	1001 – 1500	1501 – 2500	2501 – 4000
Noncompandored	any	32, 38	34, 38	35, 42	38, 42	39, 42	41, 46	43, 48
Mixed Comp. N1, ON	−10	51, 54	51, 54	51, 54	51, 54	51, 54	51, 54	52, 54
	−13	48, 51	48, 51	48, 51	48, 51	48, 51	48, 51	49, 52
	−16	45, 48	45, 48	45, 48	45, 48	45, 48	45, 48	47, 49
Noncomp or comp only N2, 3, 4	−10	44, 47	44, 47	45, 47	45, 47	45, 48	46, 48	47, 48
	−13	41, 44	42, 44	42, 45	43, 45	43, 45	44, 46	45, 46
	−16	38, 41	39, 42	40, 42	41, 43	41, 43	43, 44	44, 45
T1/D1A, B	−10	51, 53	51, 53	51, 53	51, 53	51, 53	51, 53	52, 53
	−13	48, 50	48, 50	48, 50	48, 50	48, 50	48, 50	49, 51
	−16	45, 47	45, 47	45, 47	45, 47	45, 47	45, 47	47, 48
T1/other	−10	44, 45	45, 46	45, 46	46, 48	46, 48	48, 49	48, 49
	−13	41, 42	42, 43	42, 43	43, 45	43, 45	45, 46	45, 46
	−16	38, 39	39, 40	39, 40	40, 42	40, 42	42, 43	42, 43

* First number given in each entry is the maintenance limit and the second number is the immediate action limit.

TABLE C

SIGNAL – TO – C-NOTCHED NOISE RATIO IN DB*

FACILITY		HOLDING TONE LEVEL IN dBmO	CIRCUIT LENGTH (MILES)						
			0 – 100	101 – 200	201 – 400	401 – 1000	1001 – 1500	1501 – 2500	2501 – 4000
Noncompandored		–10	48, 42	46, 42	45, 38	42, 38	41, 38	39, 34	37, 32
		–13	45, 39	43, 39	42, 35	39, 35	38, 35	36, 31	34, 29
		–16	42, 36	40, 36	39, 32	36, 32	35, 32	33, 28	31, 26
Mixed Comp	N1, ON	–10	31, 28	31, 28	31, 28	31, 28	31, 28	31, 28	30, 27
		–13	29, 26	29, 26	29, 26	29, 26	29, 26	29, 26	28, 25
		–16	27, 24	27, 24	27, 24	27, 24	27, 24	27, 24	26, 23
Noncomp or comp only	N2, 3, 4	–10	38, 35	37, 35	37, 34	36, 34	36, 34	35, 33	34, 33
		–13	36, 33	35, 33	35, 32	34, 32	34, 32	33, 31	32, 31
		–16	34, 31	33, 31	33, 30	32, 30	32, 30	31, 29	30, 29
	T1/D1A, B	any	29, 27	29, 27	29, 27	29, 27	29, 27	29, 27	28, 26
	T1/other	any	36, 35	35, 34	35, 34	34, 32	34, 32	32, 31	32, 31

* First number given in each entry is the maintenance limit and the second number is the immediate action limit.

TABLE D

IMPULSE NOISE OBJECTIVES

FACILITY	HOLDING TONE LEVEL dBmO	THRESHOLD IN dBrncO			
		CIRCUIT LENGTH (MILES)			
		0–125	126–1000	1001–2000	2001 AND OVER
Metallic	−10 −13 −16	54			
Noncompandored	−10 −13 −16	58	59	61	64
N or Mixed N and Noncompandored	−10 −13 −16	67 66 65	67 66 65	67 67 67	68 68 68
T or Mixed T and Noncompandored	−10 −13 −16	69 67 64	69 67 64	69 67 65	70 68 66
N3 (With VF amp)	−10 −13 −16	73	73	73	73

Note: Maintenance Limit: 15 counts in 15 minutes.

Immediate Action Limit: 20 counts in 15 minutes.

8.02 EDD is usually expressed as the maximum variation of the envelope delay characteristic within a particular frequency band. This measurement is usually expressed as microseconds over the band of interest. With data service, envelope delay distortion should be suspected if high error rates which cannot be attributed to message noise, impulse noise, overall loss, or slope are encountered. The P/AR (peak to average ratio) meter (Section 103-110-110) is useful in determining the condition of a data transmission connection. P/AR measurements are primarily sensitive to EDD, but attenuation distortion and return loss may also have a strong effect on P/AR readings. Table D gives the maintenance and immediate action limits for single and multiple facility trunks. If P/AR limit is met, it should not be necessary to perform the envelope delay distortion test. Requirements for P/AR are given in Table E. Note that P/AR has both maximum and minimum limits.

8.03 On occasion, envelope delay distortion will be too high within the DDD network for data transmission operation between two particular points on the network. Information about the situation should be forwarded through the lines of organization for reassignment or further investigation. It may be necessary to provide additional equalization at the data set location or to install a remote exchange (RX) line to bypass part of the network until better facilities can be provided.

9. FREQUENCY SHIFT

9.01 Frequency shift (sometimes called frequency offset) beyond the capabilities of the data

TABLE E

P/AR REQUIREMENTS

SINGLE AND MULTIPLE FACILITY TRUNKS			
FACILITY*	MAINTENANCE LIMITS**		TYPICAL
	MAXIMUM	MINIMUM	
O, ON, N3	94	86	90
N1	98	86	92
L or Radio	99	87	93
N2	101	93	97
T1	102	93	97
2T1	97	88	92
2N3	93	83	88
2N2	96	88	92
2N1	93	85	89
T1 + N3	95	87	91
T1 +N2	96	88	92
N1 + N3	97	87	92
ON + T1	96	87	91
ON + A	93	83	88
ON + N3	93	83	88
ON + N2	96	88	92
ON + N1	96	88	92
2 ON	91	83	87
T1 + N1	96	87	91
N2 + N3	97	87	92
N1 + N2	95	87	91
2 "A" Type	92	82	87
A + T1	95	86	90
A + N3	91	83	87
A + N2	96	86	91
A + N1	96	86	91
3A	83	74	78
NONREPEATERED CABLE			
Nonloaded (0—18 kft)		97	
H88 (0—18 kft)		94	
REPEATERED CABLE			
Nonloaded (0—18 kft)		90	
H88 (0—36 kft)		90	
H88 (>36 kft)		80	

* For No. 4 ESS with analog trunking, single facility, use values for T1 + facility under consideration. For No. 4 ESS with T1 carrier interfacing via a digroup terminal, use T1 values.

** Immediate Action Limits reduce maintenance limits by 1 for single facility, 2 for 2—facility and 3 for 3—facility trunks.

set will result in high error rate. If the symptoms occur and the cause cannot be readily attributed to loss, attenuation frequency distortion, steady or impulse noise, envelope delay, phase jitter or intermodulation distortion, the possibility of frequency shift should be investigated.

9.02 On carrier systems used in connection with data services, the overall carrier frequency error should be kept to ±5 Hz or less. Individual carrier facility sections should have carrier frequency errors of no more than ±2 Hz.

9.03 There will not be a frequency error problem on the "transmitted carrier" type of carrier systems, such as the Western Electric "N" (only even numbered channels with N3), "O", and "ON". With this type of carrier system, the carrier signal that is used for modulation is transmitted directly to the distant terminal for demodulation. Western Electric "J", "K", and "L" systems are of the suppressed carrier type, in which the carrier is suppressed at the transmitting terminal and resupplied at the receiving terminal. When this function is accomplished by the use of a generator that is held in synchronization with the generator at the transmitting end, frequency shift will be at a minimum and should not cause data distortion.

9.04 Frequency shift exists primarily in suppressed carrier systems where there has been no provision for synchronizing the carrier terminals at the ends of the system. Nonsynchronized Western Electric type "J", "K", "L", and "C" systems use carrier supply generators with long-term stability. These systems should not present any frequency shift problems provided they are adequately aligned and maintained at the intervals specified in the practices. Western Electric type "C" (vacuum tube modulator type) and "H" carrier systems may present more serious problems, depending upon operational environment and the maintenance routines.

9.05 Carrier systems that are not supplied by the Western Electric Company can be roughly classified in the same way as the Western Electric systems. Actual frequency shift performance of any system in the questionable category should be determined prior to the start of data service over that system and corrective action instituted if necessary.

10. INTERMODULATION DISTORTION

10.01 Intermodulation distortion is the generation of sum and difference frequencies due to nonlinearities in a channel. It is measured by transmitting four equal level tones, consisting of two pairs of tones, with a composite signal power at nominal data signal level. Two of these tones are closely spaced around a center frequency "A" (860 Hz) and the other two tones are centered around a center frequency "B" (1380 Hz). The second order distortion is determined from the B-A and B+A frequencies while the third order distortion is determined from the 2B-A frequency. Requirements are given in Table F.

11. PHASE JITTER

11.01 Various sources cause the instantaneous phase, or zero crossings, of a signal to "jitter" at rates normally less than 300 Hz. This phase jitter is typically caused by ripple in the dc power supply appearing in the master oscillator of long-haul carriers and then passing through many stages of frequency multipliers. Some phase jitter occurs in short-haul systems from incomplete filtering of image sidebands. Digital carrier systems also will exhibit phase jitter at certain input frequencies. The most common jitter frequencies are 20 Hz (ringing current) and 60 Hz (commercial power) and the second through fifth harmonics of each of these.

11.02 Noise may strongly influence phase jitter measurements; therefore, measurements should be made with a test tone at data level. Requirements are given in Tables G and H.

12. GAIN HITS, PHASE HITS, AND DROPOUTS

12.01 Gain hits and phase hits are defined to be changes in the amplitude or phase of a signal lasting for at least 4 ms and returning to the original value within 150 ms. Changes in amplitude or phase which last for more than 150 ms are referred to as gain or phase changes. Changes that last for less than 4 ms are classified as impulse noise. Objectives for these parameters are given in Table I.

12.02 A dropout is a decrease in level $\geq$ 12 dB which lasts for at least 10 ms. Deep fading of radio facilities and defective components can cause dropouts. Since dropouts tend to be long

TABLE F

INTERMODULATION
DISTORTION LIMITS

FACILITIES	RATIO OF DISTORTION PRODUCT TO FUNDAMENTAL IN dB (FOUR TONE METHOD)*							
	N1	N2	N3	ON	T/DIA DIB	T/DID, D2, D3	L, RADIO WITH F SIGNALING	L, RADIO WITH E SIGNALING
Second Order								
Minimum	28, 26	34, 32	40, 38	30, 28	32, 30	50, 47	51, 50	44, 41
Typical	36	42	46	41	40	55	57	45
Third Order								
Minimum	31, 30	44, 42	38, 36	34, 33	39, 38	54, 53	51, 50	
Typical	36	51	45	38	47	58	55	
TRUNKS:								
Second Order								
Minimum	28, 26	34, 32	40, 38	30, 28	32, 30	50, 47	44, 41	47, 41
Typical	36	42	46	41	40	55	45	46
Third Order								
Minimum	30, 29	42, 40	37, 35	33, 32	39, 38	54, 53	47, 46	
Typical	36	49	44	37	47	58	46	

* First number given in each entry is the maintenance limit and the second number is the immediate action limit.

TABLE G

PHASE JITTER LIMITS

END-TO-END LIMITS	
FREQUENCY BAND	LIMIT
4 – 20 Hz	< 10
20 — 300 Hz	< 10

with more than 40 percent in excess of 200 ms, they frequently are responsible for serious performance degradations. The objective for this parameter is no dropouts in 15 minutes or 1 dropout in 30 minutes. If one dropout occurs during a 15-minute test, continue the test for a second 15-minute interval not necessarily consecutive with the first

TABLE H

FACILITY AND TRUNK
LIMITS
(20 – 300 Hz)

N. ON D1 (T1 CARRIER CHANNELS)	
NO. OF CHANNELS	LIMIT
ALL	<1.0°
LMX CARRIER	
MILEAGE BAND	LIMIT
0-250	<4.0°
251-500	<5.0°
501-1000	<6.0°
1001-2000	<7.0°
2001-4000	<8.0°

TABLE I

GAIN AND PHASE HIT AND DROPOUT OBJECTIVES

	SHORT-HALL FACILITES (N, ON OR T)	COAXIAL CABLE, RADIO OR SHORT-HAUL RADIO (TJ)
Gain Hits ($\geq$ 3dB)	0 in 15 minutes	No more than 2 in 15 minutes*
Phase Hits ($\geq$ 20)	0 in 15 minutes	No more than 2 in 15 minutes
Dropouts	No more than 1 in 30 minutes	No more than 1 in 30 minutes

* No more than 1 in 15 minutes for counters with 4 dB threshold.

test. If no additional dropouts occur, the facility is acceptable. If additional dropouts occur (or if more than one dropout occurred in the first test), maintenance is required.

13. INVESTIGATION OF NETWORK TROUBLES

13.01 Data transmission requires control of more parameters than does voice transmission. Limits for the parameters required for data transmission are given in Tables A through I. The additional requirements described in Parts 4 through 13 of this section should then be applied to the facilities, as required, in order to accommodate the more stringent objectives of data transmission.

13.02 On a connection over the DDD network, the effects of such items as overall loss, attenuation frequency distortion, envelope delay distortion, etc, are cumulative as the length of the circuit and the number of links involved increase. All types of switched facilities are subject to some interruptions, which may be due to equipment failures, facility failures, or human errors. The object of maintenance testing for data services is to determine the location of troubles which can cause actual failures in data transmission over the message network. The malfunction may be of very short duration, measured in microseconds, fading or drop-outs which can extend seconds or minutes, or actual facility failures which will interrupt service for a considerable length of time. It is important to note that service should be restored as quickly as possible. For example, a data service operating at 1200 bps is capable of transmitting or receiving over four million bits of information in one hour. An outage of one hour due to a facility malfunction can cost the customer a considerable amount of money in lost "computer time," obsolescence of information, and extra time consumed in storing and recovering data which has accumulated during the disruption of service. Duration of intermittent interruptions is an important factor in the detection of trouble since complete failures are more readily found than momentary troubles. The message network is so arranged that a complete failure of a cable, carrier channel, or central office terminal equipment will usually be detected by means of automatic alarm systems. In connection with interruptions of shorter duration, the shorter the time interval, the more difficult will be the problem of detection. The line evaluation test covering the particular data set under test is described in the installation performance procedures of the 590 series of practices. Errors received and peak distortion determine the quality of the circuit under test.

13.03 Analysis of station record cards may give an indication as to the source of repeated data troubles. When it is possible, the circuit or connection should be "held" at the serving office and the call traced and tested through its various links in order to detect the malfunction. (See Section 314-205-300 and 590-010-300 for procedures.) Since it is not always possible to continue to "hold" the suspected circuit for immediate testing, a record should be made of the links involved and arrangements made to test the circuit at the first appropriate opportunity. A line evaluation test should be made from the "sending end" data set location. Use the suspected circuit for the test. Both locations should be equipped with digital test sets such as the 914-type data test sets.

13.04 When tests are made between the serving office and the data set location, maximum use should be made of test signal sources such as

milliwatt sources, quiet terminations, and 107-type test lines when available.

13.05 An analysis of possible results of the circuit evaluation test is shown in Table J. The result of the tests may be used as a guide for locating transmission difficulties encountered with data services.

13.06 Any trouble reports involving international service should be immediately escalated to the appropriate International Service Coordination Center. These centers and their areas of responsibility are given in Tables K and L.

14. REFERENCES

14.01 Bell System Practices mentioned in this section which cover various equipment are listed as follows:

SECTION	TITLE
010-521-100	Data Technical (DATEC) Support
103-110-110	J94027F and G Par Meter Generator and Receiver, Description, Operation, and Maintenance
107-101-100	914-Type Data Test Sets, Description and Operation
107-420-100	921 Data Test Set Description and Operation
314-205-300	Data Systems—DATAPHONE® Service on Direct Distance Dialing Network, Overall Transmission Maintenance Procedures
314-205-501	Data Systems—DATAPHONE® Service and Other Data Services on the Direct Distance Dialing Network—Test Requirements for Subscribers, Foreign Exchange and WATS Lines
314-205-503	Data Systems—"DATAPHONE"® Service and Other Data Services on the Direct Distance Dialing Network—Minimum Acceptable Performance Criteria and Test Procedures
314-820-100	Envelope Delay Characteristics of 200-Type Delay Equalizers
314-820-103	Envelope Delay Characteristics of 366- and 367-Type Equalizers
314-820-104	Envelope Delay Characteristics of 384- and 385-Type Equalizers
851-300-100	Transmission Design Consideration and Objectives, Switched Special Services and PBX Services.

TABLE J

CIRCUIT EVALUATION TEST – RESULTS USING
900-TYPE DATA TEST SETS – RECEIVING END OF CIRCUIT

TROUBLE CONDITION	REMARKS	TRANSMISSION IMPAIRMENTS (CHECK ITEMS IN SEQUENCE AS SHOWN)	REFERENCE
High distortion and high-error rate	Distortion reading is high and steady.	Attenuation Frequency Distortion C-Message and C-Notched Noise Return Loss Requirements P/AR Envelope Delay Distortion	Part 5 Part 7 Part 6 Part 9 Part 9
High distortion and high-error rate	Distortion reading is high and unsteady.	Overall Circuit Loss	Part 4
High-error rate and normal distortion	Distortion reading shows frequent peaks.	Impulse Noise C-Message and C-Notched Noise	Part 8 Part 7
High distortion and high-error rate	Distortion reading may shift gradually.	Frequency Shift	Part 10

TABLE K

INTERNATIONAL SERVICE COORDINATION CENTERS

HEADQUARTERS ISCC

American Telephone and Telegraph Co.
Long Lines
Room 3B—111
Bedminster, New Jersey 07921

Tel: (201)234—6734
ADnet: LOS—885

ATLANTIC BASIN

American Telephone and Telegraph Co.
32 Avenue of the Americas
Room 1542
New York, New York 10013

Tel: (212)334—6314
ADnet: LYO—885

American Telephone and Telegraph Co.
635 Grant Street
9th Floor
Pittsburgh, Pennsylvania 15219

Tel: (412)644—7592
ADnet: LEO—885

American Telephone and Telegraph Co.
440 Hamilton Avenue
Room 1200C
White Plains, New York 10601

Tel: (914)320—2611
ADnet: LNO—885

CARIBBEAN BASIN
CENTRAL AMERICA
VENEZUELA

American Telephone and Telegraph Co.
400 West Ashley Street
Room 703
Jacksonville, Florida 32202

Tel: (904)353—3713
Tel: (904)355—7596
ADnet: LSO—885

PACIFIC BASIN

American Telephone and Telegraph Co.
1881 Pierce Street
Lakewood, Colorado 80214

Tel: (303)233—3601
ADnet: LWO—885

TABLE L

COUNTRY RESPONSIBILITY BY ISCC

NEW YORK

Austria
Belgium
Brazil
Chile
Cuba
Cyprus
Denmark
Ecuador
Finland
Germany
Greece
Iran
Israel
Italy
Ivory Coast
Kuwait
Lebanon
Liberia
Luxembourg
Netherlands
Netherlands Antilles North/South
Norway
Peru
Portugal
Saudi Arabia
Senegal
S. Africa
Surinam
Sweden
Switzerland
U.S.S.R.
Uruguay
Yugoslavia

JACKSONVILLE

Belize
Costa Rica
El Salvadore
French West Indies
Guatemala
Haiti
Honduras
Nicaragua
Panama
Venezuela

PITTSBURGH

Argentina
Cameroon
Columbia
France
Ireland
Spain

WHITE PLAINS

India
Iraq
Kenya
Nigeria
United Kingdom

DENVER LAKEWOOD

American Samoa
Australia
China (Peking)
China (Taipei)
Fiji Island
Guam
Hong Kong
Indonesia
Japan
Korea
Malaysia
New Caledonia
New Zeland
Papua New Guinea
Philippines
Singapore
Tahiti
Thailand

NOTES

DATA SYSTEMS—"DATAPHONE®" SERVICE AND OTHER DATA SERVICE ON THE DIRECT DISTANCE DIALING NETWORK TEST LIMITS FOR SUBSCRIBER, FOREIGN EXCHANGE, PBX, AND WATS LINES

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1. GENERAL 1
2. CLASSES OF ACCESS LINES 1
3. TYPES OF ACCESS LINES 2
4. INSTALLATION TESTS 2
5. TEST LIMITS 2
6. REFERENCES 4

1. GENERAL

1.01 This section describes the transmission test requirements on subscriber, remote exchange (RX), foreign exchange (FX), PBX, and wide area telecommunications service (WATS) lines used to access the switched telecommunications network (DDD) for data transmission. Information in this section applies equally to both DATAPHONE service and other data service with customer-provided equipment (CPE) unless otherwise specified.

1.02 This section is reissued for the following reasons:

- To revise the maintenance tables
- To update references.

Since this reissue makes major revisions to the content and organization of the section, change arrows have been omitted.

1.03 The tests described in this section are made between the dial tone office and the data set location unless otherwise specified. Maximum use should be made of test signal sources such as milliwatt source, quiet termination, and 107-type test line or similar type test line, when available, to avoid the need for a second craft employee at the serving office during testing.

Note: Test requirements are frequently specified at 1000 Hz and 2800 Hz. However, in actual testing, the signal must be offset by +4 Hz to avoid quantizing problems in T-Carrier Systems.

2. CLASSES OF ACCESS LINES

2.01 Two classes of access lines are defined for data use: Lines terminated in voice jacks and lines terminated in data jacks. These jacks are used to connect both TELCO data sets and CPE. The customer may have either of the types of access lines. At installation, both are treated the same as any other business line regardlesss of bit rate or modem ownership (see Table A). That is, only a normal business line test is required. However, insertion loss is measured as part of the data jack installation. In case of problems at installation or a customer trouble report, the parameters given in Table B are measured and supported. The parameters listed in Tables A through E are given in the suggested order they should be checked during installation and maintenance activities.

2.02 Voice jacks are used to connect data sets with a fixed output level not exceeding -9 dBm. Data jacks are used for data sets with either -4 dBm or programmable output levels.

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3. TYPES OF ACCESS LINES

Local Loop

3.01 The local loop is the facility from the customer premises to the main frame of the normal serving central office. Local loops are normally 2-wire facilities, and data transmission limits for them are given in Table C.

FX Lines

3.02 A FX line provides service between the customer premises and a remote central office in an area other than the central office which normally would serve that customer location. Data service on FX lines is supported only up to 200 miles from the dial tone office. Data transmission limits are given in Table D.

WATS Lines

3.03 Wide area telecommunications service (WATS) lines may be direct (local central office is the dial tone office) or remote (local central office is not the dial tone office). Direct WATS lines have the same transmission objectives as a local loop. Remote WATS limits are given in Table E.

Data Service Through a PBX

3.04 Data stations may be located on stations behind PBXs. These may be on- or off-premises stations. The wiring and cabling from the on-premises station to the PBX, in addition to an average trunk to the serving central office, are considered as equivalent to a local loop in meeting the data test requirements. This applies only to TELCO PBXs. When CPE PBXs are involved, data requirements only apply to the trunk interface with the PBX. Data trasmission limits are given in Table C.

3.05 Meeting the local loop limits for an off-premises station may not be possible. Therefore, support for off-premises stations is limited to an on-premise station serving the same TELCO PBX. In this application, the limits that apply are given in Table D. Performance from an off-premises station to another station on the network is not specified or supported.

3.06 Note that when treatment is applied to one PBX trunk, all trunks must meet the same criteria. Centrex on customer premises is the same as PBX. Central office (CO) centrex lines are treated the same as local loops.

Remote Exchange (RX) Lines

3.07 Remote exchange (RX) lines are those lines when, for telephone company reasons, it becomes necessary to provide service from a distant central office because the nearest central office is not suitable for data transmission. RX lines are supported the same as remote WATS lines. Data transmission limits for RX lines are given in Table E.

4. INSTALLATION TESTS

4.01 Normal business line tests are required at installation except for those tests required in the data jacks installation procedures and any tests associated with TELCO data sets. However, designed services, such as FX and WATS, require other transmission tests. These tests are shown in Table A under the column headings of FX and remote WATS.

4.02 If problems are encountered which indicate a possible transmission impairment, tests in Table B should be used to isolate the cause. If the investigations show that insertion loss (voice jack) or slope (data jack) limits cannot be met, the matter should be referred to the circuit provision bureau (CPB) for action on an expedited basis.

4.03 Results of installation tests, when performed, should be recorded on the circuit layout record card (CLRC) or other record forms as "bench marks" during maintenance testing.

4.04 During trouble investigation, additional measurements may be needed to verify the transmission parameters given in Tables C, D, and E.

5. TEST LIMITS

5.01 Tables A and B list the installation and maintenance tests respectively, that should be performed depending on the type access line. Tables C, D and E give the data transmission limits for installation and maintenance tests.

TABLE A

INSTALLATION TESTS

PARAMETER	LOCAL LOOP LOCAL WATS (NOTE 1)	FX	REMOTE WATS AND RX
Insertion Loss	X*	X	X
Impulse Noise		X	X
C - Notched Noise		X	X

Note 1: Measurement of all parameters may be necessary if problems are encountered. See paragraph 2.01.

* Required for installation of data jack.

TABLE B

MAINTENANCE TESTS

PARAMETER	LOCAL LOOP		FX, REMOTE WATS AND RX
	VJ	DJ	
Insertion Loss	X	X	X
C-Notched Noise	X	X	X
Impulse Noise	X	X	X
Phase Jitter			X
Gain Slope		X	X
P/AR		X	X
Intermodulation Distortion			X
Gain Hits			X
Phase Hits			X
Dropouts			X
Frequency Shift			X
Envelope Delay Distortion*		X	X

*If P/AR limit is met, it should not be necessary to perform the envelope delay distortion test.

VJ — Voice Jack

DJ — Data Jack

TABLE C

LOCAL LOOP LIMITS (NOTE 1)

PARAMETER	LIMIT	
	VOICE JACK	DATA JACK
1004-Hz Insertion Loss	10 dB Maximum	8.5 dB Maximum
C-Notched Noise	49 dBrnC0	49 dBrnC0 Maximum
Impulse Noise at 59 dBrnC0	15 counts in 15 minutes Maximum	15 counts in 15 minutes Maximum
Attenuation Distortion (slope) 504-2804 Hz referenced to 1004 Hz	Not Specified	—1 to 3 dB Maximum
P/AR	Not Specified	90 Minimum
Transmitted Data Power (at serving CO)	—12 dBm Maximum	—12 dBm Maximum
Envelope Delay Distortion*	Not Specified	100 Microseconds (1004 to 2804 Hz)

*P/AR measurement can usually be substituted for this parameter.

Note 1: —If Limits are not met, refer to Sections 314-205-300 or 668-010-300 for corrective measures.

6. REFERENCES

6.01 Bell System Practices covering the various equipment associated with data service are as follows:

SECTION	TITLE
103-611-101	J94003C Noise Measuring Set
103-611-102	J94003CR Noise Measuring Set
103-620-101	6H and 6HR Impulse Counters (J94006H and J94006HR) Description, Operation, and Maintenance
103-626-100	6F and 6FR Voiceband Noise Measuring Sets (J94006F and J94006FR) Description, Operation, and Maintenance
311-100-500	Circuit Order and Trunk Order Transmission Tests—PBX Central Office Trunks, Off-Premises Station Lines and Tie Trunks Having Access to the Direct Distance Dialing Network
311-100-501	1000 Hz and Noise Measurements—PBX Central Office Trunks, Off-Premises Station Lines and Tie Trunks Having Access to the Direct Distance Dialing Network
314-205-300	Data Systems—DATAPHONE Service and Other Data Services on the Direct Distance Dialing Network—Overall Maintenance Procedures
314-205-500	Data Systems—DATAPHONE Service and Other Data Services on the Direct Distance Dialing Network, Overall Data Transmission Test Requirements

TABLE D

FX LIMITS

PARAMETER	LIMIT
S/N Ratio	27 dB Minimum
C-Notched Noise	50 dBrnC0 Maximum
Impulse Noise	$\leq$ 10 in 15 minutes at 71 dBrnC0
Phase Jitter, (20-30 Hz)	8° P-P Maximum
Phase Jitter, (4-300 Hz) Phase Jitter, (4-20 Hz)	12° P-P Maximum 8° P-P Maximum
Slope	-1 to 8 dB Maximum, 404-2804 Hz referenced to 1004 Hz
P/AR	70 Minimum
Intermodulation Distortion 2nd Order 3rd Order	 28 dB Minimum 35 dB Minimum
Gain Hits	$\leq$ 6 in 15 minutes $\geq$ 3 dB
Phase Hits	$\leq$ 6 in 15 minutes $\geq$ 20°
Dropouts	1 in 30 minutes $\geq$ 12 dB
Frequency Shift	±3 Hz Maximum
Envelope Delay Distortion	1000 Microseconds 900-2500 Hz

314-205-503	Data Systems—DATAPHONE Service and Other Data Services on the Direct Distance Dialing Network—Minimum Acceptable Performance (MAP) Criteria	330-300-501	Completion Tests of Exchange-Area Cables Apparatus, Records, and Forms
		330-300-502	Completion Tests of Exchange-Area Cables Preparation
314-410-500	Voice Bandwidth Private Line Data Circuits, Tests and Requirements	330-300-503	Completion Tests of Exchange-Area Cables Testing
330-300-500	Completion Tests of Exchange-Area Cables Introduction	330-300-504	Completion Tests of Exchange-Area Cables Analysis and Reports

TABLE E

REMOTE WATS AND RX LINES

PARAMETER	LIMIT
S/N Ratio	29 dB Minimum
C-Notched Noise	48 dBrnC0 Maximum
Impulse Noise	$\leq$ 5 in 15 minutes at 71 dBrnC0
Phase Jitter (20-300 Hz)	2° P-P Maximum
Phase Jitter (4-300 Hz) Phase Jitter (4-20 Hz)	3° P-P Maximum 2° P-P Maximum
Slope	−1 to 4.5 dB 404-2804 Hz referenced to 1004 Hz
P/AR	85 minimum
Intermodulation Distortion 2nd Order 3 rd Order	 33 dB Minimum 39 dB Minimum
Gain Hits	$\leq$ 2 in 15 minutes $\geq$ 3 dB
Phase hits	$\leq$ 2 in 15 minutes $\geq$ 20°
Dropouts	1 in 30 minutes $\geq$ 12 dB
Frequency Shift	±2 Hz Maximum
Envelope Delay Distortion	400 Microseconds 900-2500 Hz

590-101-103	Jacks for Registered Data Equipment—Single and Multiline Installations	on the Direct Distance Dialing Network, Data Test Center, Trouble Analysis Procedure
668-010-300	Data Systems—DATAPHONE Service and other Data Services	

DATA SYSTEMS—"DATAPHONE®" SERVICE AND OTHER DATA SERVICE ON THE DIRECT DISTANCE DIALING NETWORK MINIMUM ACCEPTABLE PERFORMANCE (MAP) CRITERIA

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3. PARAMETERS MEASURED 2
4. TEST EQUIPMENT 2
5. BASIC PROCEDURES 2
6. REQUIREMENTS 2
7. REFERENCES 3

1. GENERAL

1.01 The switched telecommunications network and other switched networks may provide a large number of possible tandem arrangements of equipment and facilities on successive calls between two specific locations. It would be impractical to attempt to specify transmission requirements for every arrangement, and to maintain each arrangement to its separate requirement. Although transmission performance on the network is maintained in such a manner that on an "average," customers will receive satisfactory performance on a large percentage of data calls, it is recognized that a small number of customers may, because of geographical location, calling patterns, limited network access, etc, experience frequent or consistent substandard performance. The minimum acceptable performance (MAP) program has been initiated as an aid in identifying the situations where a substandard grade of service exists.

1.02 This section is reissued to provide revised MAP parameters and limits. Since this is a general revision, arrows ordinarily used to indicate changes have been omitted.

1.03 The MAP program is intended to be used with assistance from data technical (DATEC) support personnel investigating escalated data trouble reports. Trouble reports are normally escalated to the DATEC teams when craft personnel are not able to clearly establish that a trouble situation exists or are not able to correct a trouble situation satisfactorily. Normally, the DATEC personnel will not be involved until after it has been determined that operational problems, timing arrangements, data set strapping options, and other nontransmission problems are not causing the problems experienced. Similar problems involving data circuits on private switched networks may also be investigated.

2. MAP PROGRAM

2.01 The MAP program requires the measurement of up to 12 critical transmission parameters to determine whether any of the parameters are out of limits on over 85 percent of calls. The program may be applied either where telephone company (TELCO) or customer-provided equipment (CPE) data sets are used. The MAP program applies only to supported arrangements using data jacks at both ends.

3. PARAMETERS MEASURED

3.01 The parameters used in the MAP program to rate transmission performance are: 1004-Hz insertion loss, C-notched noise (measured using a 1004-Hz holding tone on the facility), impulse noise, phase jitter, slope between 404 and 2804-Hz

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referenced to 1004-Hz, peak-to-average signal ratio (P/AR), intermodulation distortion (second and third order measured using the 4-tone method), gain hits, phase hits, dropouts, frequency shift, and envelope delay distortion. These parameters are supported data jack to data jack.

3.02 If two of the MAP criteria parameters are at the limits and nominal amounts of other impairments are present on the channel, degraded performance can be expected. Survey statistics indicate that there will be less than one percent of the direct distance dialing (DDD) connections where more than two of the parameter limits specified in this section are exceeded.

4. TEST EQUIPMENT

4.01 A list of test equipment which has been evaluated for use in making transmission measurements is given in the AT&T Product Evaluation (PER) 117. Appropriate test equipment for measuring the parameters listed in paragraph 3.01 should be available to the DATEC personnel at each test location.

5. BASIC PROCEDURES

5.01 The basic procedure followed by DATEC teams in identifying trouble situations where MAP measurements are required, is to dispatch personnel to the selected test locations, place test calls, and measure the MAP parameters. Test requirements are given in paragraph 6.02.

5.02 The MAP program is intended only to identify the connections on which trouble situations exist. Craft personnel will (with the guidance of DATEC) refer to appropriate sections for corrective actions.

Choosing Test Locations

5.03 An analysis of trouble reports may be helpful in determining the proper test locations. If trouble has been experienced while transmitting to a particular location, end-to-end tests will be made to that location. If reports indicate that more than one location is involved in trouble reports, tests should be made to the location reporting the most trouble.

5.04 If trouble has been experienced in sending to more than one location without a pattern, test locations must be chosen arbitrarily. Under such conditions, it should be remembered that the trouble is likely to be located in the calling loop, the serving central office, or in the toll connecting trunks at the calling end.

5.05 If the trouble reports indicate that the difficulties are experienced in a particular time period in the day, tests should be made during that specific time period.

Placing Test Calls

5.06 Where TELCO data sets are used, the DATEC team should place test calls in the same manner as a customer would or may ask the customer to place the calls. If CPE data sets are used, the customer should be asked to place a series of calls in the usual operating manner. In either case, steps should be taken to insure that the customer is not billed for the test calls by following the procedures given in Section 010-250-001.

6. REQUIREMENTS

6.01 A simplified procedure may be used where the customer establishes a connection which is "bad" and has the same problem that has been referred to DATEC. All MAP parameters are then measured on this connection. If all parameters are in limit on two such connections, terminate testing. If any parameter is out of limits, corrective action is required.

6.02 When a test call has been set up, measurement of the parameters listed in Table A should be made. Note that P/AR may be substituted for envelope delay distortion measurement in most cases. In the following sequence, if (1) or (2) is accomplished, the service can be rated as satisfactory and no further action is required. If condition (3) exists, holding and tracing will be required to isolate a possible trouble condition. Action should be taken to correct out of limit transmission performance so that condition (1) or (2) is met. Complete one of the following series of calls as follows:

(1) Seven calls are completed with no parameter limit exceeded on any call or

(2) Ten calls are completed with one or more parameter limits exceeded on only one call or

(3) Two calls are completed with one or more parameter limits exceeded on each before accomplishing either (1) or (2).

6.03 Requirements for the measured parameters are given in Table A. If two or more MAP criteria are at the limits, a connection is considered unsatisfactory and additional investigation will be required.

6.04 If the facility is proven satisfactory in a case where customer-provided modems are used, it is the responsibility of the customer to test the modems.

7. REFERENCES

7.01 When a trouble situation has been identified, reference should be made to appropriate sections for aid in isolating and clearing the indicated troubles. The following sections cover maintenance procedures and give information about test equipment used in making MAP investigations.

SECTION	TITLE
010-250-001	Crediting Charges on Test Calls
100-520-101	KS-14510 Volt-Ohm-Milliammeter—Description and Application
103-115-101	25B and 25BR Voiceband Gain and Delay Sets (J94025B and J94025BR)—Description, Operation, and Maintenance
103-204-100	Model TTS-4 Series of Transmission Test Sets—Instruction Manual
103-611-102	3C Noise Measuring Set—Description
103-626-100	6F and 6FR Voiceband Noise Measuring Sets (J94006F and J94006FR)—Description, Operation, and Maintenance
107-101-100	914B Data Test Set—Description and Operation
107-402-100	921A Data Test Set—Description and Operation
314-205-300	Data Systems—DATAPHONE Service and Other Data Services on the Direct Distance Dialing Network—Overall Maintenance Procedures
314-205-500	Data Systems—DATAPHONE Service and Other Data Services on the Direct Distance Dialing Network/Overall Data Transmission Test Limits
314-205-501	Data Systems—DATAPHONE Service and Other Data Services on the Direct Distance Dialing Network—Test Requirements for Subscriber, Foreign Exchange, PBX, and WATS Lines
590-101-103	Jacks for Registered Data Equipment-Single and Multiline Installations

TABLE A

MAP PROGRAM PARAMETERS AND LIMITS

PARAMETER	LIMITS (JACK TO JACK)
1004-Hz Insertion Loss	30 dB
C-Notched Noise (1004-Hz Holding Tone)	24 dB below received power of 1004-Hz test tone at data level
Impluse Noise (1004-Hz Holding Tone)	15 counts in 15 min, threshold at 6 dB below received data level
Phase Jitter (20-300 Hz) (4-300 Hz) (4-20 Hz)	10 degrees, peak-to-peak 15 degrees, peak-to-peak 10 degrees, peak-to-peak
Slope, 1004 to 2804 Hz (Referenced to 1004 Hz)	$\leq$14 dB
P/AR	$\geq$48
Intermodulation Distortion 2nd order 3rd order	27 dB below received fundamental level 32 dB below received fundamental level
Gain Hits	8 in 15 min $\geq$3 dB
Phase Hits	8 in 15 min $\geq 20^{\circ}$
Dropouts	1 in 30 minutes, $\geq$12 db
Frequency Shift	$\pm$5 Hz
Envelope Delay Distortion*	800 μs maximum (1000 to 2400 Hz) 2600 μs (600 to 2800 Hz)

*If the P/AR limit is met, it should not be necessary to measure the envelope delay distortion test.

PART III

VOICE BANDWIDTH PL DATA CIRCUITS

VOICE BANDWIDTH PRIVATE LINE DATA CIRCUITS

DESCRIPTION

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1. GENERAL

1.01 This section describes the voice bandwidth (300-3200 Hz) channels used for private line (PL) data services. Voice bandwidth data is defined as data signals occupying a single voice-frequency channel (approximately 300 to 3200 Hz or less with some types of facilities). These services include

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data, telemetry, and alternate voice/data service; for example, 2001 and 3002 channels covered by FCC Tariff No. 260. These channels may be used to provide 2-point, multipoint, and certain switching arrangements. The information in this section includes the description of various types of conditioning that can be obtained on these different channels.

1.02 This section is reissued to update and realign information consistent with the Data General Layer, 314-010-ZZZ. Since this is a general revision, no revision arrows have been used to denote significant changes.

1.03 Descriptive information common to the transmission of data on the Public Switched Network (PSN), private line (PL) services, and Switched Service Networks (SSN) is covered in the following sections:

- Data General—Analog Transmission Parameters—Description (Section 314-010-100)
- Data General—Data Testing Principles (Section 314-010-101)
- Data General—Data Services Support (Section 314-010-102)
- DataGeneral—Interconnection/Interpositioning (Section 314-010-103).

A basic understanding of the Data General Sections is recommended prior to the use of this section.

1.04 The references to various related voiceband data maintenance sections are given in Fig. 1. Voice-only operation is not covered in this section but may be found in the Division 310 and 311 series of practices.

1.05 There is no difference technically in the transmission requirements of the 2000 series channels when ordered for data operation and those of a 3002 channel, except in some cases (such as PBX tie trunks) for standard 1004-Hz loss. The difference arises from applications that are described in FCC Tariff No. 260 and the local administration of these channels. The 2000 series of channels may be connected to exchange and toll services, but the 3002 channel must not.

1.06 Although operation of these services is basically 2-point, certain multipoint and switched arrangements are also used. One-way, half-duplex, and full-duplex modes may be used. Both 2-wire and 4-wire facilities and terminals are employed. Where 4-wire facilities are used, an equal-level loop-back arrangement is specified in all cases.

2. APPLICATION OF PROTECTIVE ARRANGEMENTS

2.01 The standard means of terminating PL data channels is with the data auxiliary set (DAS) 829 channel interface unit (CIU). The DAS 829 provides signal level adjustments and equalization as required. It also provides maintenance features, such as test jacks and equal-level loop-back capability. These functions are necessary in providing and maintaining the service, and the DAS 829is therefore required in all installations involving Bell System and customer-provided equipment (CPE).

2.02 Protection of the network from hazardous voltages and longitudinal imbalances is provided by inherent characteristics of the DAS 829. That is, the protection is assured by components (diodes, transformers, fuses) which are an integral part of the device and essentially used in its other functions. Signal level protection is provided at the central office (CO) by means of surveillance. Customer transmit levels are not usually sources of trouble on PL data channels. PL data channels are designed for a fixed overall loss of 16 dB, and therefore the customer does not have the incentive to raise the signal level to improve performance.

3. CHANNEL INTERFACE UNITS (CIU)

A. General

3.01 The DAS 829 is the Bell System standard CIU for terminating 4-wire PL voiceband data channels. Other types of station equipment may be specified and are generally similar in function, such as the older DAS 828. The work order record detail (WORD) document should indicate the type of station equipment to be used to provide protection against potentially hazardous voltages and longitudinal imbalance.

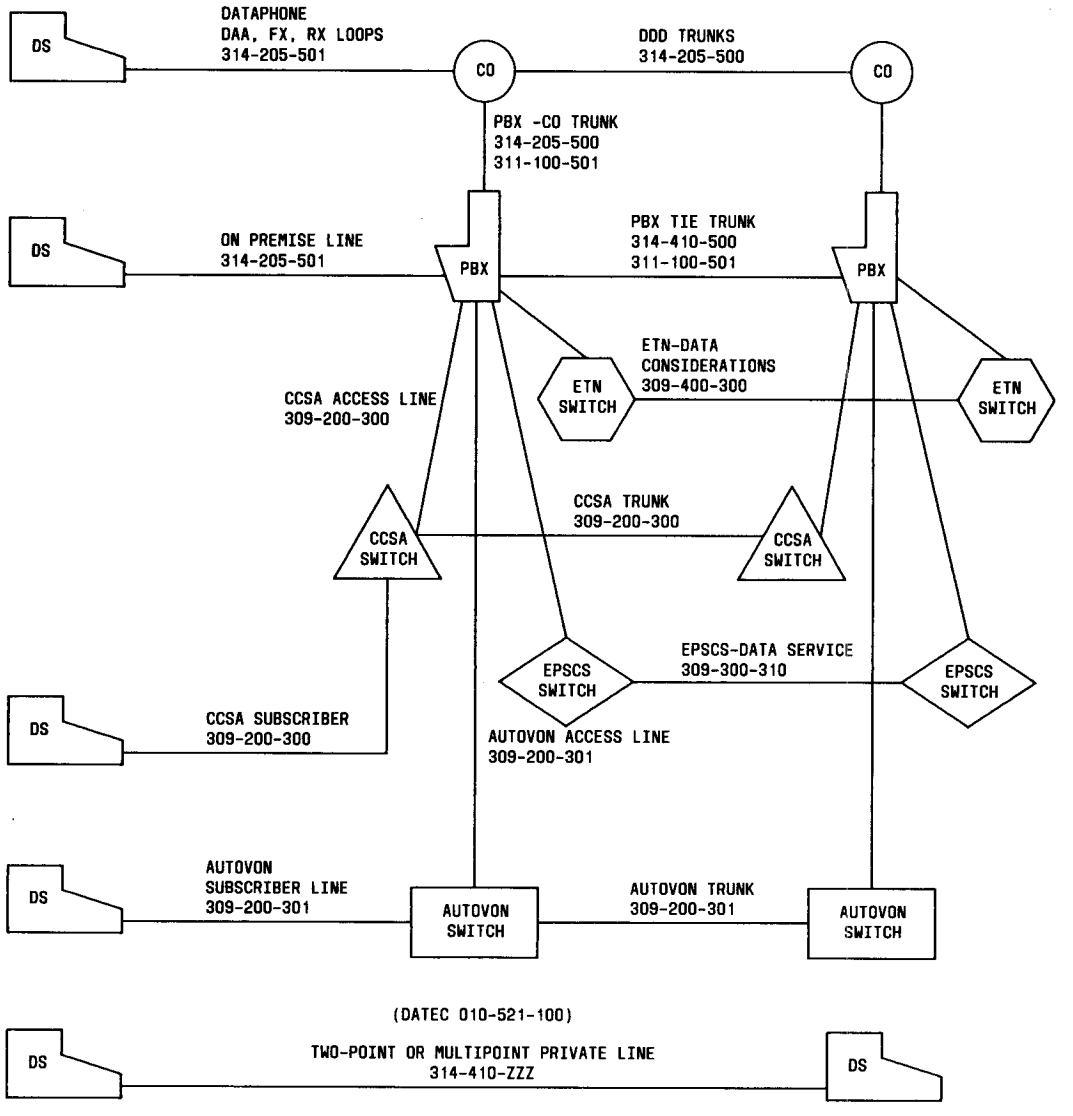

Fig. 1—Reference for Voiceband Data Transmission

B. Channel Interface Levels

3.02 The current standard transmit power at the data set interface is 0 dBm. This design is used for those data sets which can transmit at 0 dBm. The standard receiver power at the data set interface is -16 dBm. Typical arrangements showing the DAS 829 using these designs are shown in Fig. 2, 3, 4, and 5.

3.03 The basic ground rules for determining 4-wire circuit design when using DAS 829-type are as follows:

(a) The modem interface will be 0 dBm transmit and -16 dBm receive.

(b) Equal-level loop-back is always provided.

Additional transmission circuit design guidelines for use with DAS 829-type are provided in Section 598-082-100.

C. Data Auxiliary Set 829-Type

3.04 As previously mentioned, the standard CIU for 4-wire PL data circuits is the DAS 829. The physical interface is the miniature 50-position ribbon plug provided as part of the mounting arrangement of the DAS 829 and associated data units. Additional information covering interconnection/interpositioning is found in Section 314-010-103. Additional information covering the 50-position ribbon plug and associated leads is found in Section 598-082-100.

3.05 The DAS 829 is available in three basic station codes as follows:

DAS 829A

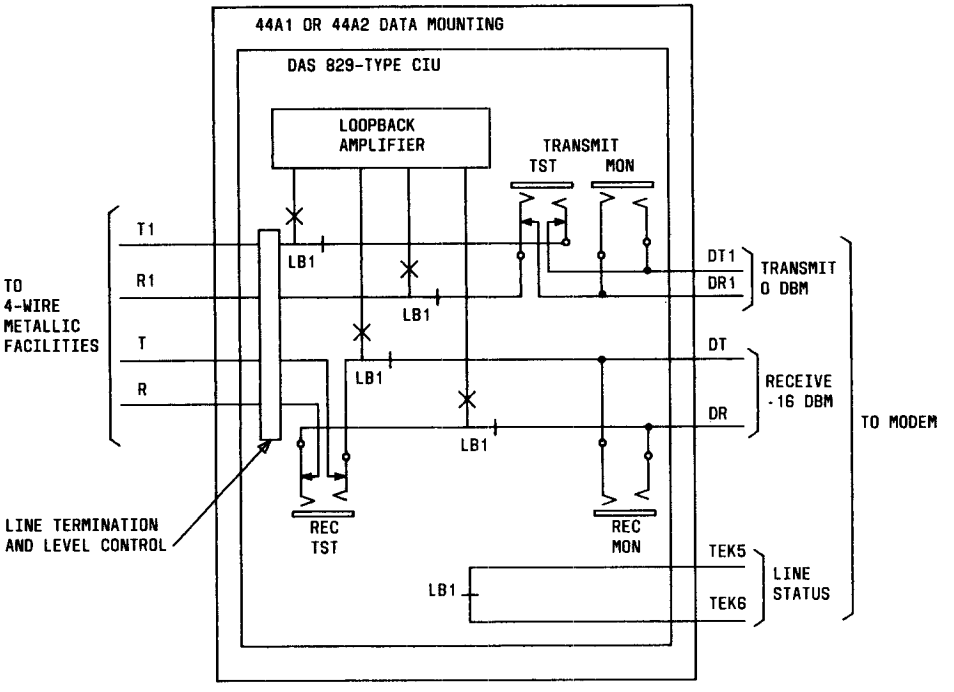

Fig. 2—Circuit Design for Data Only, 4-Wire Data Set

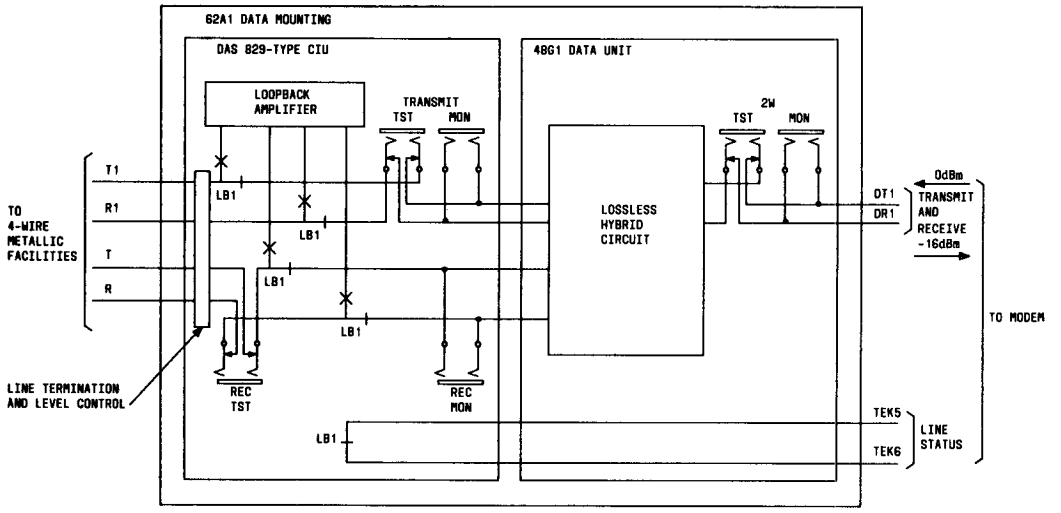

Fig. 3—Circuit Design for Data Only, 2-Wire Data Set

DAS 829B

DAS 829C

Any one particular PL channel termination requires the use of only one code of CIU. The CIU code that is used depends on the facilities involved.

3.06 Each of the three DAS 829 types is described as follows:

DAS 829A—is used for nonloaded or short loaded loops when no gain is required in transmit or receive paths. Slope equalization is accomplished with 600- or 1200-ohm line terminations. Attenuation is accomplished in the transmit or receive paths.

DAS 829B—is used for nonloaded or short loaded loops. It is required for long nonloaded loops and provides 150-, 600-, or 1200-ohm line termination for slope equalization. Gain or attenuation can be provided in the receive path. Attenuation is provided in the transmit path.

DAS 829C—is used for short nonloaded or for loaded loops and provides extensive equalization capability. This unit provides the same equalization capabilities as the 359A or the 359K equalizer. Gain or attenuation can be provided in the receive path. Attenuation is provided in the transmit path.

3.07 A standard, self-contained, tone-activated, loop-back capability is present in each DAS 829-type. Loop-back is equal level and provides controlled impedances.

3.08 Two data mountings, the 44A1 and 46A1, are designed for use with the DAS 829-type.

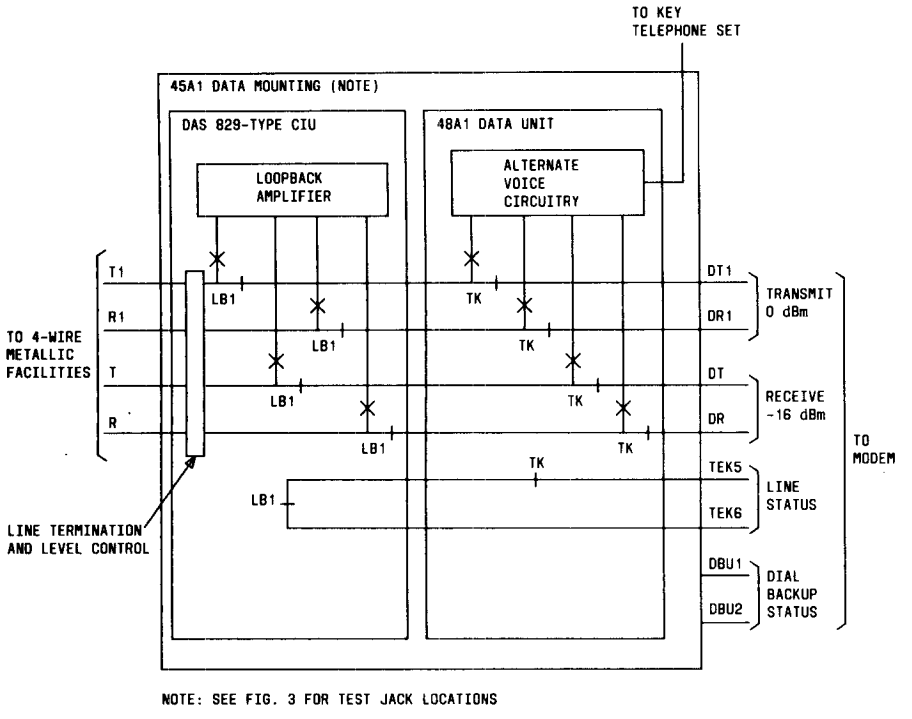

Fig. 4—Circuit Design for Data/Voice, 4-Wire Data Set

The 44A1 provides a single card housing for one DAS 829-type. The 46A1 provides a housing for a maximum of eight DAS 829-type and can be any combination of the three codes of DAS 829. The single card mounting is the same size as the new data set 202 S/T, and the multiple housing is the same size as the data set 202 S/T multiple housing. These arrangements are considerably smaller than the equivalent DAS 828-type described in Section 598-080-100.

3.09 Supplementary functions of alternate voice and dial backup are provided by data units, which are plug-in circuit packs of the same size as the DAS-829-type. These are the 48A1 and the 48B1 data units, respectively. Various single and multiple channel termination arrangements are available and are described in Sections 598-082-100 and 598-082-101.

3.10 The 2-wire data set option is provided by the use of the 48G1 data unit. A hybrid transformer provides the interface between the 2-wire modem and the DAS 829-type CIU that terminates a standard 16-dB channel. The transmit and receive amplifiers in the transmit and receive pairs of the 48G1 data unit have a fixed gain that offsets the circuit losses and provides a 0-dB insertion loss in the transmit and receive paths.

D. 150 Channel Service Unit (CSU)

3.11 The 150A channel service unit (CSU) is a passive device which provides a 2-wire interface between voiceband data station equipment and a 2-wire PL circuit. The 150A CSU provides the following:

- 2-way transmission path
- 2-way protection against hazardous voltages
- 2-way current surge protection

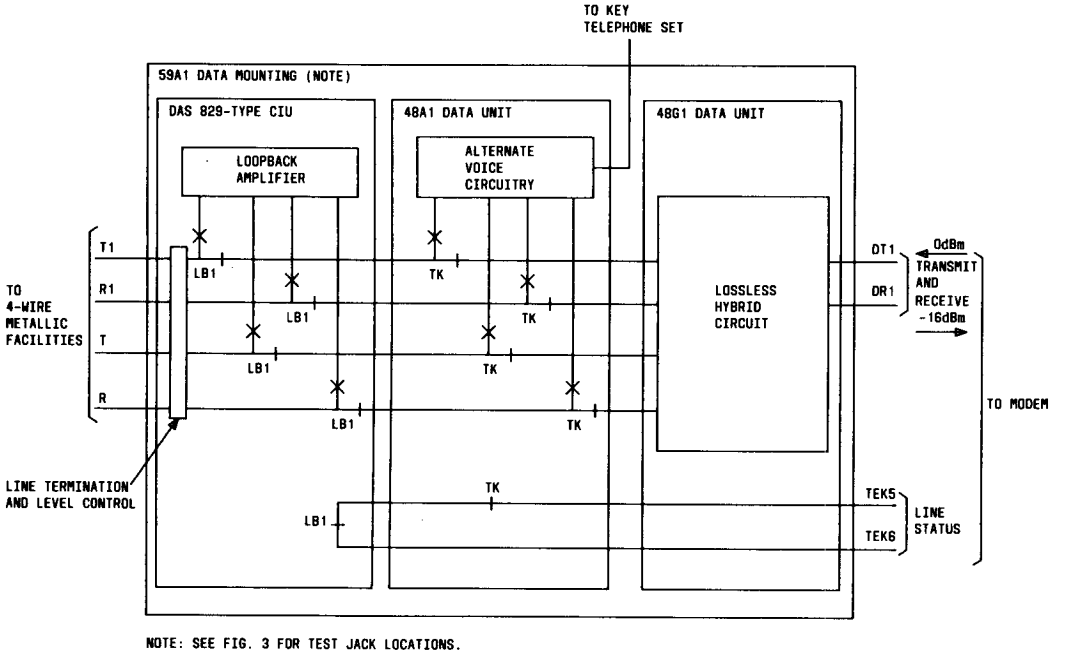

Fig. 5—Circuit Design for Data/Voice, 2-Wire Data Set

- Balanced termination
- Signal level adjustment
- Dc isolation between the station equipment and the telephone facilities.

Additional information covering the 150 CSU can be found in Section 590-101-000.

E. Loop-Back Arrangements

3.12 A remotely controlled equal-level loop-back arrangement is required at the customer location on those circuits which may be accessed by an STC (or similar organization equipped with a voice-frequency transmission testing capability).

3.13 The DAS 829-type has tone loop-back circuitry which operates like a DAS 828A equipped with a 44A1 data unit. The tone activated loop-back circuit is an integral part of all codes of the DAS 829-type.

3.14 To activate the loop-back at locations equipped with the 44A1 data unit, a 2713 ±2 Hz tone is applied toward the station at data level for not less than 5 seconds. Upon removal of the tone, the loop-back path will be established. To deactivate the loop-back, the 2713-Hz tone is again applied for a minimum of 5 seconds. The 406A tone generator is available for use at the testboard to supply the 2713-Hz signal for activation and release of the tone activated loop-back. More descriptive information on the 406A tone generator is given in Section 314-821-100.

4. SIGNALING ARRANGEMENTS

4.01 When DAS 829-type is used at the station, inband, end-to-end locked-in signaling with 30-second time-out can be provided by the addition

of the 48A1 data unit. This data unit provides for alternate voice use of the PL and uses an inband signal of 2600-Hz for ringdown signaling. An interrupted tone signal is returned to the calling station to indicate that the called station is receiving the 2600-Hz signaling tone at -13 dBm0. A 2-wire telephone set is used. Additional information on this type of signaling is given in Section 598-082-101.

> ***Note:*** The alternate voice arrangement provided by the 48A1 data unit is not interchangeable with alternate voice arrangements of either the DAS 828-type or locally engineered systems requiring 20-Hz ringdown signaling unless signal conversion equipment is provided.

4.02 On those installations where the DAS 829 is not used, as in the case of the DAS 828, CO signaling equipment must be used. The typical arrangement uses a D1B ringdown converter (SD-56163-01) or the Metallic Facility Terminal (MFT) ringdown converter signaling unit (J99343EB). The ringdown converter converts a 20-Hz signal on the 4-wire simplex path to E&M signaling. The E&M signaling is compatible with out-of-band signaling carrier channels, such as N1, ON, or T carrier using D1, D2, or D3 channel banks. On carrier channels requiring in-band signaling, such as L and R, a single frequency (SF) unit is used.

5. CIRCUIT CONDITIONING

5.01 FCC Tariff No. 260 provides for a basic voicegrade channel (2001, 3002) and eight types of C conditioning. These are designated as follows:

- 2001, 3002—Basic channel
- C1
- C2
- C3—Used only for Switched Services Networks (SSN) such as CCSA or SCAN (See Section 309-200-300)
- C4
- C5—Used only for 2-point circuits
- C6-Used only for protective relaying channel (See Sections 310-540-100 and 310-540-500)
- C7 and C8—Used only for Electronic Tandem Network (ETN) (See Section 309-400-300).

5.02 The differences between the C1, C2, C4, and C5 grades of conditioning are the attenuation distortion and envelope delay distortion limits which must be met in order to meet the requirements of FCC Tariff No. 260. All other parameters are the same for both basic and C-conditioning selected. The parameter requirements are listed in Section 314-410-500.

High Performance Data Conditioning (HPDC)

5.03 An offering called HPDC or D-type conditioning is available on interstate voicegrade analog data channels. This conditioning provides more stringent control over intermodulation distortion and signal-to-noise ratio than that on previously offered data channels. These parameters are the ones most likely to affect high-speed voiceband modems operating on analog channels.

5.04 High performance data conditioning (HPDC) is available in any one of three offerings. They are listed and defined as follows:

(a) ***Type D1 HPDC*** is designed for a 2-point channel not arranged for switching where there is not more than one station per service point (see Fig. 6).

(b) ***Type D2 HPDC*** is designed for a 3-point channel equipped with central office (CO)

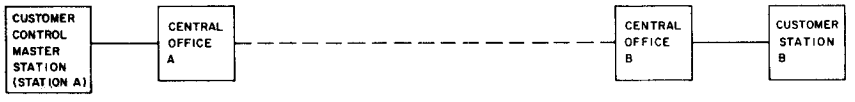

Fig. 6—Type D1 HPDC Circuit

switching arranged so that only two of the three stations may transmit to each other at any given time as illustrated in Fig. 7 and 8. The customer master station (CMS) can communicate with customer station B or, when switched, with customer station C. In no case can customer stations B and C communicate with each other. The CO switching can be assigned to be controlled from any one of the three stations. A dc control channel between the CO and the control station is included in the offering if both the CO and the control station are located within the same rate center (see Fig. 7). A separate series 1000 channel must be provided to control the switching if the CO and the control station are located in different rate centers (see Fig. 8). In the examples shown in Fig. 7 and 8, the CMS is shown as the control station.

(c) ***Type D3 HPDC*** is designed for access lines associated with AUTOVON networks, formally called switched circuits automatic network (SCAN). Type D3 HPDC is discussed in Section 309-200-301.

Restrictions

5.05 The HPDC should be provided on Type 3002, 5032, 5302, and 8302 voicegrade channels. The HPDC may be provided on an alternate voice-data arrangement (if degraded voice performance due to removal of compandors is acceptable to the customer). The option should not be provided on transfer arrangements, such as alternate night use of PBX tie trunks, because of degraded voice performance.

5.06 The HPDC equipped channel may be equipped with C-type conditioning if desired by the customer.

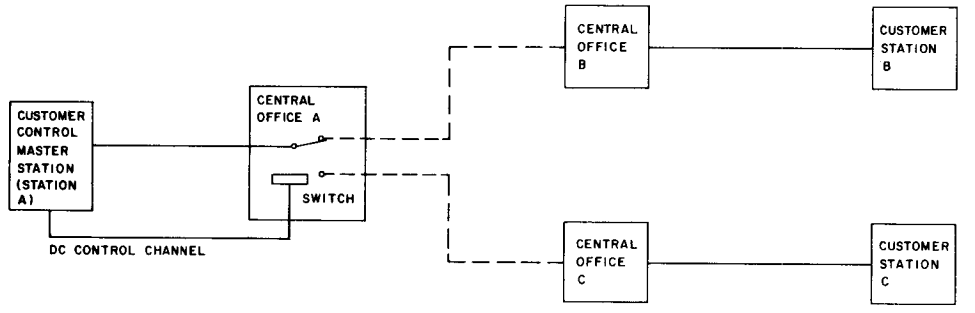

Fig. 7—Type D2 HPDC Circuit With CO Switch in Same Rate Center as Control Station

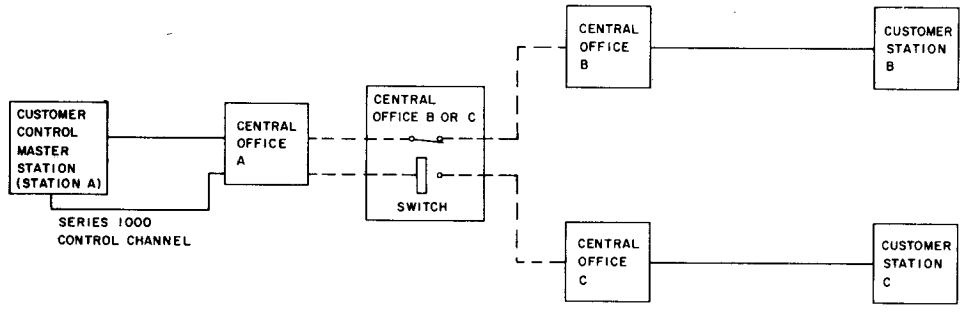

Fig. 8—Type D2 HPDC Circuit With CO Switch Not in Same Rate Center as Control Station

5.07 The HPDC will not be provided in locations where facilities capable of supporting it (such as, consistent with the following facility considerations) are not available.

Facility and Equipment Considerations

5.08 All facility selection should be made by or under the direction of the circuit design engineer. The following information is included for completeness only and is not intended to imply that such selection or design considerations should be made in the field.

5.09 Careful selection of facilities is necessary in order to meet the strict C-notched noise and intermodulation distortion requirements for HPDC circuits. LMX channels and metallic facilities are preferred. When a choice of short-haul carrier systems is available, select T carrier equipped with D1D, D2, or D3 channel banks.

5.10 If N2, N3, or ON carrier must be used, VF amplifiers will generally be required. Enhanced levels should be used on N2 channels as specified in Section 362-800-510. N1 carrier and T carrier equipped with D1A or D1B channel banks normally should not be used.

5.11 No more than three links of short-haul carrier (such as N, ON, or T carrier) should be used. No more than two links of N or ON carrier should be used in the overall channel.

> ***Note:*** A link is defined as a facility terminated by a pair of channel banks.

5.12 The use of noncompandored N or ON channels will generally result in higher C-notched noise levels than if compandored channel units are used. However, the compandored channel units have greater intermodulation distortion than the noncompandored channel units, and this may be a greater problem than noise. In cases where the overall HPDC C-notched noise requirements cannot be met but the intermodulation distortion requirements can be easily met, it may be worthwhile to try compandored channel units as a means of improving the noise performance. The intermodulation distortion test must be repeated after making this equipment substitution to ensure that it is still within limits.

5.13 The facility C-notched noise and intermodulation distortion requirements for T-carrier channels and compandored N- and ON-carrier channels are given in Section 314-410-500. Noncompandored N and ON channels that barely meet the noise requirements in Division 362 practices may not be satisfactory for HPDC circuits. The N and ON channels which meet a C-notched noise requirement of 31 dB or better will generally be satisfactory.

5.14 Where alternate voice is provided, mode signaling may be implemented using SF equipment. F-type equipment is preferred over E-type. The E3B and E4B signaling units should not be used because they may contribute an excessive amount of third-order intermodulation disorder.

6. CIRCUIT CONFIGURATIONS

6.01 The basic circuit configurations for PL data service are as follows:

(a) 2-Point

(b) Multipoint

(c) Central Office Relay Switched

(d) Customer Premises Switched.

Combinations of these configurations may appear in a single PL circuit.

6.02 The "point" in 2-point and multipoint is defined to be one or more stations terminating a serving link (local channel). This is typically a single station on a long-haul circuit but may consist of more than one data station, providing the local distributing arrangement introduces negligible distortion to data and none of the stations requires more than 1500 feet of cable from the distributing arrangement. This distributing arrangement may consist of a bridging and/or a switching arrangement. To meet the requirement of negligible distortion, a bridge in such an application needs to be of the 2-wire resistive type that presents 600 ohms to all legs. In the case of 4-wire, a separate 2-wire bridge is installed for each direction of transmission on the 4-wire circuit.

> ***Note:*** The facilities on the two sides of a local distributing arrangement are considered to be a part of the station equipment and are not considered as constituting separate links.

If more than 1500 feet of cable is required to connect a station with the local distributing arrangement, that station should be served by a separate end link from a CO bridge as shown in the lower portion of Fig. 9.

Intraexchange circuits may be subject to fewer restrictions, depending on local practice.

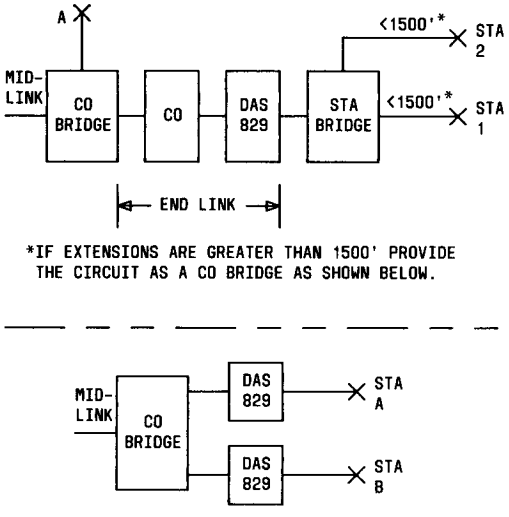

Fig. 9—Circuit Conversion of End Link to Midlink

A. 2-Point Circuits

6.03 Two-point circuits provide data communication between two locations. These circuits may be basic or have C1, C2, C4, or C5 conditioning. C5 conditioning can be ordered only on 2-point circuits.

B. Multipoint Circuits

6.04 These circuits may be basic or have C1, C2, or C4 conditioning. If any part of a multipoint circuit is conditioned, all parts must be conditioned to the same degree. C4 conditioning on multipoint circuits is restricted to 3- or 4-point operation. An example of 4-point operation is given in Fig. 10 where only one station is shown for each exchange. Station A is the master station and B, C, and D are remote stations. The grade of C4 conditioning can be specified between A and B, A and C, and A and D. No conditioning is specified between remote stations. Three-point operation is similar, with Station D omitted.

6.05 Figure 11 shows the maximum of four midlinks permitted with the basic or the C1 or C2 conditioned channel.

> ***Note:*** The links between bridges in the same building are not considered middle links. These bridges should be electrically as close together as feasible and in no case farther than 1500 feet of 22-gauge wire apart.

C. Central Office Relay Switched Circuits

6.06 Figure 12 shows a configuration utilizing a maximum of three CO switches that are allowed under the interstate tariff. The circuit may be unconditioned or have C1 or C2 conditioning between all pairs of stations.

D. Customer Premises Switched Circuits

6.07 Figure 13 shows a customer premises switched connection. This arrangement is permissible; however, no overall conditioning can be guaranteed.

7. SEALING CURRENT

7.01 Sealing current is low-level dc applied to a cable pair to break down a high resistance film which may build up at nonsoldered hand-to-twisted splices. Continued application of this current sustains the normal resistance of the cable pair.

7.02 The application of sealing current is a recommended maintenance action as well as a preventive maintenance item. The following troubles can be resolved by the application of sealing current:

- High dc resistance, often more than 60 percent above normal
- High 1-kHz loss, often more than 50 percent (of the value in dB) above normal
- C-notched noise, often more than 20 dB above normal, and
- Unbalance in resistance of tip and ring conductors.

The recommended sealing current is 15 milliamps of continuous dc preceded by 30 to 50 milliamps dc for several seconds, commonly referred to as "zap".

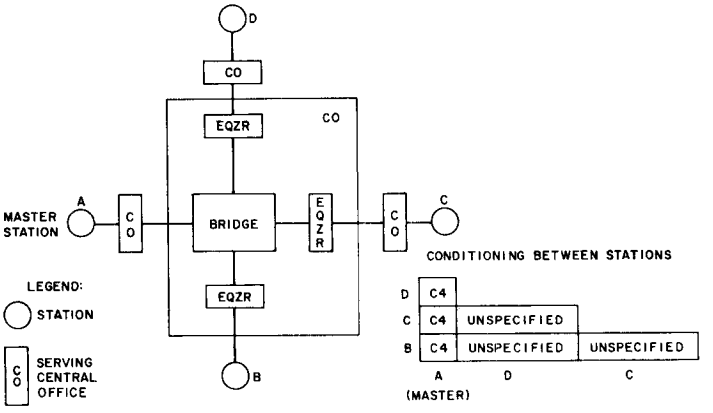

Fig. 10—4-Point Arrangement

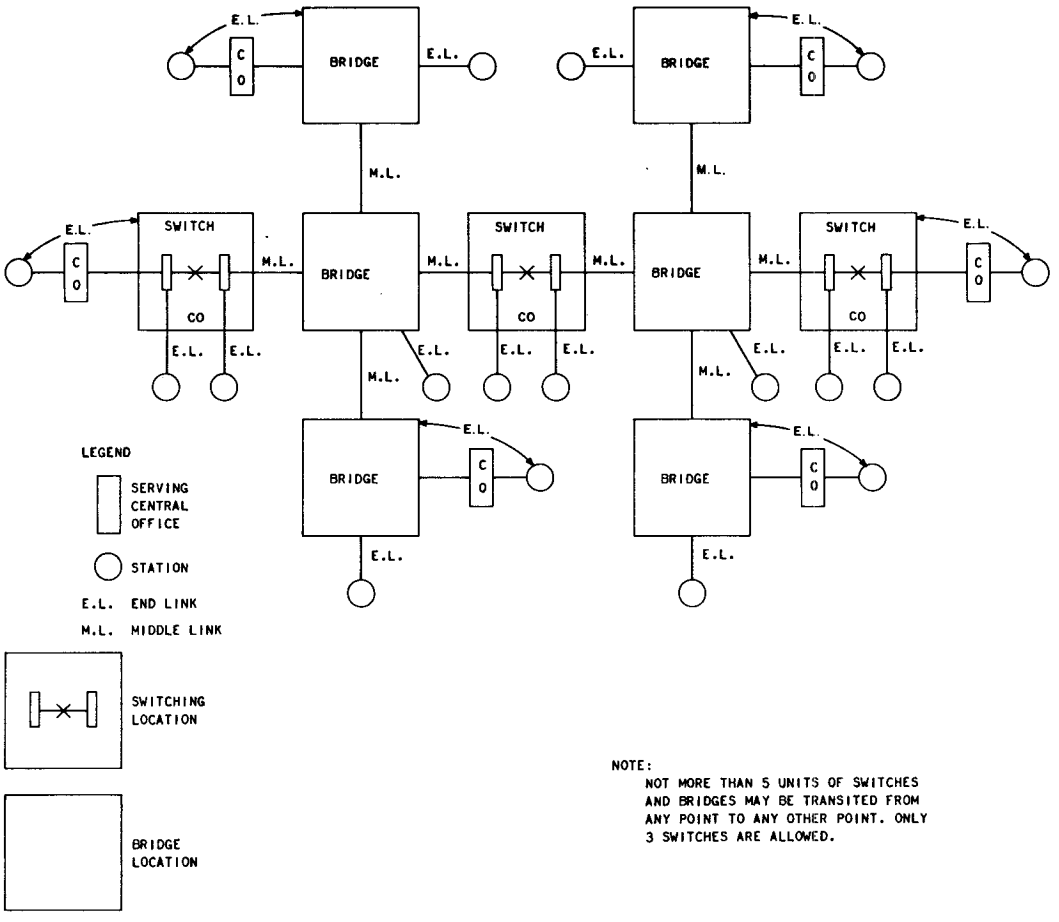

Fig. 11—Combined Central Office Switched Multipoint Circuit

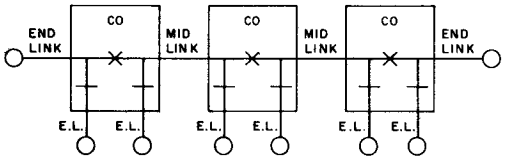

Fig. 12—Interstate Central Office Relay Switched Configuration

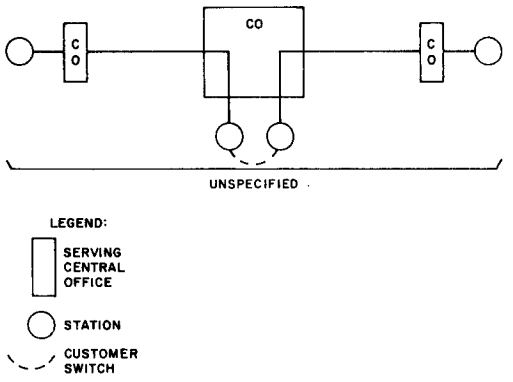

Fig. 13—Customer Switching Arrangement

8. REFERENCES

8.01 The following documents provide additional descriptive information on facilities and equipment associated with PL voiceband data service.

PUBLICATION	DESCRIPTION
AT&T PUB 41004	Data Communications Using Voiceband Private Line Channels—October 1973
AT&T PUB 41008	Analog Parameters Affecting Voiceband Data Transmission—Description of Parameters—July 1974
AT&T PUB 41009	Transmission Parameters Affecting Voiceband Data Transmission — Measuring Techniques—January 1972

SECTION	DESCRIPTION
010-521-100	Data Technical (DATEC) Support
309-200-301	Switched Services Network Using Central Office Switching Machine—AUTOVON—Service Maintenance
Division 310	Non-Switched Special Services System
Division 311	Switched Special Services System
314-010-100	Data General—Analog Transmission Parameters—Description
314-010-001	Data General—Data Testing Principles
314-010-102	Data General—Data Services Support
314-010-103	Data General—Interconnection/Interpositioning
314-410-104	Voice Bandwidth Private Line Data Circuits—Circuit Conditioning Requirements Using the Collins CLA-Type System
314-410-300	Voice Bandwidth Private Line Data Circuits—Maintenance
314-410-500	Voice Bandwidth Private Line Data Circuits—Tests and Requirements
314-820-100	Data Systems—Common Circuits, Equipment and Procedures—Envelope Delay Characteristics of 200-Type Delay Equalizers
314-820-104	Envelope Delay Characteristics of 384- and 385-Type Equalizers
314-820-106	J99347 VF Amplitude and Delay Equalizing Equipment—Description
314-820-107	950A-Type Equalizer—Description
314-820-108	950B-Type Equalizer—Description
314-820-207	950B-Type Equalizer—Prescription Settings
314-821-100	Data Systems—Central Office—406A Tone Generator—Description

SECTION	DESCRIPTION
332-912-250	Metallic Facility Terminal—Amplitude and Delay Equalizer (J99343SN)—SD-1C359-01—Description and Installation
598-080-100	Data Auxiliary Set 828A—Description and Operation
598-080-101	Data Auxiliary Set 828C—Description and Operation
598-082-100	Data Auxiliary Set 829-Type—Channel Interface Units—Voiceband Private Line Channels—Description
660-200-301	Special Services—Protection and Safeguarding

NOTES

VOICE BANDWIDTH PRIVATE LINE DATA CIRCUITS
CIRCUIT CONDITIONING REQUIREMENTS
USING THE COLLINS CLA-TYPE SYSTEM

1. GENERAL

1.01 This section provides attenuation and envelope delay distortion requirements for voice bandwidth private line data channels when tests are performed using the Collins CLA-type system.

1.02 This section is reissued to replace the term "CLA-1C1A" with "CLA-type". This change allows for newer versions of the test set to be included when the term is used. In addition, Table C has been deleted because information contained in that table is no longer supported. Since this reissue is a general revision, no revision arrows have been used to denote significant changes.

1.03 The CLA-type system uses test frequencies spaced at 250-Hz intervals ranging from 250 Hz to 3500 Hz. The conditioning test requirements for voice bandwidth data channels are stated differently when using the CLA-type system test equipment. This difference is due to the different test frequencies that are used. Limits have been developed for attenuation and envelope delay distortion at the CLA-type frequencies that will give reasonable assurance that the channel conditioning requirements are met within the specified frequency bands.

1.04 The limits for attenuation and envelope delay distortion are given in Tables A and B of this section. These tables should be substituted for the attenuation and envelope delay distortion requirements given in Section 314-410-500 up through C4 when the Collins CLA-type system is used to perform these tests. Manual measurements must be performed for C5 tests. Use the requirements as given in Section 314-410-500. However, it is recommended to make CLA-type measurements for benchmark readings.

1.05 The amplitude characteristic (attenuation distortion) of a network or interexchange facility is commonly determined by measuring the loss of a single-frequency tone as it is tuned across the bandwidth of interest. This type of measurement is referred to as the static frequency response. A static measurement performed on private line data channels may not provide the same amplitude characteristic results as that given by using a complex test waveform, due to level and frequency sensitive devices and the presence of nonlinearities. Measurement results with differences of up to 2 dB have been obtained on some compandored facilities when using other measuring techniques. These differences result from the relative placement of filters with respect to level sensitive and nonlinear devices, and generally are larger near the limits of the frequency band. In these cases the frequency response is a function of the bandwidth of the signal on the channel. This type of response is referred to as the dynamic frequency response.

1.06 The Collins CLA-type system uses a complex signal and performs a dynamic frequency response measurement. By comparison, the Bell System measurement technique used at this time is a static frequency response measurement.

1.07 A compandored channel will appear to have a wider bandwidth when using a dynamic frequency response measurement than with a static frequency response measurement. In some cases the customer, when using a single frequency transmission measuring set, may report that the frequency response is out of limits. However, subsequent testing using the Collins CLA-type system may indicate the frequency response is within specified limits. In these cases, the circuit must be adjusted to meet requirements using the static frequency response technique.

NOTICE
Not for use or disclosure outside the
Bell System except under written agreement

TABLE A

PRIVATE LINE VOICE BANDWIDTH CIRCUIT ATTENUATION DISTORTION REQUIREMENTS (dB) USING COLLINS CLA-TYPE SYSTEM

FREQUENCY RANGE IN HZ	0		1		2		3		4	
	2-POINT	MID LINK END LINK	MID LINK END LINK	MID LINK MID LINK	MID LINKS END LINK	MID LINKS MID LINK	MID LINKS END LINK	MID LINKS MID LINK	MID LINKS END LINK	MID LINKS MID LINK
3002 (ALSO 2000)										
BASIC	(VB)	(VBE0)	(VBE1)	(VBM1)	(VBE2)	(VBM2)	(VBE3)	(VBM3)	(VBE4)	(VBM4)
500-2500	-2 to +8	-1.5 to +4	-1 to +4	-1 to +3.5	-1 to +4	- to +3.5	-1 to +3.5	-0.8 to +3.5	-0.8 to +3.5	-0.8 to +3
250-3000	-3 to +12	-1.5 to +6	-1.5 to +6	-1.5 to +6	-1.5 to +6	-1.5 to +5	-1 to +5	-1 to +4.5	-1.5 to +4.5	-1 to +4.5
C1	(C1)	(C1E0)	(C1E1)	(C1M1)	(C1E2)	(C1M2)	(C1E3)	(C1M3)	(C1E4)	(C1M4)
1000-2500	-1 to +3	-0.7 to +1.5	-0.6 to +1.5	-0.5 to +1.5	-0.5 to +1.5	-0.5 to +1.5	-0.5 to +1.5	-0.5 to +1	-0.5 to +1.5	-0.5 to +1
250-2750	-2 to +6	-1.5 to +3	-1 to +3	-1 to +3	-1 to +3	-1 to +2.5	-1 to +3	-0.8 to +2	-0.8 to +3	-0.8 to +2
250-3000	-3 to +12	-1.5 to +6	-1.5 to +6	-1.5 to +6	-1.5 to +6	-1.5 to +5	-1.5 to +5	-1.5 to +4.5	-1.5 to +4.5	-1 to +4.5
C2	(C2)	(C2E0)	(C2E1)	(C2M1)	(C2E2)	C2M2)	(C2E3)	(C2M3)	(C2E4)	(C2M4)
500-2750	-1 to +2.7	-0.6 to +1.4	-0.5 to +1.4	-0.5 to +1.4	-0.5 to +1.4	-0.5 to +1.4	-0.5 to +1.4	-0.5 to +1	-0.5 to +1.4	-0.5 to +1
250-3000	-2 to +6	-1.5 to +3	-1 to +3	-1 to +3	-1 to +3	-1 to +2.5	-1 to +3	-0.8 to +2	-0.8 to +3	-0.8 to +2
C3 ACCESS LINE*†	(C3A)	(C3AC)								
500-2750	-0.5 to +1.3									
250-3000	-0.8 to +3									
C3 TRUNK*	(C3T)									
500-2750	-0.5 to +1									
250-3000	-0.8 to +2									
C4	(C4)									
500-3000	-2 to +3									
250-3250	-2 to +7									
C5‡										

( ) Figures in parentheses are classification codes which may be found on some CLRs to indicate the conditioning requirement for each link of the circuit.

* C3 conditioning requirements apply to AUTOVON and CCSA circuits only. Refer to Sections 309-200-300 and 309-200-301 for more information.

† Classification code C3AC assumes measurement taken with compromise equalizer temporarily out of service.

‡ Manual measurements are required and the CLA-type system is recommended for benchmark measurement only.

TABLE B

PRIVATE LINE VOICE BANDWIDTH CIRCUIT ENVELOPE DELAY REQUIREMENTS (MICROSECONDS) USING COLLINS CLA-TYPE SYSTEM

FREQUENCY RANGE IN HZ		0	1		2		3		4	
	2-POINT	MID LINK END LINK	MID LINK		MID LINKS		MID LINKS		MID LINKS	
			END LINK	MID LINK	END LINK	MID LINK	END LINK	MID LINK	END LINK	MID LINK
3002 (ALSO 2000)										
BASIC	(VB)	(VBE0)	(VBE1)	(VBM1)	(VBE2)	(VBM2)	(VBE3)	(VBM3)	(VBE4)	(VBM4)
750-2750	1900	1050	750	630	630	450	450	420	420	300
C1	(C1)	(C1E0)	(C1E1)	(C1M1)	(C1E2)	(C1M2)	(C1E3)	(C1M3)	(C1E4)	(C1M4)
1000-2500	1000	550	400	300	300	250	250	200	200	175
750-2750	1900	1050	750	630	630	450	450	420	420	300
C2	(C2)	(C2E0)	(C2E1)	(C2M1)	(C2E2)	(C2M2)	(C2E3)	(C2M3)	(C2E4)	(C2M4)
1000-2500	400	240	200	150	150	125	125	100	100	80
750-2750	1100	700	520	380	380	330	330	250	250	220
500-2750	2500	1500	1100	800	800	690	690	600	600	450
C3 ACCESS LINE*†	(C3A)(C3AC)									
1000-2500	100									
750-2750	240									
500-2750	600									
C3 TRUNK*	(C3T)									
1000-2500	80									
750-2750	200									
500-2750	450									
C4	(C4)									
1000-2500	260									
750-2750	450									
750-3000	1500									
500-3000	3000									
C5‡										

( ) Figures in parentheses are classification codes which may be found on some CLRs to indicate the conditioning requirement for each link of the circuit.

* C3 conditioning requirements apply to AUTOVON and CCSA circuits only. Refer to Sections 309-200-300 and 309-200-301 for more information.

† Classification code C3AC assumes measurement taken with compromise equalizer temporarily out of service.

‡ Manual measurements are required and the CLA-type system is recommended for benchmark measurement only.

NOTES

VOICE BANDWIDTH PRIVATE LINE DATA CIRCUITS

MAINTENANCE

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Table

A. Recommended Order of Tests to be Performed Due to Trouble Reports . 7

1. GENERAL

1.01 This section provides the maintenance considerations and testing policy to be used when performing maintenance tasks on voice bandwidth private line data circuits. At this time, there are several types of data sets used in private line data service, ranging in bit speed from low (below 300 bits per second) to high (up to 9600 bits per second).

1.02 This section is reissued to update and realign information consistent with the Data General Layer (314-010-ZZZ). Information previously covered in this section can be found in the Data General Layer. Since this reissue is a general revision, no revision arrows have been used to denote significant changes.

1.03 Descriptive information common to the transmission of data on the Public Switched Network (PSN), private line (PL) services, and Switched Service Networks (SSN) is covered in the following sections:

- Data General—Analog Transmission Parameters—Description (Section 314-010-100)

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- Data General—Data Testing Principles (Section 314-010-101)
- Data General—Data Service Support (Section 314-010-102)
- DataGeneral—Interconnection/Interpositioning (Section 314-010-103).

A basic understanding of the Data General Sections is recommended prior to the use of this section.

1.04 In order to prevent high level signals from causing harm to the telephone plant, a program of signal power measurements should be established. Broadband carrier systems should be surveyed for problems caused by high signal power. In addition, signal power measurements are required by the serving test center (STC) or special service center (SSC) every 6 months and are a part of every trouble report involving customer provided equipment (CPE).

2. MAINTENANCE CONSIDERATIONS

2.01 This part provides maintenance and test access information on 2-point and multipoint circuits.

A. 2-Point Circuits

2.02 The 2-point circuits provide data communication between two locations. These circuits may be basic, or have C1, C2, C4, or C5 conditioning. C3 conditioning is restricted to switched services network only. Information on this type of conditioning is given in Section 309-200-301. C6 conditioning is restricted to protective relaying channels as discussed in Section 310-540-100. C7 and C8 conditioning is restricted to electronic tandem networks (ETN) and is contained in Section 309-400-300. C5 conditioning can be ordered only on 2-point circuits.

2.03 End-to-end measurements are preferred in all cases and should be performed if service conditions permit. Sectional measurements made with the Collins CLA-type system are considered equivalent to end-to-end measurements. End-to-end measurements are required in all cases where the customer is not satisfied and/or the need for technical escalation is indicated.

2.04 For the purpose of estimating end-to-end performance from non-Collins CLA-type sectional measurements, a basic, C1 or C2, 2-point circuit should be divided into only two sections. One section should normally be from the control SSC or STC to its station and the other section should be from the same SSC/STC to the distant station. Care should be exercised to ensure that no office equipment or wiring is omitted or measured twice in this sectionalization. End-to-end performance is estimated from sectional measurements as given in Section 314-010-101.

> ***Note:*** If sectional measurements are to be made and are made partly with the Collins CLA-type equipment and partly with other test equipment, the static measurements should be made using the CLA-type equipment frequencies where possible. Testing with the Collins CLA-type equipment is covered in Section 314-410-104.

B. Multipoint Circuits

2.05 The end link/midlink concept allocates end-to-end transmission parameter requirements to individual link requirements. This simplifies the design and maintenance of multipoint and switched networks and reduces the need for end-to-end testing. Networks can be altered or expanded with a minimum of redesign or testing. Sometimes to accommodate planned growth, circuits are engineered with links designated to tighter limits than are immediately required. In these cases they should be maintained on the same basis that they were engineered and shown on the work order and record detail (WORD) document.

2.06 The end link/midlink allocation rules take advantage of statistics when combining link parameters and thus do not guarantee that the end-to-end connection will always meet limits. End links generally contain voice frequency cable plant, and their high-frequency response characteristics tend to be similar and cumulative. The limits on end links have been tightened over previous limits to reflect this condition. Even with the tighter limits it is possible for all the end links and midlinks to be within limits and the end-to-end limits to be exceeded. Particularly on end links it is important that the full capability of any selected equalizers be used; ie, do not add extra equalizers to optimize the parameters, but ***do select the optimum equalizer(s) and optimize any adjustments on lineup.***

2.07 When acceptable mid-link and end-link tests are completed, end-to-end attenuation distortion and delay distortion tests will not be required on multipoint circuits with conditioning requirements equivalent to C2 or less. End-to-end tests are required on C4 conditioned circuits.

2.08 Where a customer is dissatisfied with performance on a multipoint channel, end-to-end measurements are required between at least one pair of points where service is not satisfactory to the customer before technical escalation on circuits of any grade of conditioning. If the complaint concerns service between one pair of points, the measurements should be between those points. If the complaint concerns service between more than one pair of points but some are worse than others, the worst pair should be chosen for measurement tests. If they are equally bad, choose any convenient pair.

C. Central Office Relay Switched Circuits

2.09 The end link/midlink concept is also used with central office relay switched circuits. The circuit may be unconditioned or have C1 or C2 conditioning between all pairs of stations. End-to-end (customer-to-customer) attenuation distortion and envelope delay distortion measurements are not normally required.

2.10 Although the transmission parameters are normally measured on an end link/midlink basis, the overall transmission requirements must be met between any pairs of customer stations. These measurements must be made between the two worst-case stations through the switched connection in the event of a trouble report before technical escalation.

D. Customer Premises Switched Circuits

2.11 A customer premises switched arrangement is permissible.

2.12 The overall connection may be arranged to approximate the bandwidth parameter response of a basic channel or a C2 conditioned channel. Only the individual channel should be measured, never the overall connection; and no overall conditioning can be guaranteed.

2.13 The end-to-end facility parameter must be met on each individual channel. However, it is not required to assure that end-to-end facility parameter requirements will be met on the overall connection, since it may include more local and short-haul facilities in tandem than normal.

E. Test Points

2.14 Although there may be a number of points where transmission tests can be made, it is best to limit the choice of test access points to a few locations in order to be certain of measuring at a known impedance and test level. Figure 1 illustrates a typical 4-wire data set circuit design at a customer location using a DAS 829 channel interface unit (CIU). The test access points would be at the point where the data set is connected to the circuit or the jacks provided. These points have been chosen because they are fixed 600-ohm points, and terminated measurements can be made (with the data set disconnected from the circuit) which include all the pads and amplifiers at the station.

> ***Note:*** The station loss between the jacks and the connection to the data set must be tested before the jack access point is used. The jack access point should ***not*** be used when tests are being performed, in the case of repeated trouble reports, to check that the end-to-end transmission parameters are within limits. Only the point where the data set is connected is used.

2.15 When making transmission measurements at the customer location, DAS 829 type CIU part of the channel facilities and tests are to be made through it.

2.16 The test equipment should not be connected directly to the local cable pairs when transmission components (such as pads, repeat coils, and amplifiers) are used at the customer location, as this will result in the incorrect measurement of attenuation distortion, delay distortion, and other parameters.

2.17 Figure 2 illustrates a typical long haul circuit which is 4-wire station-to-station but converts to 2-wire for connection of a 2-wire modem. The test access point is at the point where the data set is connected to the circuit. The 2-wire test access of a DAS 829 type CIU would correspond to the 2-WIRE IN jack of the data mounting. Measurements are made on a 600-ohms terminated

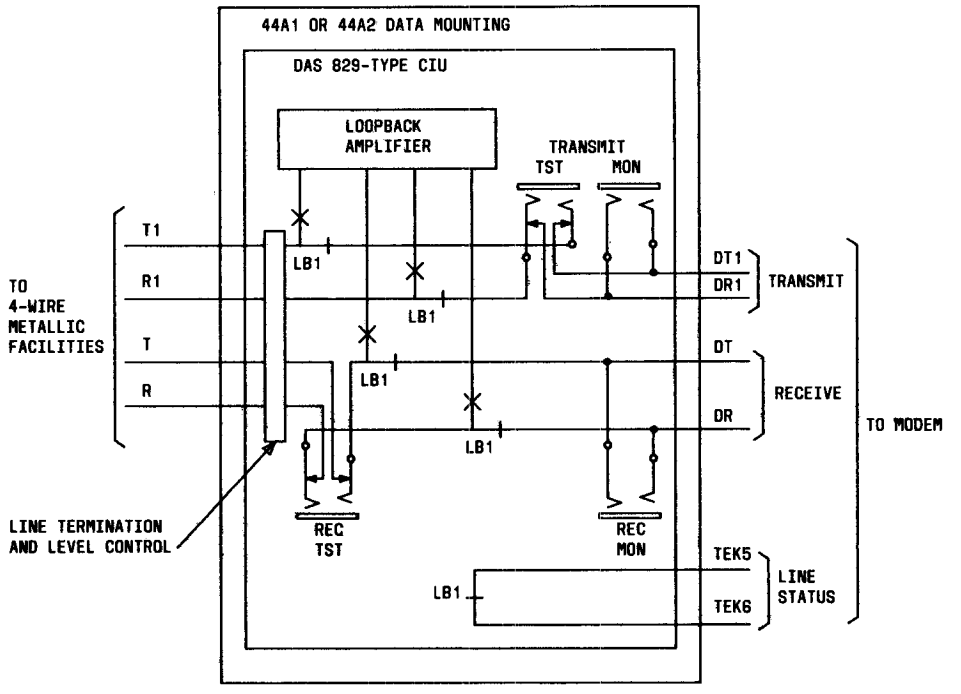

Fig. 1—Standard Circuit Design for Data Only, 4-Wire Data Set

basis unless the WORD document specifies some other impedance.

2.18 Figure 3 illustrates a 4-wire circuit at a typical SSC or STC. Measurements should be made at a point where the impedance is known to be 600 ohms rather than looking directly at the cable pair. An excellent measuring point is the VF jacks or equivalent private line testboard jacks associated with a 4-wire carrier channel.

2.19 Figure 4 illustrates a 4-wire multipoint circuit at a central office bridge location. Measurements should be made at the closest test access point to the bridge in order to measure the effect of all equipment used to make up the end link or midlink.

When testing a link off a bridge, it is necessary to first terminate that appearance in 600 ohms (both transmitting and receiving) in order to avoid unbalancing the bridge and to permit use by the customer of other portions of the circuit without interference from test tones or other trouble conditions.

3. TESTING POLICY

A. Required Channel Transmission Tests

3.01 Table A lists the tests required for trouble investigation. Section 314-010-101 lists the tests required for installation, routine and trouble. While this section deals specifically with maintenance

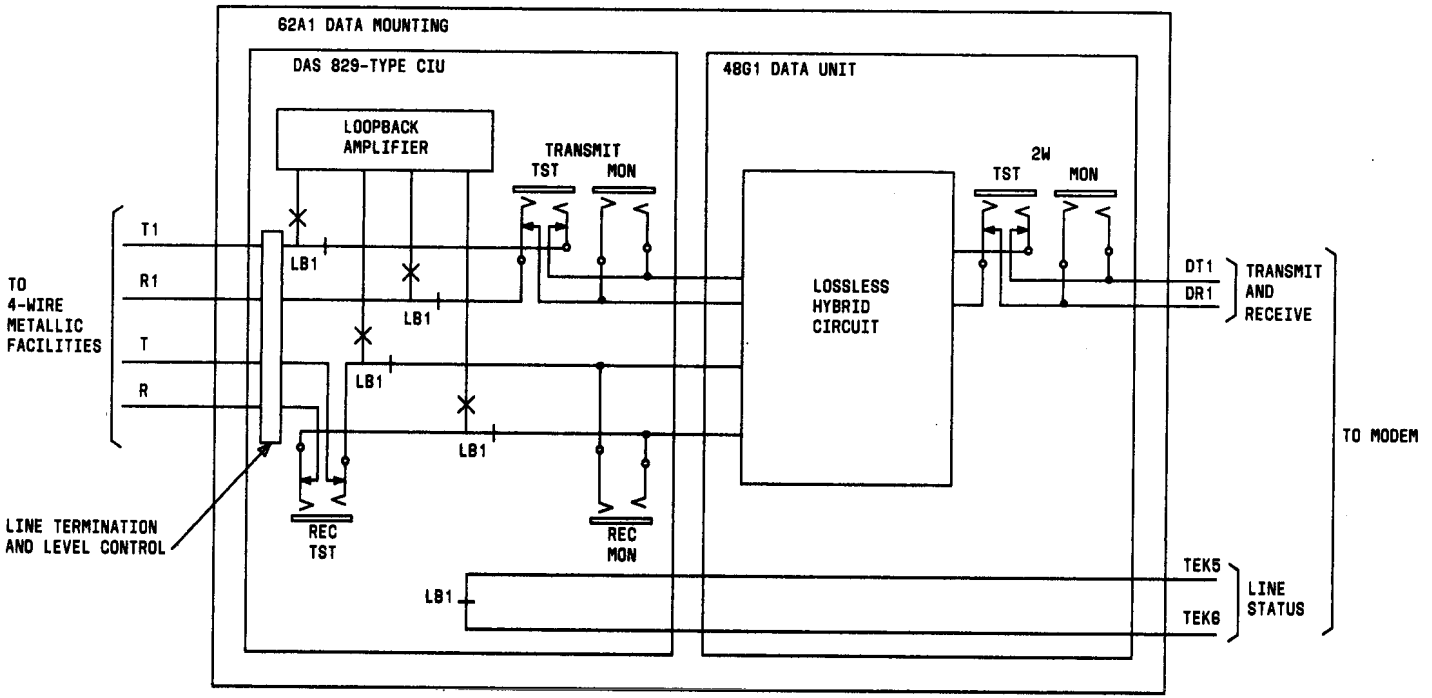

Fig. 2—Standard Circuit Design for Data Only, 2-Wire Data Set

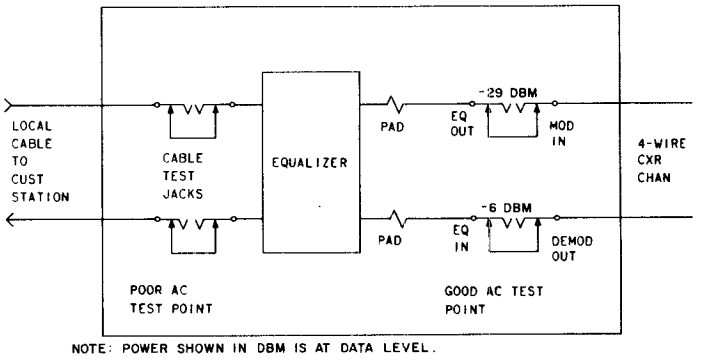

Fig. 3—Test Access Points on 4-Wire Circuit at Typical STC Office

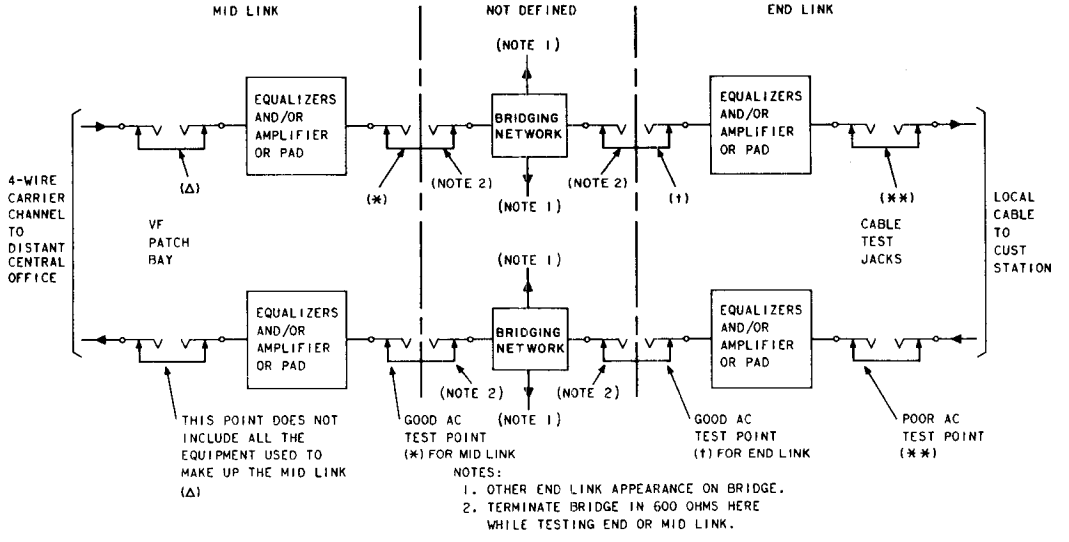

Fig. 4—Test Access Points on 4-Wire Multipoint Circuit at Bridge Location

TABLE A

RECOMMENDED ORDER OF TESTS TO BE PERFORMED DUE TO TROUBLE REPORTS

RECOMMENDED ORDER OF TESTS	MANUAL TESTING	SARTS
Continuity	*	(1)
Loss	*	(1)
"C" Notched Noise	*	(1)
Impulse Noise	*	(2)
Phase Jitter	(3)	(2) (4)
Gain Slope (3-tone)	*	(1)
P/AR	(5)	(2) (5)
Attenuation Distortion	*	(1)
Intermodulation Distortion	*	(2)
Hits, Dropouts	*	—
Return Loss	(6)	(1) (6)
Single Frequency Interference	*	—
Frequency Offset	*	(1)
Envelope Delay Distortion	*	—

Notes:

1. Available on SARTS, generic 1A.
2. Available on SARTS, generic 2.
3. Two of three phase jitter measurements required (4-20, 20-300, or 4-300 Hz).
4. Available in 4-20 and 20-300 Hz bands only.
5. If P/AR fails, skip immediately to measuring attenuation distortion return loss and envelope delay distortion.
6. Required on all data channels with 2-wire sections or 2-wire data terminals.

— Test is not available

* Test required

of PL data circuits, installation and routine tests must also be considered.

B. Loop-Back Tests

3.02 The following loop-back tests should be performed for purposes of trouble sectionalization on 4-wire facilities from the SSC or STC.

- Net Loss
- C-Notched Noise
- Impulse Noise
- Intermodulation Distortion (When the local channel includes short-haul channels, such as N, ON, or T).

The actual loop is made at the customer station. Before operating the loop-back arrangement at the customer station, the transmit leg from the customer location ***must be terminated*** at a point looking toward the other customer stations. At the VF patch bay, a 600-ohm termination placed in the MOD IN jack will be suitable. This is important to prevent the possibility that tests made toward the local customer station might affect service to other stations on multipoint circuits. In the case of some tone-operated loop-back arrangements, it

will prevent the loop-back control tone towards the local station from causing loop-back relays at the other customer stations to operate.

3.03 The application of direct current to the 4-wire simplex path for purposes of operating the loop-back relay at the customer station may cause troubles, such as opens or noise, to come clear. This is generally caused by a poor solder connection. In the event of repeated trouble reports of this nature, do not apply direct current to the circuit but isolate the trouble by applying a tone to the circuit and monitoring the circuit at appropriate test points (such as the frame). If a trouble of this nature cannot be isolated, the use of sealing current is recommended.

C. Interexchange and Midlink Tests

3.04 The initial trouble report tests given in Section 314-011-101 should be performed on the interexchange facilities (in the case of a 2-point private line) or on a suspected midlink or links in the case of a multipoint circuit.

D. End-to-End Trouble Tests

3.05 The end-to-end trouble tests are required if the customer is not satisfied with the service and the following steps have been taken:

(1) Loop-back tests have been made at each end of the circuit and all limits met.

(2) Interexchange or midlink tests have been made and all limits met.

(3) The customer has been requested to verify the proper operation of his equipment and has reported back that no trouble has been found but problems are still being encountered overall.

3.06 To make the tests, repair personnel should be dispatched to the appropriate customer locations for purposes of end-to-end trouble tests. In the case of certain multipoint circuits, where the trouble is limited to transmission to a single remote station, it may only be necessary to make tests of the end link from the bridge to the customer location, and coverage may not be required at any other stations.

3.07 It is not necessary to make all end-to-end transmission tests at the customer location if the tests are primarily intended to verify the proper operation of carrier facilities (such as phase jitter tests). Instead, these tests may be made at the ends of only the carrier portion of the circuit if suitable test equipment is not available at the customer location.

3.08 When the modem is CPE, the initial trouble report tests specified in Section 314-010-101 should be made and any troubles found cleared.

3.09 There will be some circumstances under which special technical support will be needed in order to solve a service problem. Technical support should be sought under the following conditions:

(a) The service meets all Bell System specifications but does not meet the customer's performance expectations. Telephone company personnel should not attempt to provide better than Bell System specifications without higher management approval.

(b) The service does not meet Bell System specifications and the problem source cannot be identified.

(c) Excessive trouble reports have been received and have been closed out as "Test OK," "Came Clear," "Found OK," or "No Trouble Found." This type of condition should be escalated immediately upon receipt of the third trouble report.

(d) The customer reports a transmission parameter as being out of limits but no mention is made in this section of that parameter. As an example, a report of "percent phase distortion" should be referred for technical support.

3.10 Refer to Section 010-521-100 for guidelines regarding data technical support (DATEC).

E. Routine Tests

3.11 Routine tests, other than total power output, are not necessary except where required by local practices. Total power output should be checked as a part of initial installation tests and all trouble report tests. It should be tested on a

routine basis about 6 months after circuit order tests have been completed to verify that changes have not been made in the modem output level. If the total output power is excessive, action should be taken to bring it within limits. Repeated failures to keep the total output power from exceeding Telco specifications may require the suspension of the customer's service. Ten days after written notice of the tariff violation is delivered to the customer, in those cases where the customer refuses to reduce the total power output, disconnection of the device may be appropriate.

4. USE OF FORM E-5596

4.01 The tests to be performed are given in Table A. These measurements should be made and the results recorded on Form E-5596. The back of Form E-5596 is used for recording benchmark measurements. Loop-back and straightaway measurements are both provided and should be used at the time of installation for later reference. Note that the circuit mileage is doubled when loop-back tests are made for purposes of determining C-notched noise and impulse noise requirements.

4.02 The following is an explanation of entries for Form E-5596 (Fig. 5).

1. ***Circuit Number:*** Enter circuit number.

2. ***Link:*** Enter appropriate link or section of circuit if straightaway measurements are recorded. Also, use this space to indicate loop-back test results.

3. ***Test Date:*** Enter date of test.

4. ***CKT Order No.:*** Enter circuit order number.

5. ***ED/AD:*** Enter results for attenuation distortion and envelope delay distortion (EDD) measurements made for circuit order or trouble tests.

6. ***1004-Hz Net Loss:*** Enter the 1004-Hz loss measurement.

7. ***C-Notched Noise:*** Enter the C-notched noise test results.

8. ***Impulse Noise:*** Enter the impulse noise measurement.

9. ***Phase Jitter:*** Enter phase jitter measurements as required.

10. ***Gain Slope:*** Enter the three tone measurements.

11. ***P/AR:*** Enter the peak-to-average ratio measurement.

12. ***Intermodulation Distortion:*** Enter the intermodulation distortion measurements as required.

13. ***Phase Hits:*** Enter the phase hits measurements as required.

14. ***Gain Hits:*** Enter the gain hits measurements as required.

15. ***Dropouts:*** Enter the dropout measurements as required.

16. ***Return Loss:*** Enter the return loss measurements as required.

17. ***Single Frequency Interference:*** Enter the single frequency interference measurements as required. Also enter the approximate frequency of the tone.

18. ***Frequency Offset:*** Enter the frequency offset measurements as required.

19. Enter routine measurements of total power and any others as required by local practices. The total power measurement is a high-impedance level measurement.

20. Enter the benchmark measurements as provided for on the back.

4.03 Form E-5596 is available only in package units of 25 forms. Orders should be placed in multiples of 25 forms and worded as follows:

(Quantity), Form E-5596

4.04 This form will not be stocked automatically at the Western Electric Company Service Center. Each company must authorize its local service center to stock new forms. In case of revised forms, disposition must be given of the old forms before the revised forms can be stocked.

314-410-500 E-5596

CIRCUIT NUMBER (1) DATA TRANSMISSION HISTORY CARD LINK (2) PRINTED IN U.S.A.

TEST DATE	(3)		(3)		(3)		(3)		(3)		(3)	
CKT. ORDER NO. (4)	(5) TR (INITIAL)		(5) REC (INITIAL)		(5) TR		(5) REC		(5) TR		(5) REC	
	DELAY	GAIN FREQ	DELAY	GAIN FREQ	DELAY	GAIN FREQ	DELAY	GAIN FREQ	DELAY	GAIN FREQ	DELAY	GAIN FREQ
300	X		X		X		X		X		X	
500												
600												
800												
1000												
1200												
1400												
1600												
1800												
2000												
2200												
2400												
2500												
2600												
2700												
2800												
3000												
3200	X		X		X		X		X		X	
(6) FREQ. SHIFT HZ												
(7) PHASE JITTER DEGREES												
(8) SINGLE-FREQ INT. DBRNCO												
(9) HARMONIC DIST. (2ND/3RD) DB												
(10) C-NOTCHED NOISE DBRNCO												
(11) RETURN LOSS - SP DB												
(12) DC LOOP RESISTANCE OHMS												

A - Form E-5596 (Front)

ROUTINE MEASUREMENTS

CIRCUIT NUMBER (1) LINK (2)

TEST DATE	Total Power DBMO		1000 HZ Loss DEVIATION		Noise DBRNCO		Impulse Noise COUNTS/15 Min.		P/AR	
	TR	REC	TR	REC	TR	REC	TR	REC	TR	REC
INITIAL MSMNTS	(13)	(13)	(14)	(14)	(15)	(15)	(16)	(16)	(17)	(17)
(3)	(18)	(18)	(18)	(18)	(18)	(18)	(18)	(18)	(18)	(18)
(3)										

B - Form E-5596 (Back)

Fig. 5—Form E-5596—Data Transmission History Card

VOICE BANDWIDTH PRIVATE LINE DATA CIRCUITS

TRANSMISSION REQUIREMENTS

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1. GENERAL

1.01 This section lists the transmission requirements for voice-bandwidth channels used for private line data service. This service includes telemetry, alternate voice/data, 2-point, multipoint, and certain switched arrangements.

1.02 This section is reissued to update and realign information consistent with the Data General Layer (314-010-ZZZ). This section now contains ***only transmission requirements.*** Information previously covered in this section can be found in the Data General Layer or Section 314-410-300. Since this reissue is a general revision, no revision arrows have been used to denote significant changes.

1.03 This issue affects Equipment Test Lists. The Equipment Test List for Digital and Analog Data Transmission is covered in Section 314-001-011.

1.04 Descriptive information common to the transmission of data on the Public Switched Network (PSN), private line (PL) services, and

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Switched Service Networks (SSN) is covered in the following sections:

- Data General—Analog Transmission Parameters—Description (Section 314-010-100)
- Data General—Data Testing Principles (Section 314-010-101)
- Data General—Data Services Support (Section 314-010-102)
- DataGeneral—Interconnection/Interpositioning (Section 314-010-103)

A basic understanding of the Data General Sections is recommended prior to the use of this section.

2. TRANSMISSION REQUIREMENTS

2.01 The PL data transmission requirements are given in Tables A through Q. These requirements correspond to the order of tests as required for trouble investigation.

TABLE A

1004-HZ LOSS DEVIATION (NOTE)

CONNECTION	CIRCUIT ORDER	ROUTINE OR TROUBLE ISOLATION
End Link	±0.5 dB	±2.0 dB
Middle Link	±0.5 dB	±1.0 dB
End-to-End	±1.0 dB	±4.0 dB
Loop-Back	±0.8 dB	±2.0 dB

Note: Maximum deviation from EML stated on circuit layout record card.

TABLE B

C-NOTCHED NOISE REQUIREMENTS
ON COMPANDORED FACILITIES

FACILITY LENGTH (MILES)	dBrnc0	
	N-TYPE CARRIER	T1/D-TYPE CARRIER
0—100	41	41
101—200	42	42

TABLE C

C-NOTCHED NOISE REQUIREMENTS
ON UNCOMPANDORED FACILITIES

CIRCUIT LENGTH (MILES)	NOISE MEASUREMENT (dBrnc0)
0—100	32
101—200	34
201—400	35
401—1000	38
1001—1500	39
1501—2500	41
2501—4000	43

TABLE D

MAXIMUM ALLOWABLE IMPULSE
COUNTS (15-MINUTE PERIOD)

COUNTER CIRCUIT		MAXIMUM COUNTS
1	Threshold	15
2	Threshold + 4 dB	9
3	Threshold + 8 dB	5

Note: See Table E for threshold settings.

TABLE E

IMPULSE NOISE THRESHOLD
SETTINGS IN dBrnc0

LENGTH (MILES)	TYPE FACILITY				
	(1)	(2)	(3)	(4)	(5)
0 — 59	54	73	67	70	58
60 — 124	54	73	67	70	58
125 — 249	54	73	67	70	59
250 — 499	54	73	67	70	59
500 — 999	—	—	—	—	59
1000 — 1999	—	—	—	—	61
over 2000	—	—	—	—	64

(1) Voice frequency cable facilities only

(2) N3 carrier with VF amplifiers

(3) N1, O, ON, N3L junction facilities or T carrier facilities

(4) N2, N3, or N4 carrier facilities

(5) LMX carrier facilities.

Note 1: These thresholds assume the use of a -13 dBm0 holding tone. Do not use other holding tone levels as the above thresholds for type 2 (compandored) facilities would be incorrect.

Note 2: On PBX tie trunks, a minimum threshold of 59 dBrnc0 should be used to account for impulse noise which may originate at the PBX switch.

TABLE F

MAXIMUM PEAK-TO-PEAK PHASE JITTER REQUIREMENTS

FACILITY LENGTH (MILES)	MAXIMUM LIMITS (DEGREES P-P)		
	BELL (20–300 Hz)	LF (4–20 Hz)	BELL PLUS LF 4–300 Hz
0 – 250	2	5	7
251 – 500	4	5	9
501 – 1000	6	5	11
1001 – 2000	8	5	13
2001 – 4000 (Overall)	10	5	15

TABLE G

MINIMUM P/AR OBJECTIVES

CONNECTION	MINIMUM VALUE
Mid Link	80
End Link	80
End-to-End	50

TABLE H

P/AR VALUES FOR SINGLE AND MULTIFACILITY CHANNELS

TYPE	MAXIMUM (NOTE 1)	MAINTENANCE LIMIT (NOTE 2)	TYPICAL VALUE (NOTE 3)
O, ON, N3	94	86	90
N1	98	86	92
L or Radio	99	87	93
N2	101	93	97
T1	102	93	97
2T1	97	88	92
2N3	93	83	88
2N2	96	88	92
2N1	93	85	89
T1 + N3	95	87	91
T1 + N2	96	88	92
N1 + N3	97	87	92
ON + T1	96	87	91
ON + A	93	83	88
ON + N3	93	83	88
ON + N2	96	88	92
ON + N1	96	88	92
2 ON	91	83	87
T1 + N1	96	87	91
N2 + N3	97	87	92
N1 + N2	95	87	91
2 "A" Type	92	82	87
A + T1	95	86	90
A + N3	91	83	87
A + N2	96	86	91
A + N1	96	86	91
3A	83	74	78

Note 1: Highest allowable value

Note 2: Minimum allowable value

Note 3: Expected value.

TABLE I

P/AR VALUES FOR NONREPEATERED CABLE

TYPE	LENGTH	MAINTENANCE LIMIT
Nonloaded	0 — 18 kft	97
H88	0 — 18 kft	94

TABLE J

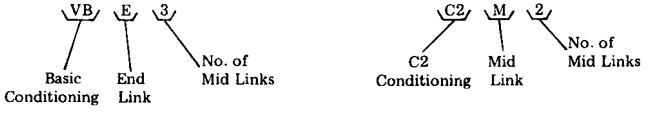
P/AR VALUES FOR REPEATERED CABLE

TYPE	LENGTH	MAINTENANCE LIMIT
Nonloaded	0 — 18 kft	90
H88	0 — 36 kft	90
H88	> 36 kft	80

TABLE K

PRIVATE LINE VOICE BANDWIDTH CIRCUIT ATTENUATION DISTORTION REQUIREMENTS (dB) (NOTE)

FREQUENCY RANGE IN HZ	2-POINT	0	1		2		3		4	
		MID LINK	MID LINK		MID LINK		MID LINK		MID LINK	
		END LINK	END LINK	MID LINK	END LINK	MID LINK	END LINK	MID LINK	END LINK	MID LINK
3002 (ALSO 2001)										
BASIC	(VB)	(VBE0)	(VBE1)	(VBM1)	(VBE2)	(VBM2)	(VBE3)	(VBM3)	(VBE4)	(VBM4)
500 — 2500	−2 to +8	−1.5 to +4	−1 to +4	−1 to +3.5	−1 to +4	−1 to +3.5	−1 to +3.5	−0.8 to +3.5	−0.8 to +3.5	−0.8 to +3
300 — 3000	−3 to +12	−1.5 to +6	−1.5 to +6	−1.5 to +6	−1.5 to +6	−1.5 to +5	−1.5 to +5	−1 to +4.5	−1.5 to +4.5	−1 to +4.5
C1	(C1)	(C1E0)	(C1E1)	(C1M1)	(C1E2)	(C1M2)	(C1E3)	(C1M3)	(C1E4)	(C1M4)
1000 — 2400	−1 to +3	−0.7 to +1.5	−0.6 to +1.5	−0.5 to +1.5	−0.5 to +1.5	−0.5 to +1.5	−0.5 to +1.5	−0.5 to +1	−0.5 to +1.5	−0.5 to +1
300 — 2700	−2 to +6	−1.5 to +3	−1 to +3	−1 to +3	−1 to +3	−1 to +2.5	−1 to +3	−0.8 to +2	−0.8 to +3	−0.8 to +2
2700 — 3000	−3 to +12	−1.5 to +6	−1.5 to +6	−1.5 to +6	−1.5 to +6	−1.5 to +5	−1.5 to +5	−1.5 to +4.5	−1.5 to +4.5	−1 to +4.5
C2	(C2)	(C2E0)	(C2E1)	(C2M1)	(C2E2)	(C2M2)	(C2E3)	(C2M3)	(C2E4)	(C2M4)
500 — 2800	−1 to +3	−0.7 to +1.5	−0.6 to +1.5	−0.5 to +1.5	−0.5 to +1.5	−0.5 to +1.5	−0.5 to +1.5	−0.5 to +1	−0.5 to +1.5	−0.5 to +1
300 — 3000	−2 to +6	−1.5 to +3	−1 to +3	−1 to +3	−1 to +3	−1 to +2.5	−1 to +3	−0.8 to +2	−0.8 to +3	−0.8 to +2
C4	(C4)	Classification Codes — Examples								
500 — 3000	−2 to +3									
300 — 3200	−2 to +6									
C5	(C5)									
500 — 2800	−0.5 to +1.5									
300 — 3000	−1 to +3									



( ) Figures in parentheses are classification codes which may be found on some CLR cards to indicate the conditioning requirement for each link of the circuit.

\+ means loss with respect to 1004 Hz.

− means gain with respect to 1004 Hz.

Note: Requirements using the Collins CLA-101A system are given in Section 314-410-104.

TABLE L

OVERALL INTERMODULATION DISTORTION LIMITS

WITHOUT D-TYPE CONDITIONING	
PRODUCT	LIMIT
Second Order Third Order	27 dB 32 dB
WITH D-TYPE CONDITIONING	
PRODUCT	LIMIT
Second Order Third Order	35 dB 40 dB

TABLE M

PHASE HIT, GAIN HIT, AND DROPOUT LIMITS

TRANSIENT	MID LINK	END LINK	END-TO-END
Phase Hits	$\leq$ 2 in 15 min $\geq$ 20°	$\leq$ 2 in 15 min $\geq$ 20°	$\leq$ 8 in 15 min $\geq$ 20°
Gain Hits	$\leq$ 2 in 15 min $\geq$ 3 dB	$\leq$ 2 in 15 min $\geq$ 3 dB	$\leq$ 8 in 15 min $\geq$ 3 dB
Dropouts	$\leq$ 2 in 1 hour $\geq$ 12 dB	$\leq$ 2 in 1 hour $\geq$ 12 dB	$\leq$ 2 in 1 hour $\geq$ 12 dB

Note: $\geq$ Equal to or greater than.

$\leq$ Equal to or less than.

TABLE N

RETURN LOSS REQUIREMENTS

NUMBER OF 2-WIRE STATIONS	MINIMUM RETURN LOSS (EACH STATION)
1 — 2	10 dB
3 — 4	16 dB
5 — 8	22 dB
Over 8	28 dB

TABLE O

SINGLE FREQUENCY INTERFERENCE REQUIREMENTS

CIRCUIT LENGTH MILES	LEVEL OF MEASURED TONE dBrnc0
0 - 50	28
51 - 100	31
101 - 400	34
401 - 1000	38
1001 - 1500	40
1501 - 2500	42
2501 - 4000	44
4001 - 8000	47
8001 - 16,000	50
Satellite Channel	41

TABLE P

FREQUENCY OFFSET REQUIREMENTS

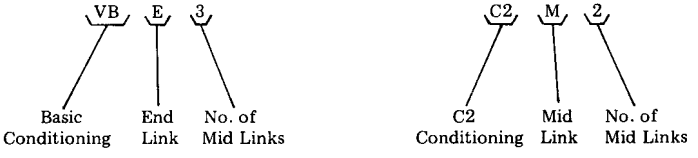
CONNECTION	MAXIMUM ALLOWABLE SHIFT
Mid Link	$\leq$ 1 Hz
End Link	$\leq$ 1 Hz
End-to-End	$\leq$ 5 Hz Max

Note: $\leq$ Equal to or less than.

TABLE Q

PRIVATE LINE VOICE BANDWIDTH CIRCUIT ENVELOPE DELAY REQUIREMENTS (MICROSECONDS) (NOTE)

FREQUENCY RANGE IN HZ	2-POINT	0	1		2		3		4	
		MID LINK	MID LINK		MID LINK		MID LINK		MID LINK	
		END LINK	END LINK	MID LINK	END LINK	MID LINK	END LINK	MID LINK	END LINK	MID LINK
3002 (ALSO 2001)										
BASIC	(VB)	(VBE0)	(VBE1)	(VBM1)	(VBE2)	(VBM2)	(VBE3)	(VBM3)	(VBE4)	(VBM4)
800 — 2600	1750	960	685	550	550	400	400	375	375	275
C1	(C1)	(C1E0)	(C1E1)	(C1M1)	(C1E2)	(C1M2)	(C1E3)	(C1M3)	(C1E4)	(C1M4)
1000 — 2400	1000	550	400	300	300	250	250	200	200	175
800 — 2600	1750	960	685	550	550	400	400	375	375	275
C2	(C2)	(C2E0)	(C2E1)	(C2M1)	(C2E2)	(C2M2)	(C2E3)	(C2M3)	(C2E4)	(C2M4)
1000 — 2600	500	275	200	150	150	125	125	100	100	80
600 — 2600	1500	825	600	450	450	375	375	300	300	260
500 — 2800	3000	1650	1200	900	900	750	750	600	650	500
C4	(C4)	Classification Codes — Examples								
1000 — 2600	300									
800 — 2800	500									
600 — 3000	1500									
500 — 3000	3000									
C5	(C5)									
1000 — 2600	100									
600 — 2600	300									
500 — 2800	600									



( ) Figures in parentheses are classification codes which may be found on some CLR cards to indicate the conditioning requirement for each link of the circuit.

Note: Requirements using the Collins CLA-101A system are given in Section 314-410-104.

DATA AUXILIARY SET 829-TYPE
CHANNEL INTERFACE UNITS
VOICEBAND PRIVATE LINE CHANNELS
INSTALLATION AND CONNECTIONS

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1. GENERAL

1.01 This section contains information and instructions for the installation and connection of data auxiliary set (DAS) 829-type and the supplementary data units and data mountings. This section does not cover the installation of modems used in conjunction with the DAS and the supplementary apparatus.

1.02 This section is reissued to add information on the 48ER1, 48FR1, and 48G1 data units and the 44A2, 46A2, 46C2, 59A1, and 62A1 data mountings. Since this reissue is a general revision, arrows normally used to indicate changes have been omitted.

1.03 The DAS 829-type functions as a channel interface unit (CIU) to provide a prewired

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and tested standard termination for 4-wire private line voiceband data channels. Basic station arrangements use the DAS 829-type CIU to provide 4-wire data only service. Other station arrangements use the DAS 829-type CIU and the supplementary apparatus to provide 4-wire data with alternate voice, dial backup, and switched dial backup service. Two-wire data only and data with alternate voice service are also provided.

1.04 A choice of six codes for the DAS 829-type CIU provides proper termination of channels having various loop facilities.

- DAS 829A-L1 or L1A for short loops.
- DAS 829B-L1 or L1A for longer nonloaded loops.
- DAS 829C-L1 or L1A for longer loaded loops.

1.05 A choice of seven data units combined with a DAS 829-type CIU provides the following features:

- 48A1 data unit for 4-wire or 2-wire alternate voice service.
- 48B1 data unit for 4-wire dial backup service with manual dialing.
- 48C1 data unit (switching matrix) for switching any one of four 4-wire modems to either one of two 4-wire dial backup channels.
- 48D1 data unit (interface adapter) for use with a 46C-type and/or 46B1 data mounting to concentrate control leads in an 18- or 30-button CALL DIRECTOR® key telephone set.
- 48ER1 data unit for 4-wire dial backup service with manual or automatic dialing. This data unit complies with all requirements of the FCC Registration Program. The registration number for the 48ER1 data unit is AS593M-67751-PC-E. The ringer equivalence number for each line is 0.5A.
- 48FR1 data unit for 4-wire dial backup service with automatic answering. This data unit complies with all requirements of the FCC Registration Program. The registration number for the 48FR1 data unit is AS593M-67757-PC-E. The ringer equivalence number for each line is 0.5A.
- 48G1 data unit for 2-wire to 4-wire conversion.

1.06 A choice of seven data mountings house single or multiple arrangements of DAS 829-type CIUs and/or 48-type data units without any change in wiring.

- 44A1 or 44A2 data mounting houses one DAS 829-type CIU.
- 45A1 data mounting houses one DAS 829-type CIU or one DAS 829-type CIU with the following data units: one 48A1 or 48B1, or one 48A1 and one 48B1.
- 46A1 or 46A2 data mounting houses up to eight DAS 829-type CIUs.
- 46B1 data mounting houses up to eight 48A1 or 48G1 data units.
- 46C1 data mounting houses one or two 48B1 data units and up to six 48C1 data units.
- 46C2 data mounting houses one or two 48B1 or 48ER1 data units and up to six 48C1 data units.
- 59A1 data mounting houses one DAS 829-type CIU or one DAS 829-type CIU with the following data units: one 48A1, 48B1, 48ER1, 48FR1, or 48G1; or one 48A1 and one 48B1, 48ER1, or 48G1.
- 62A1 data mounting houses one DAS 829-type CIU or one DAS 829-type CIU and one 48G1 data unit.

1.07 The 44A-type, 45A1, 59A1, and 62A1 data mountings can be mounted on a desk, shelf, or wall. The 46A-type, 46B1, and 46C-type data mountings and the 48D1 data unit can be mounted on 19- or 23-inch relay racks. Mounting in KS-20018-type cabinets is recommended. Descriptive information on KS-20018-type cabinets is provided in Section 590-010-201. The DAS 829-type CIUs and the 48A1, 48B1, 48C1, 48ER1, 48FR1, and 48G1 data units consist of plug-in circuit packs that are housed in the appropriate data mountings.

2. INSTALLATION

2.01 No special tools are required to install the data mountings and data units.

2.02 The data mountings and data units are to be installed in accordance with the general instructions provided in Section 590-010-200.

A. 44A-Type, 45A1, 59A1, and 62A1 Data Mountings

2.03 The 44A-type, 45A1, 59A1, or 62A1 data mounting can be used as a free standing unit on a desk or shelf or it can be wall-mounted as described in paragraph 2.04. If the 44A-type, 45A1, 59A1, or 62A1 data mounting is used as a free-standing unit, omit (1) through (3) of paragraph 2.04.

2.04 The 44A-type, 45A1, 59A1, or 62A1 data mounting is wall-mounted by using a 193A backboard (Fig. 1) as follows:

(1) Install four No. 6 binding-head studs (supplied with the backboard) into the threaded holes in the data mounting.

(2) Install the backboard in the desired location by using four wood screws in the outer flanges.

Note: The backboard should be installed with the elevated tab pointing downward.

(3) Install the data mounting on the backboard by placing the binding-head studs in the slotted holes in the backboard and sliding the data mounting into position.

(4) Install the required plug-in option straps on the required circuit pack or packs, as specified on the service order.

(5) Install the wall-mounted transformer that is supplied with the data mounting. This transformer is a KS-21239-L1 or L4 for the 44A-type or 62A1 data mounting and a KS-21362-L1 for the 45A1 or 59A1 data mounting. The customer must provide a standard 3-wire, grounded 105 to 129V at 57 to 63 Hz, power receptacle that is easily accessible to the data mounting. The receptacle must not be under control of a switch.

Caution: If the receptacle has a metal cover, do not remove the center screw to mount the transformer. When this screw is removed, the metal cover can fall across the prongs of the transformer.

(6) Make all connections to the data mounting as shown on the appropriate connection diagrams, including connection of the 6-foot power cord (840807028, supplied with the data mounting) to the wall-mounted transformer. Dress of the cable connections is shown in Fig. 2 for the 44A1 data mounting, Fig. 3 for the 44A2 data mounting, Fig. 4 for the 45A1 data mounting, Fig. 5 for the 59A1 data mounting, and Fig. 6 for the 62A1 data mounting.

(7) Install the circuit pack or packs in the data mounting. Installation of the circuit packs is shown in Fig. 7 for the 45A1 data mounting, Fig. 8 and 9 for the 59A1 data mounting, and Fig. 10 for the 62A1 data mounting.

(8) Apply 117-Vac power to the data mounting and perform the installation tests, as specified in paragraphs 5.01 through 5.03.

B. 46A-Type and 46B1 Data Mountings

2.05 The 46A-type or 46B1 data mounting is rack-mounted as follows:

(1) Assemble and set up relay rack and mounting bars.

(2) Install the data mounting on the mounting bars.

(3) Make all connections to the data mounting as shown on the appropriate connection diagrams.

(4) Install the required plug-in option straps on the required circuit packs, as specified on the service order.

(5) Install the circuit packs in the data mounting.

(6) Plug the 4-foot power cord (840339907, supplied with the data mounting) into connector P2 on the rear of the data mounting.

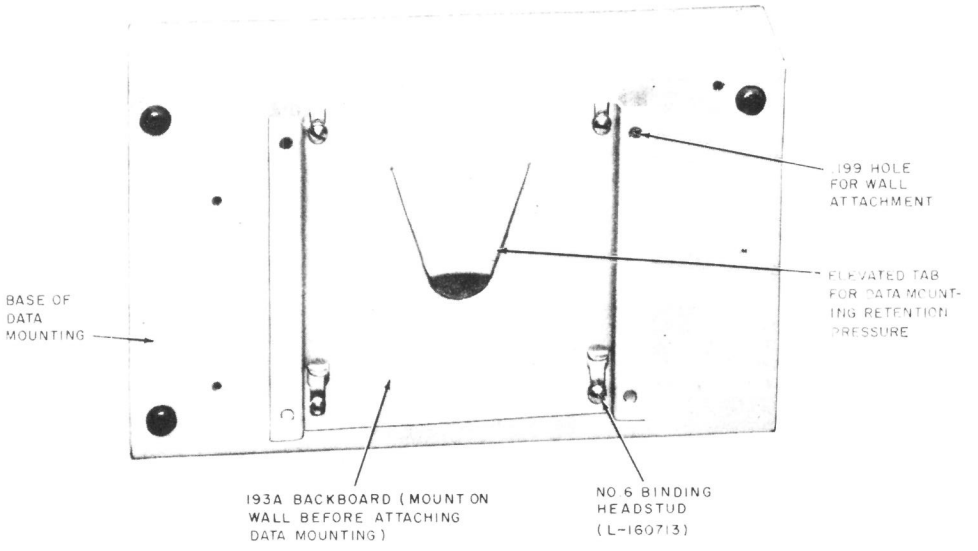


Fig. 1—44A-Type, 45A1, 59A1, or 62A1 Data Mounting Installed on 193A Backboard

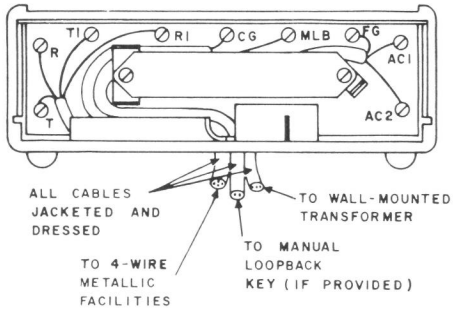


Fig. 2—44A1 Data Mounting Showing Dress of Cable Connections

(7) Apply 117-Vac power to the data mounting and perform the installation tests, as specified in paragraphs 5.01 through 5.03.

C. 46C-Type Data Mounting and 48D1 Data Unit

2.06 The 46C-type data mounting and 48D1 data unit are rack-mounted as follows:

(1) Assemble and set up relay rack and mounting bars.

(2) Install the 46C-type data mounting and 48D1 data unit on the mounting bars.

Note: The 48D1 data unit mounts directly under the 46C-type data mounting.

(3) Make all connections to the data mounting and data unit as shown on the appropriate connection diagrams.

(4) Install the required plug-in option straps on the required circuit packs, as specified on the service order.

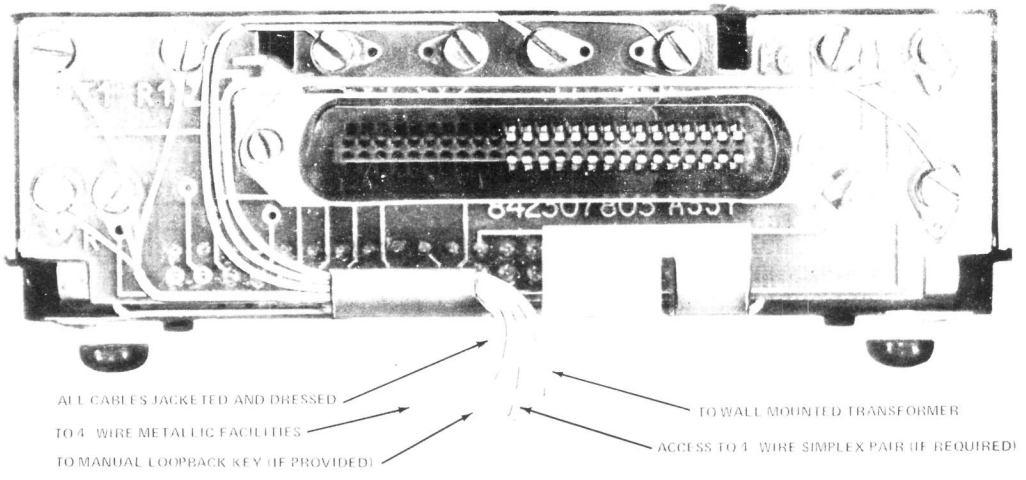


Fig. 3—44A2 Data Mounting Showing Dress of Cable Connections

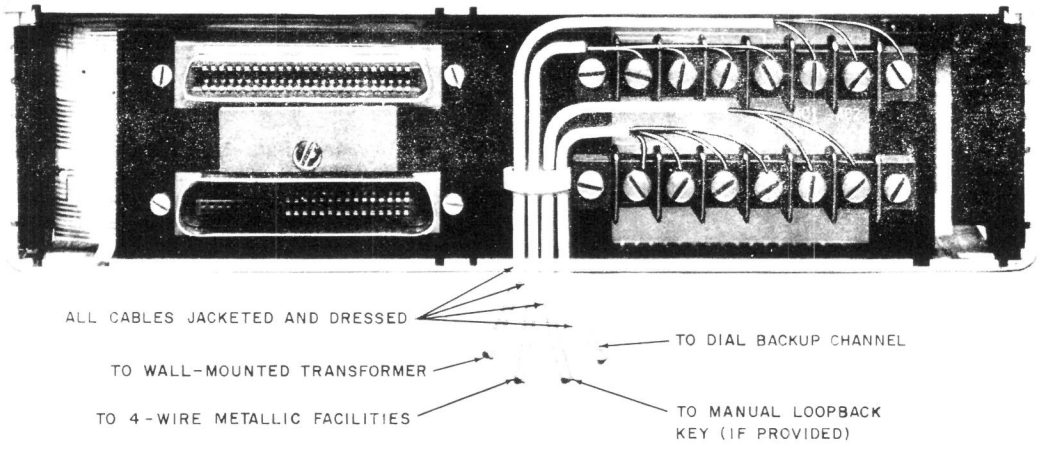


Fig. 4—45A1 Data Mounting Showing Dress of Cable Connections

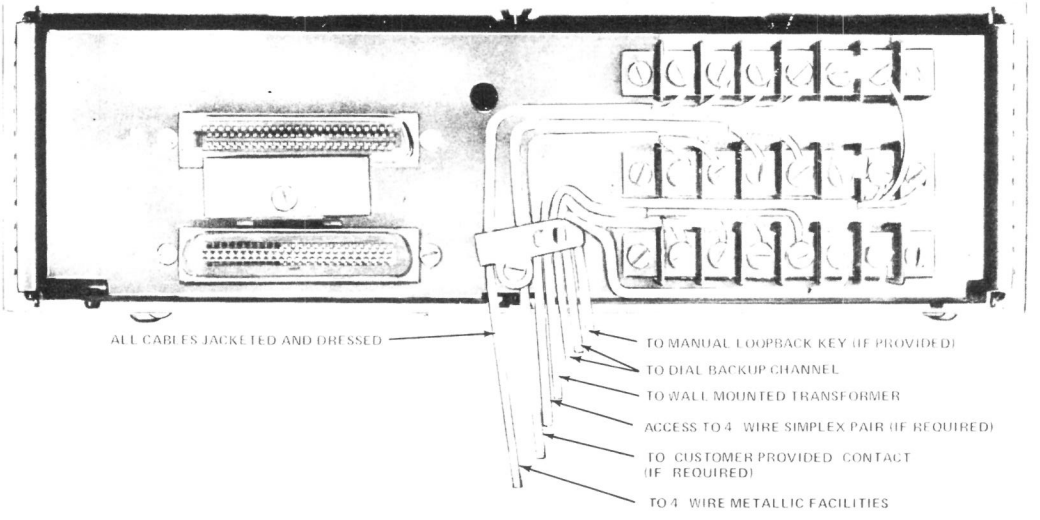


Fig. 5—59A1 Data Mounting Showing Dress of Cable Connections

(5) Install the circuit packs in the 46C-type data mounting.

(6) Perform the required wiring changes and connect the key telephone set to connectors J1 through J3 (for 18-button set) or J1 through J5 (for 30-button set) on the rear of the 48D1 data unit.

(7) Plug the 4-foot power cord (840339907, supplied with the 48D1 data unit) into connector P13 on the rear of the 48D1 data unit.

(8) Apply 117-Vac power to the 48D1 data unit and perform the installation tests, as specified in paragraphs 5.01 through 5.03.

3. CONNECTIONS

A. 44A-Type, 45A1, 59A1, and 62A1 Data Mountings

3.01 Connections for the various types of service using 44A-type, 45A1, 59A1, and 62A1 data mountings are shown in Fig. 11 through 27. The figure numbers and titles of these connection drawings are listed as follows:

Fig. 11—44A-Type Data Mounting—4-Wire Data Only Service

Fig. 12—45A1 Data Mounting—4-Wire Data With Alternate Voice Service

Fig. 13—45A1 Data Mounting—4-Wire Data With 4-Wire Dial Backup Service (Manual Dialing)

Fig. 14—45A1 Data Mounting—4-Wire Data With Alternate Voice and 4-Wire Dial Backup Service (Manual Dialing)

Fig. 15—59A1 Data Mounting—4-Wire Data With Alternate Voice Service

Fig. 16—59A1 Data Mounting—2-Wire Data With Alternate Voice Service

Fig. 17—59A1 Data Mounting—4-Wire Data With 4-Wire Dial Backup Service (Manual Dialing)

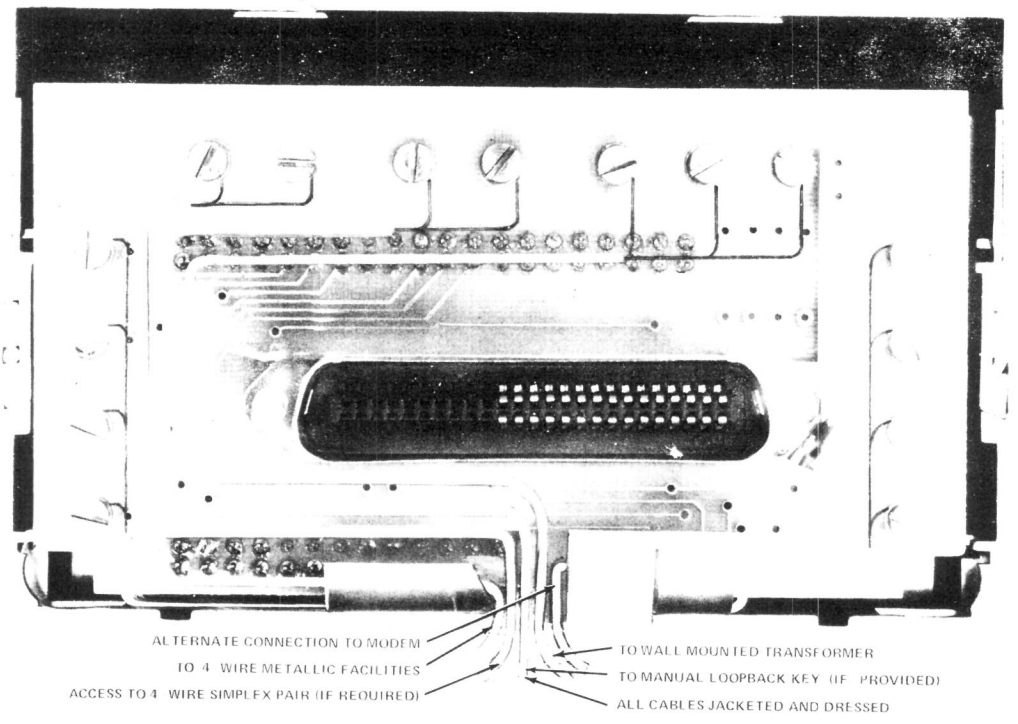


Fig. 6—62A1 Data Mounting Showing Dress of Cable Connections

Fig. 18—59A1 Data Mounting—4-Wire Data With Alternate Voice and 4-Wire Dial Backup Service (Manual Dialing)

Fig. 19—59A1 Data Mounting—4-Wire Data With 4-Wire Dial Backup Service (Automatic Dialing)

Fig. 20—59A1 Data Mounting—4-Wire Data With 4-Wire Dial Backup Service (Automatic Answering)

Fig. 21—59A1 Data Mounting—Connections to 43A or 53A Station Dial

Fig. 22—59A1 Data Mounting—Connections to DAS 801CR-L1/2 ACU

Fig. 23—62A1 Data Mounting—2-Wire Data Only Service

Fig. 24—44A-Type, 45A1, 59A1, or 62A1 Data Mounting—Multiple Arrangement

Fig. 25—Customer-Provided Modem—4-Wire Data Service (With or Without Alternate Voice Service)

Fig. 26—Customer-Provided Modem—2-Wire Data Service (With or Without Alternate Voice Service)

Fig. 27—Customer-Provided Modem—4-Wire Data With 4-Wire Dial Backup Service (With or Without Alternate Voice Service)

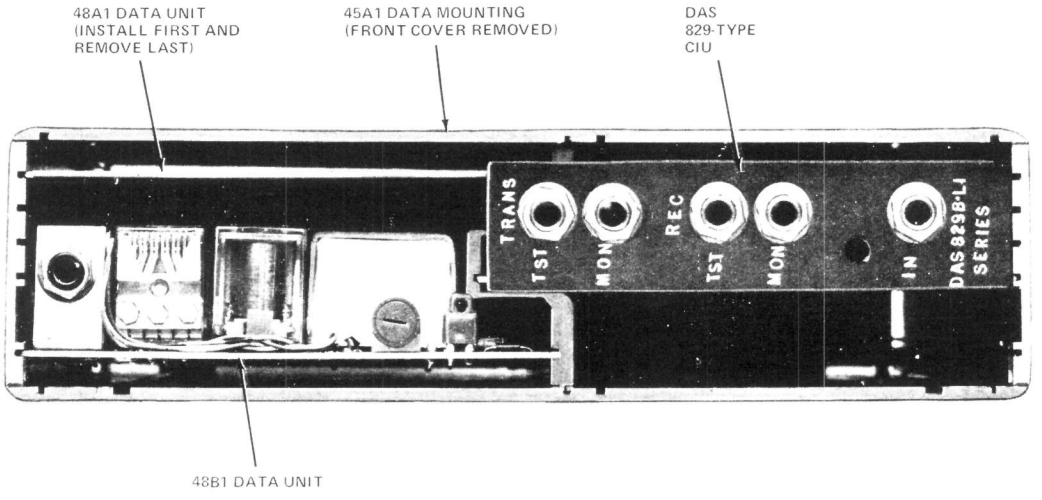


Fig. 7—45A1 Data Mounting Equipped With a DAS 829-Type CIU, a 48A1 Data Unit, and a 48B1 Data Unit

B. 46A-Type and 46B1 Data Mountings

3.02 Connections for the various types of service using 46A-type and 46B1 data mountings are shown in Fig. 28 through 38. The figure numbers and titles of these connection drawings are listed as follows:

Fig. 28—46A-Type Data Mounting—4-Wire Data Only Service

Fig. 29—46A-Type and 46B1 Data Mountings—2-Wire Data Only Service

Fig. 30—46A-Type and 46B1 Data Mountings—4-Wire Data With Alternate Voice Service

Fig. 31—46A-Type and 46B1 Data Mountings—2-Wire Data With Alternate Voice Service

Fig. 32—46A-Type Data Mounting—Connections to 4-Wire Metallic Facilities

Fig. 33—Data Set 202T—4-Wire Multiple Arrangement

Fig. 34—Data Set 202T—2-Wire Multiple Arrangement

Fig. 35—Data Set 201C, 202D, 202T, 208A, or 209A—4-Wire Multiple Arrangement

Fig. 36—Data Set 201C or 202T—2-Wire Multiple Arrangement

Fig. 37—Customer-Provided Modem—Multiple Arrangement Using KS-21253-L1 Adapter

Fig. 38—Customer-Provided Modem—Multiple Arrangement Using 66E-Type Connecting Block

C. 46C-Type Data Mounting and 48D1 Data Unit

3.03 The 46C-type data mounting and the 48D1 data unit provide the interconnection facilities for a variety of multiple arrangements, as described in paragraphs 3.07 through 3.25.

Note: The 48D1 data unit must be used with the 46C-type data mounting.

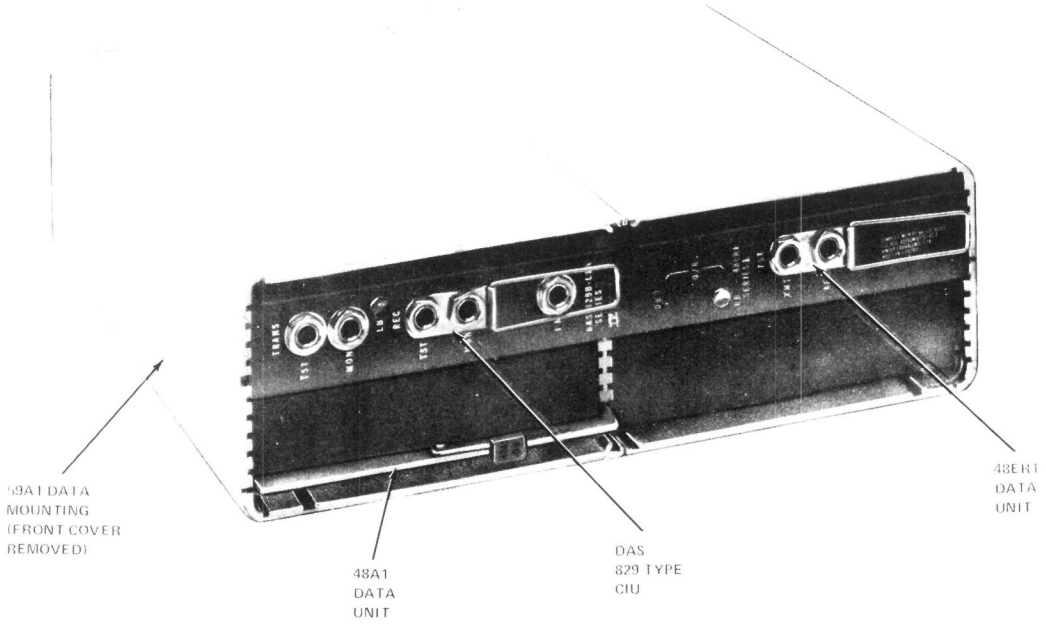


Fig. 8—59A1 Data Mounting Equipped With a DAS 829-Type CIU, a 48A1 Data Unit, and a 48ER1 Data Unit

3.04 The 46C1 data mounting (Fig. 39) houses one or two 48B1 data units and up to six 48C1 data units. The 46C2 data mounting (Fig. 40) houses one or two 48B1 or 48ER1 data units and up to six 48C1 data units. The 46C1 and 46C2 data mountings are the same except a protective cover has been added at the front of the 46C2 data mounting. A cable and connector J1 attached to each 48C1 data unit permits direct connection to connectors P4 through P9 on the 48D1 data unit.

> ***Note:*** The 46C1 data mounting and the 48B1 data unit must not be used in registered arrangements.

3.05 The backplane of the 46C-type data mounting (Fig. 41) contains eight 50-pin connectors and eight screw terminals. Connector P1 permits direct connection to connector J6 on the 48D1 data unit. Connectors P2 through P4 permit connection to a maximum of twenty-three modems. To provide 4-wire data with switched 4-wire dial backup service, connectors J10 through J12 permit connection to up to three 46A-type data mountings containing a maximum of twenty-three DAS 829-type CIUs. To provide 4-wire data with alternate voice and switched 4-wire dial backup service, connectors J10 through J12 permit connection to up to three 46B1 data mountings containing a maximum of twenty-three 48A1 data units. Connector J1 or the eight screw terminals permit connection to one or two dial backup channels consisting of two 2-wire switched network lines per channel.

> ***Note:*** Connector J1 must not be used in registered arrangements.

3.06 The backplane of the 48D1 data unit (Fig. 41) contains twelve 50-pin connectors. Connectors P1 through P3 permit connection to up to three 46B1 data mountings containing a maximum of twenty-three 48A1 data units. Connectors P11 and P12 permit concentrated connection to a

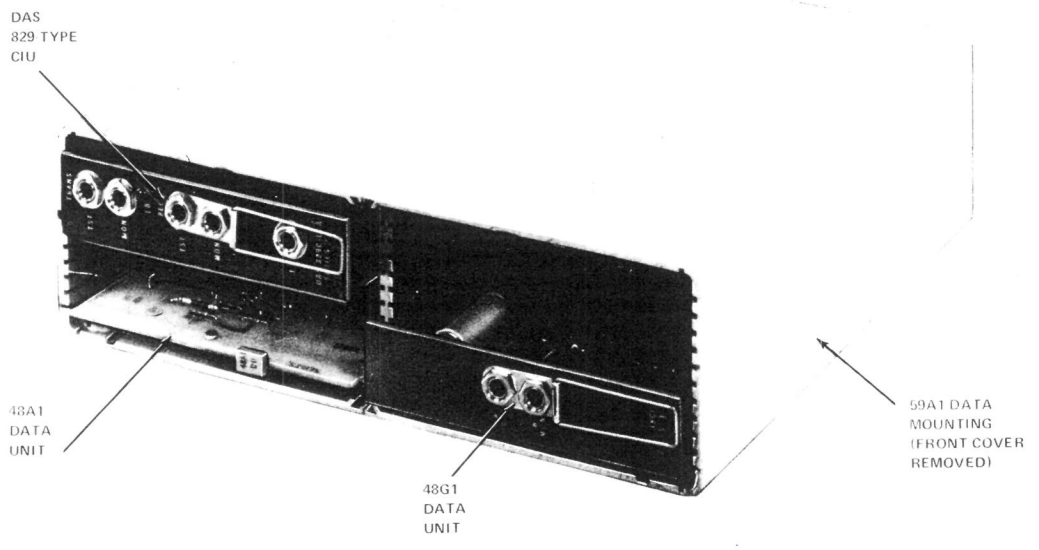


Fig. 9—59A1 Data Mounting Equipped With a DAS 829-Type CIU, a 48A1 Data Unit, and a 48G1 Data Unit

maximum of twenty-three modems to provide dial backup status to modems requiring this information. Connector P10 is provided for future use. Power cord connector P13 is located on the rear of the 48D1 data unit adjacent to the backplane. Connector J6 permits direct connection to connector P1 on the 46C-type data mounting. Connectors J1 through J3 permit connection to an 18-button CALL DIRECTOR key telephone set. Connectors J1 through J5 permit connection to a 30-button CALL DIRECTOR key telephone set. The 18- or 30-button CALL DIRECTOR key strip should be labeled as shown in Table A.

D. Multiple Arrangements

3.07 The DAS 829-type CIU and the 48A1, 48B1, 48C1, and 48ER1 data units are used with the 46C-type data mounting and the 48D1 data unit to provide a variety of multiple 4-wire data only (FD) and/or 4-wire data with alternate voice (FDA) arrangements with or without switched 4-wire dial backup service. Connections for these types of multiple arrangements are shown in Fig. 33, 35, 37, 38, and 42 through 47. The figure numbers and titles of these connection drawings are listed as follows:

Fig. 33—Data Set 202T—4-Wire Multiple Arrangement

Fig. 35—Data Set 201C, 202D, 202T, 208A, or 209A—4-Wire Multiple Arrangement

Fig. 37—Customer-Provided Modem—Multiple Arrangement Using KS-21253-L1 Adapter

Fig. 38—Customer-Provided Modem—Multiple Arrangement Using 66E-Type Connecting Block

Fig. 42—Multiple 4-Wire FD or FDA Arrangement With Switched 4-Wire Dial Backup Service for 11 Modems or Less

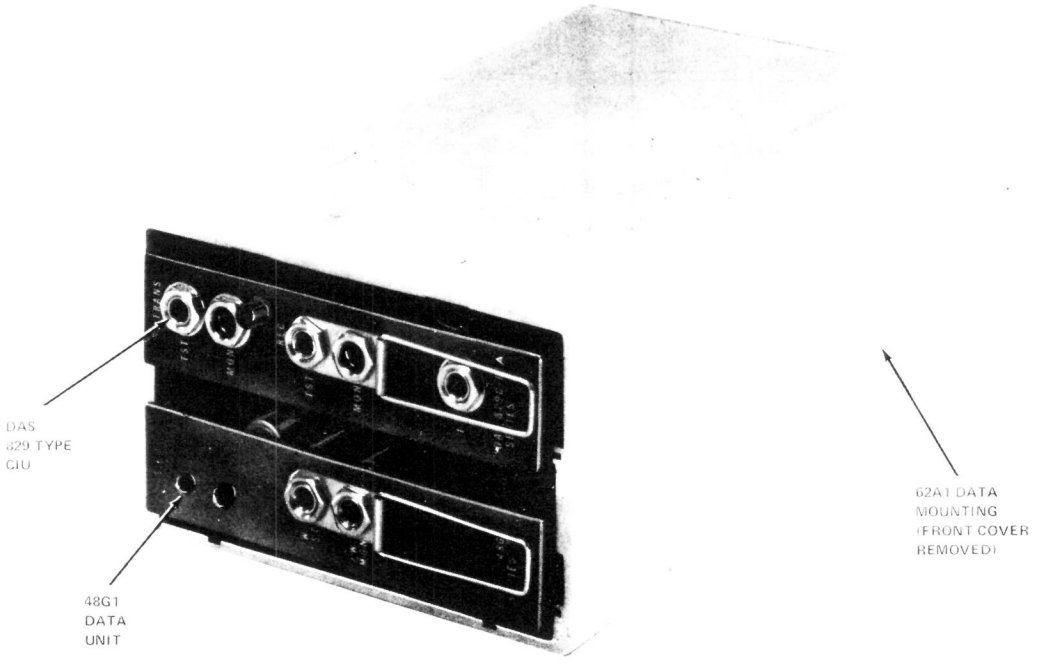


Fig. 10—62A1 Data Mounting Equipped With a DAS 829-Type CIU and a 48G1 Data Unit

Fig. 43—Multiple 4-Wire FD or FDA Arrangement With Switched 4-Wire Dial Backup Service for 23 Modems or Less

Fig. 44—Multiple 4-Wire FD and FDA Arrangements With and Without Switched 4-Wire Dial Backup Service

Fig. 45—46C-Type Data Mounting—Connections to DDD Lines

Fig. 46—Multiple Arrangement Showing Cable Length Restrictions

Fig. 47—Multiple Arrangement Using KS-21253-L4 Adapter for Dial Backup Status to Modems

If none of the FD and FDA arrangements require switched dial backup service, the arrangements should be connected as given in paragraph 3.02.

Design Rules

3.08 The following design rules should be used to determine the equipment required to provide a given multiple arrangement.

(1) Determine the number of FD and/or FDA arrangements to be provided with switched dial backup service. When the number of arrangements is 11, or less, an 18-button CALL DIRECTOR key telephone set is used to control the service. When the number of arrangements is 23, or less, a 30-button CALL DIRECTOR key telephone set is used to control the service. When the number of arrangements is greater than 23, more than one CALL DIRECTOR is required; for example, 46 FDA arrangements with switched dial backup service require two separate CALL DIRECTOR arrangements.

(2) Determine the number of FDA arrangements to be provided without switched dial backup

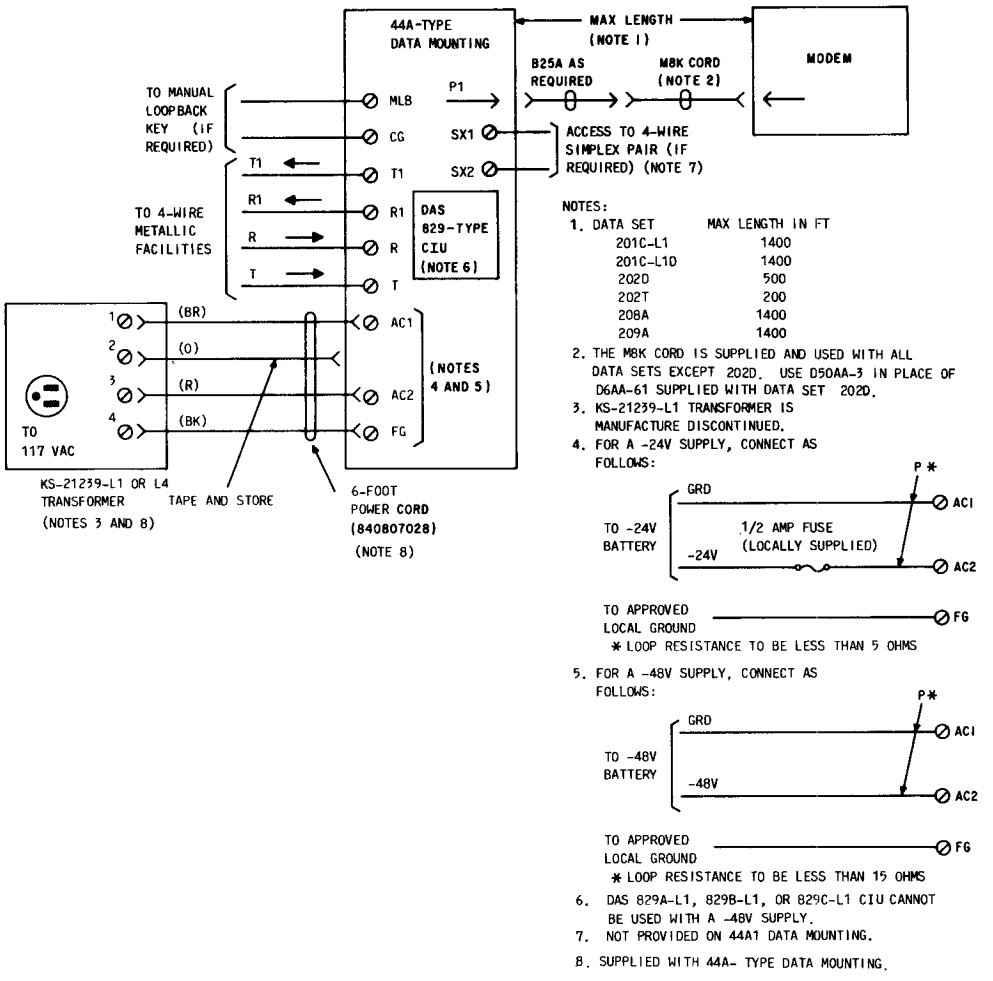
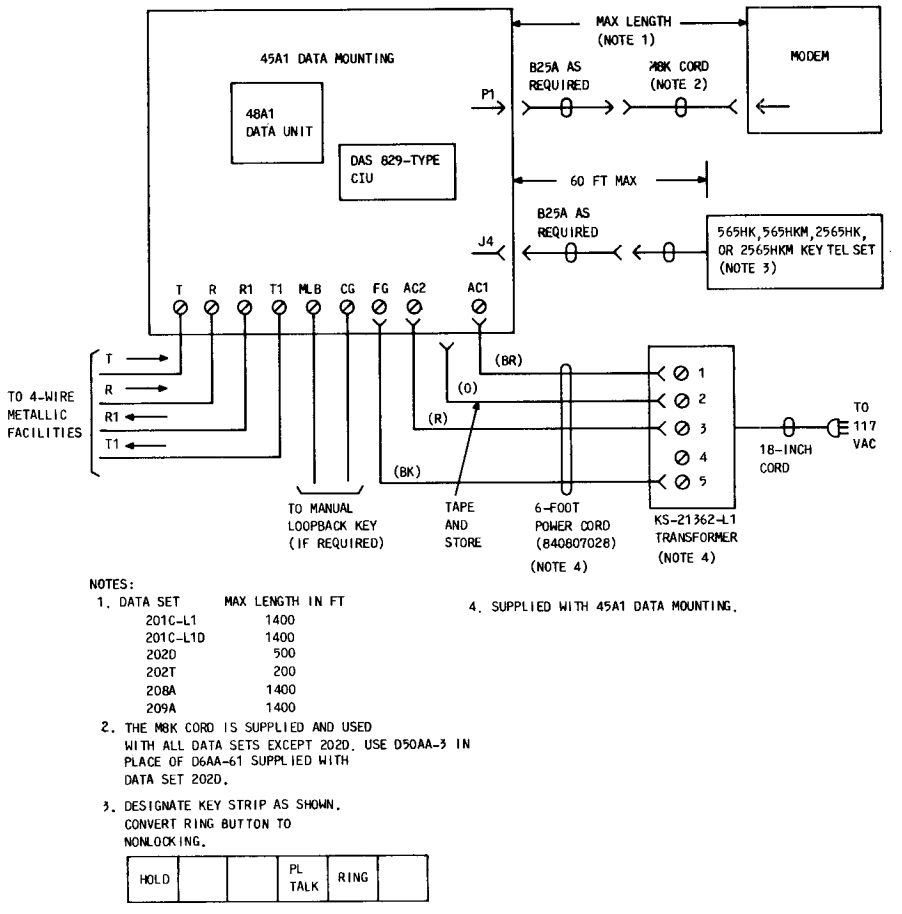


Fig. 11—44A-Type Data Mounting—4-Wire Data Only Service

service. When possible, concentrate the control for the FDA arrangements in the CALL DIRECTOR used to control the switched dial backup service. Table B provides guidelines for using a 30-button CALL DIRECTOR to control FDA arrangements with and without switched dial backup service. When control of the FDA arrangements cannot be concentrated in the CALL DIRECTOR, or when no switched dial backup service is provided, the FDA arrangements should be connected as given in paragraph 3.02.

(3) Determine the number of FD arrangements to be provided without switched dial backup service. These arrangements do not require CALL DIRECTOR control and normally are connected as given in paragraph 3.02. However, when FDA arrangements are provided without switched dial backup service, there may be connections available for FD arrangements. For example, if 12 FDA arrangements are required, the multiple arrangement (two pairs of properly interconnected 46A-type and 46B1 data mountings)



NOTES:

1. DATA SET — MAX LENGTH IN FT

201C-L1	1400
201C-L1D	1400
202D	500
202T	200
208A	1400
209A	1400

2. THE M8K CORD IS SUPPLIED AND USED WITH ALL DATA SETS EXCEPT 202D. USE D50AA-3 IN PLACE OF D6AA-61 SUPPLIED WITH DATA SET 202D.

3. DESIGNATE KEY STRIP AS SHOWN. CONVERT RING BUTTON TO NONLOCKING.

HOLD			PL TALK	RING	

4. SUPPLIED WITH 45A1 DATA MOUNTING.

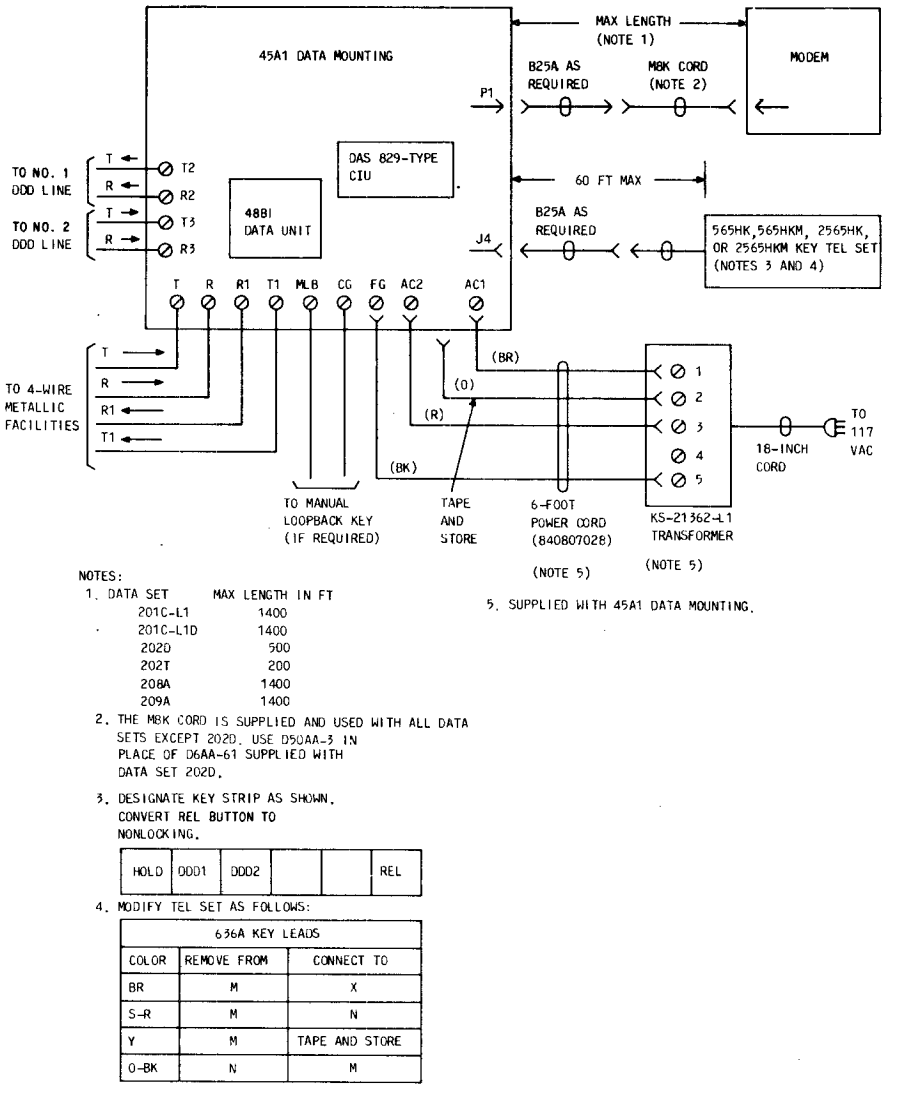
Fig. 12—45A1 Data Mounting—4-Wire Data With Alternate Voice Service

provides for 16 FDA arrangements. The four connections not used for FDA arrangements can be used for FD arrangements.

3.09 Two multiple arrangements are used to explain the above design rules. The examples chosen illustrate the interconnections required between the 48C1 and 48D1 data units and the 46-type data mountings.

First Example—23 FDA Arrangements With Switched Dial Backup Service

3.10 The first example (Fig. 43) is a multiple arrangement consisting of 23 FDA arrangements with switched dial backup service to either one of two dial backup channels. Design rule No. 1 indicates that one 30-button CALL DIRECTOR can be used to control the multiple arrangement. Therefore, for this example, the 631DAM or the



NOTES:

1. DATA SET — MAX LENGTH IN FT

DATA SET	MAX LENGTH IN FT
201C-L1	1400
201C-L1D	1400
202D	500
202T	200
208A	1400
209A	1400

2. THE M8K CORD IS SUPPLIED AND USED WITH ALL DATA SETS EXCEPT 202D. USE D50AA-3 IN PLACE OF D6AA-61 SUPPLIED WITH DATA SET 202D.

3. DESIGNATE KEY STRIP AS SHOWN. CONVERT REL BUTTON TO NONLOCKING.

HOLD	DDD1	DDD2			REL

4. MODIFY TEL SET AS FOLLOWS:

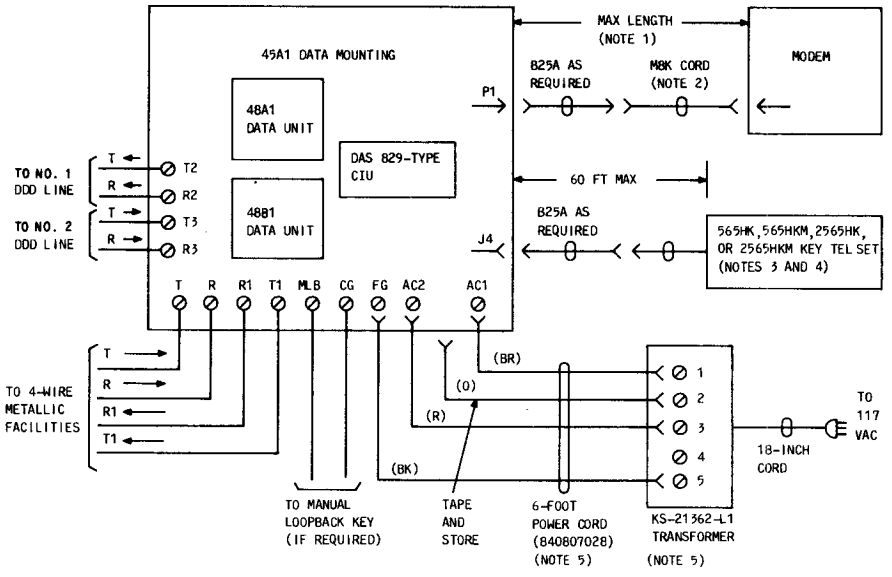
636A KEY LEADS		
COLOR	REMOVE FROM	CONNECT TO
BR	M	X
S-R	M	N
Y	M	TAPE AND STORE
O-BK	N	M

5. SUPPLIED WITH 45A1 DATA MOUNTING.

Fig. 13—45A1 Data Mounting—4-Wire Data With 4-Wire Dial Backup Service (Manual Dialing)

2631DAM 30-button CALL DIRECTOR key telephone set, with the wiring modifications given in Fig. 43, is used to control the multiple arrangement. The CALL DIRECTOR is connected to connectors J1 through J5 of the 48D1 data unit. Design rules No. 2 and 3 do not apply to this example.

3.11 The 23 FDA arrangements are provided by interconnecting 3 pairs of 46A-type and 46B1 data mountings. The three 46A-type data mountings house the twenty-three DAS 829-type CIUs that terminate the 4-wire private lines. The three 46B1 data mountings house the twenty-three 48A1 data



NOTES:

1. DATA SET — MAX LENGTH IN FT

201C-L1	1400
201C-L1D	1400
202D	500
202T	200
208A	1400
209A	1400

2. THE M8K CORD IS SUPPLIED AND USED WITH ALL DATA SETS EXCEPT 202D. USE D50AA-3 IN PLACE OF D6AA-61 SUPPLIED WITH DATA SET 202D.

3. DESIGNATE KEY STRIP AS SHOWN. CONVERT RING AND REL BUTTONS TO NONLOCKING.

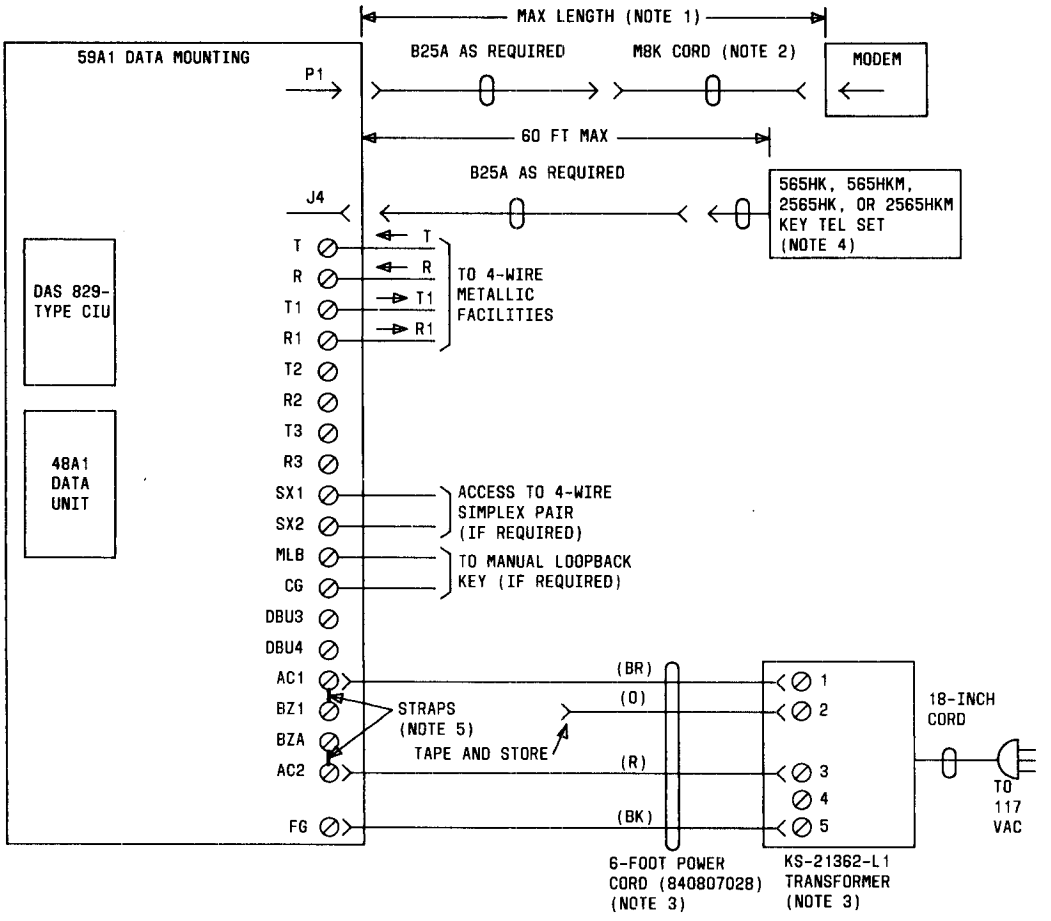
HOLD	DDD1	DDD2	PL TALK	RING	REL

4. MODIFY TEL SET AS FOLLOWS:

636A KEY LEADS		
COLOR	REMOVE FROM	CONNECT TO
BR	M	X
S-R	M	N
Y	M	TAPE AND STORE
O-BK	N	M

5. SUPPLIED WITH 45A1 DATA MOUNTING.

Fig. 14—45A1 Data Mounting—4-Wire Data With Alternate Voice and 4-Wire Dial Backup Service (Manual Dialing)



NOTES:

1. DATA SET MAX LENGTH IN FT

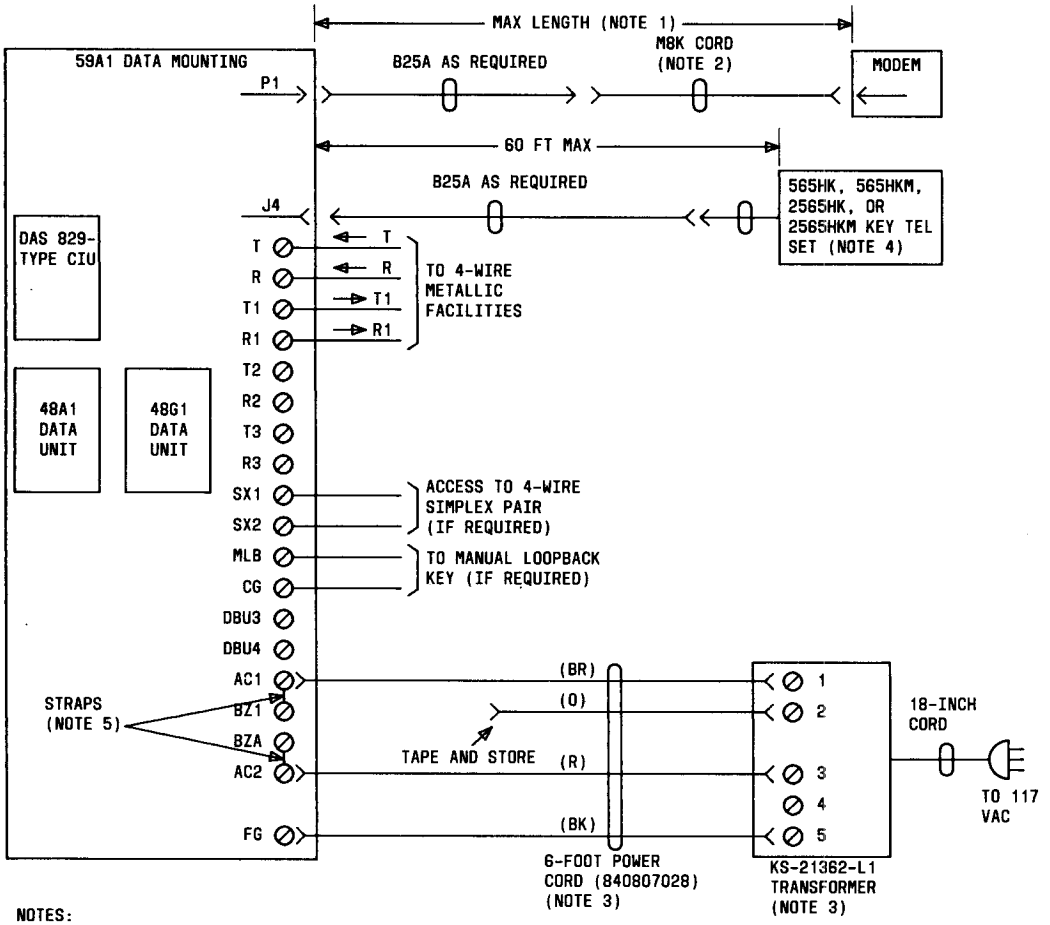
201C-L1	1400
201C-L1D	1400
202D	500
202T	200
208A	1400
209A	1400

2. THE M8K CORD IS SUPPLIED AND USED WITH ALL DATA SETS EXCEPT 202D. USE D50AA-3 IN PLACE OF D6AA-61 SUPPLIED WITH DATA SET 202D
3. SUPPLIED WITH 59A1 DATA MOUNTING
4. DESIGNATE KEY STRIP AS SHOWN. CONVERT RING BUTTON TO NONLOCKING

HOLD				PL TALK	RING	

5. STRAPS PROVIDED AS PART OF 59A1 DATA MOUNTING. DO NOT REMOVE STRAPS

Fig. 15—59A1 Data Mounting—4-Wire Data With Alternate Voice Service



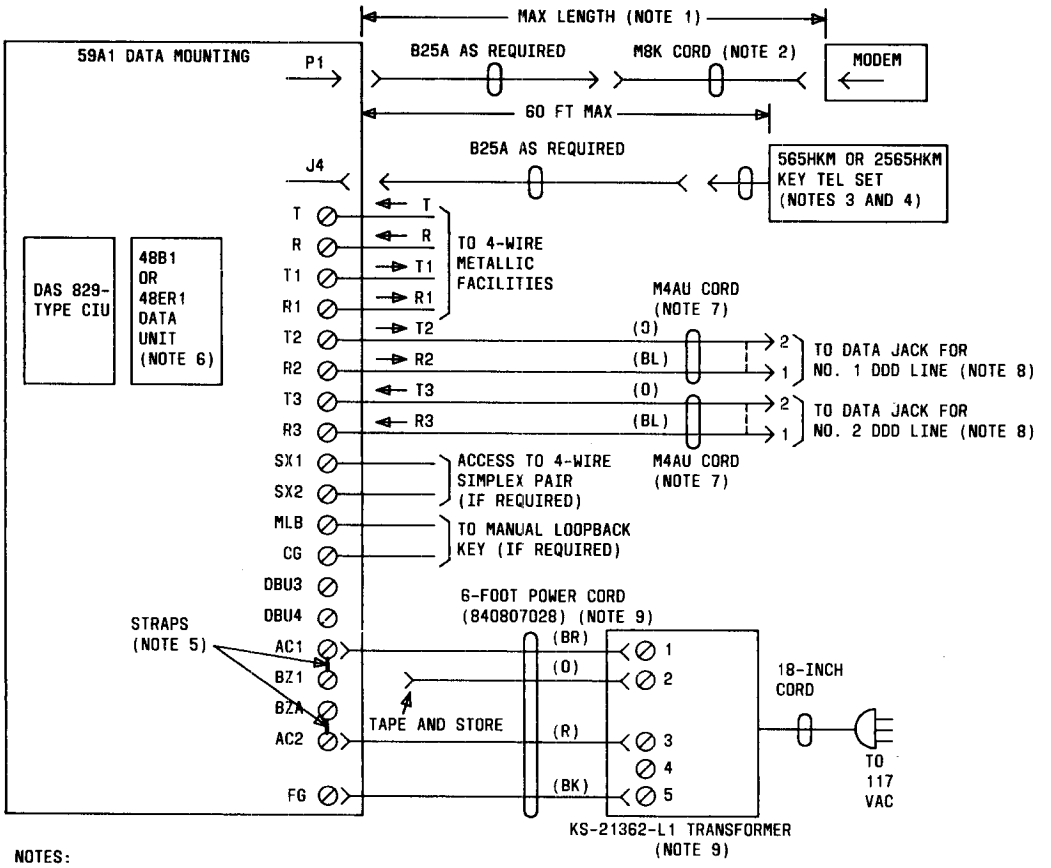
NOTES:

1. DATA SET — MAX LENGTH IN FT
   - 201C-L1 — 1400
   - 201C-L1D — 1400
   - 202T — 200
2. SUPPLIED WITH DATA SET
3. SUPPLIED WITH 59A1 DATA MOUNTING
4. DESIGNATE KEY STRIP AS SHOWN. CONVERT RING BUTTON TO NONLOCKING

HOLD			PL TALK	RING	

5. STRAPS PROVIDED AS PART OF 59A1 DATA MOUNTING. DO NOT REMOVE STRAPS

Fig. 16—59A1 Data Mounting—2-Wire Data With Alternate Voice Service



NOTES:

1. DATA SET MAX LENGTH IN FT
   - 201C-L1 1400
   - 201C-L1D 1400
   - 202D 500
   - 202T 200
   - 208A 1400
   - 209A 1400
2. THE M8K CORD IS SUPPLIED AND USED WITH ALL DATA SETS EXCEPT 202D. USE D50AA-3 IN PLACE OF D6AA-61 SUPPLIED WITH DATA SET 202D
3. DESIGNATE KEY STRIP AS SHOWN. CONVERT REL BUTTON TO NONLOCKING

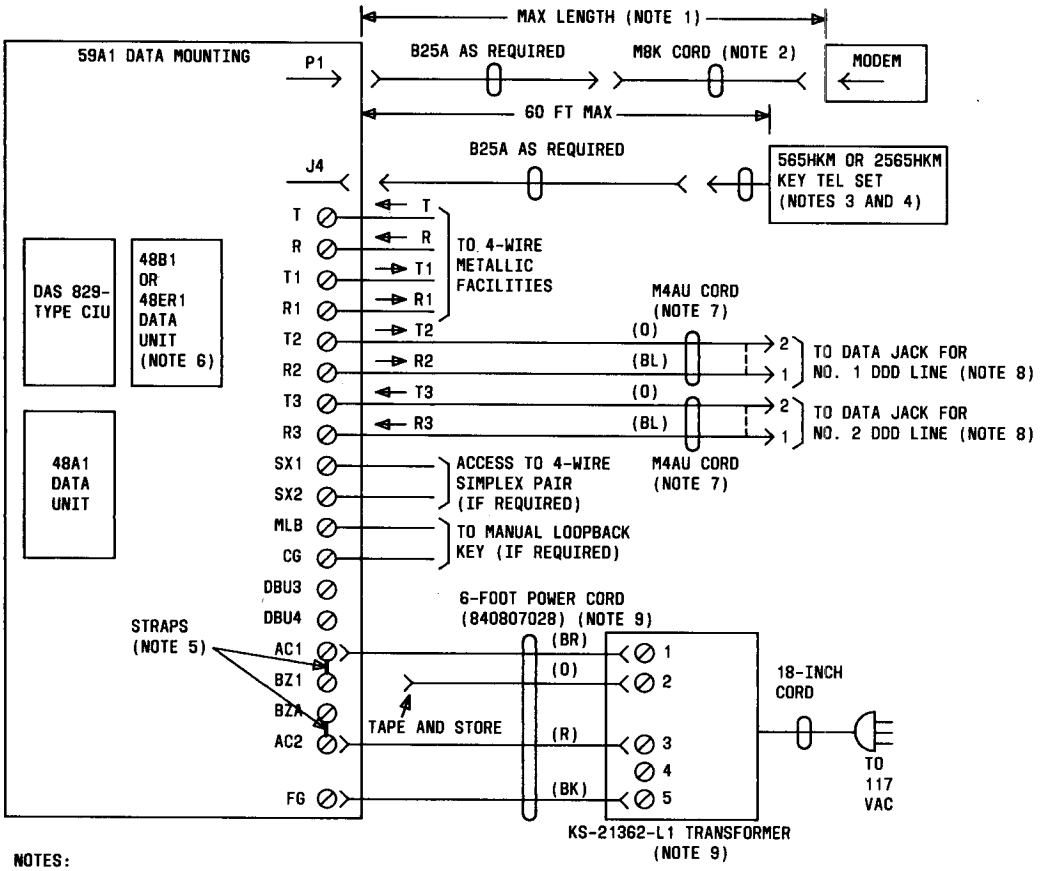
HOLD	DOD1	DOD2			REL

4. MODIFY TEL SET AS FOLLOWS:

636A KEY LEADS		
COLOR	REMOVE FROM	CONNECT TO
BR	M	X
S-R	M	N
Y	M	TAPE AND STORE
O-BK	N	M

5. STRAPS PROVIDED AS PART OF 59A1 DATA MOUNTING. DO NOT REMOVE STRAPS
6. THE 48B1 DATA UNIT CANNOT BE USED IN REGISTERED ARRANGEMENTS OR WHEN THE FAR END OF THE DIAL BACKUP CHANNEL IS EQUIPPED FOR UNATTENDED OPERATION
7. THE TWO M4AU CORDS MUST BE ORDERED SEPARATELY. TAPE AND STORE UNUSED LEADS
8. USE DATA JACK USOC RJ41S WITH SWITCH SET TO FLL. THE TWO DATA JACKS MUST BE ORDERED SEPARATELY
9. SUPPLIED WITH 59A1 DATA MOUNTING

Fig. 17—59A1 Data Mounting—4-Wire Data With 4-Wire Dial Backup Service (Manual Dialing)



NOTES:

1. DATA SET MAX LENGTH IN FT

201C-L1	1400
201C-L1D	1400
202D	500
202T	200
208A	1400
209A	1400

2. THE M8K CORD IS SUPPLIED AND USED WITH ALL DATA SETS EXCEPT 202D. USE D50AA-3 IN PLACE OF D6AA-61 SUPPLIED WITH DATA SET 202D
3. DESIGNATE KEY STRIP AS SHOWN. CONVERT RING AND REL BUTTONS TO NONLOCKING

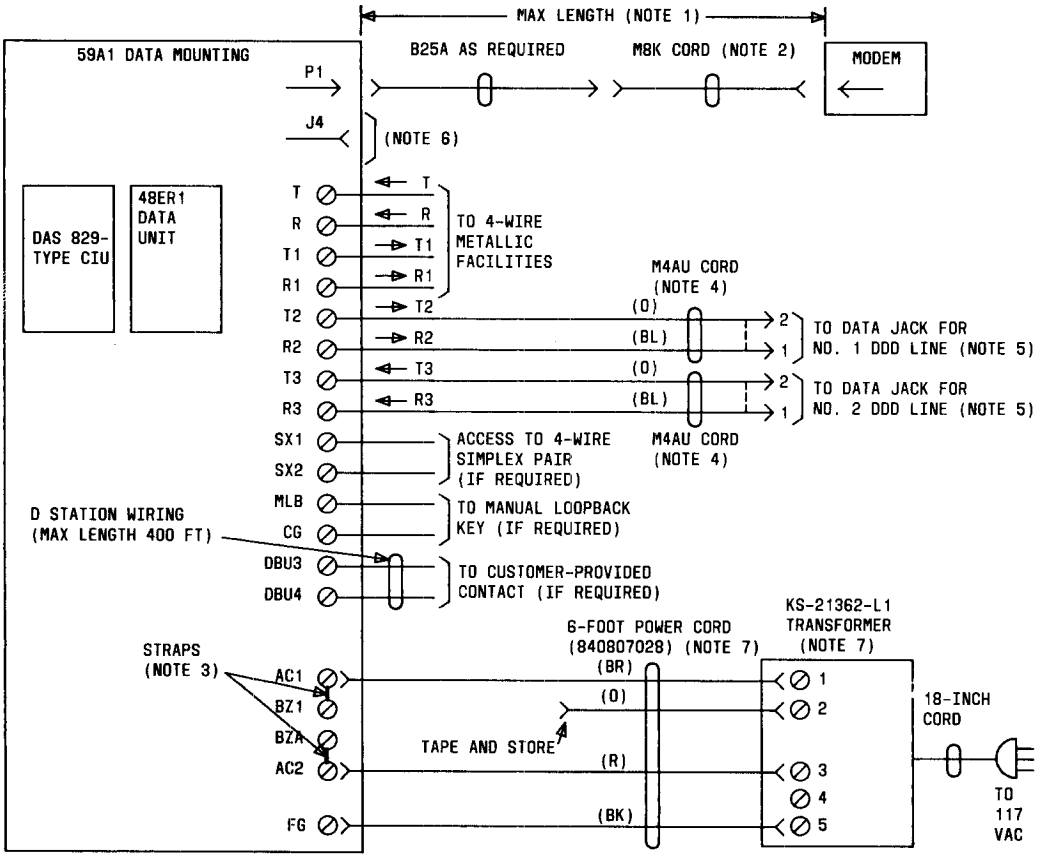
HOLD	DOD1	DOD2	PL TALK	RING	REL

4. MODIFY TEL SET AS FOLLOWS:

636A KEY LEADS		
COLOR	REMOVE FROM	CONNECT TO
BR	M	X
S-R	M	N
Y	M	TAPE AND STORE
O-BK	N	M

5. STRAPS PROVIDED AS PART OF 59A1 DATA MOUNTING. DO NOT REMOVE STRAPS
6. THE 48B1 DATA UNIT CANNOT BE USED IN REGISTERED ARRANGEMENTS OR WHEN THE FAR END OF THE DIAL BACKUP CHANNEL IS EQUIPPED FOR UNATTENDED OPERATION
7. THE TWO M4AU CORDS MUST BE ORDERED SEPARATELY. TAPE AND STORE UNUSED LEADS
8. USE DATA JACK USOC RJ41S WITH SWITCH SET TO FLL. THE TWO DATA JACKS MUST BE ORDERED SEPARATELY
9. SUPPLIED WITH 59A1 DATA MOUNTING

Fig. 18—59A1 Data Mounting—4-Wire Data With Alternate Voice and 4-Wire Dial Backup Service (Manual Dialing)



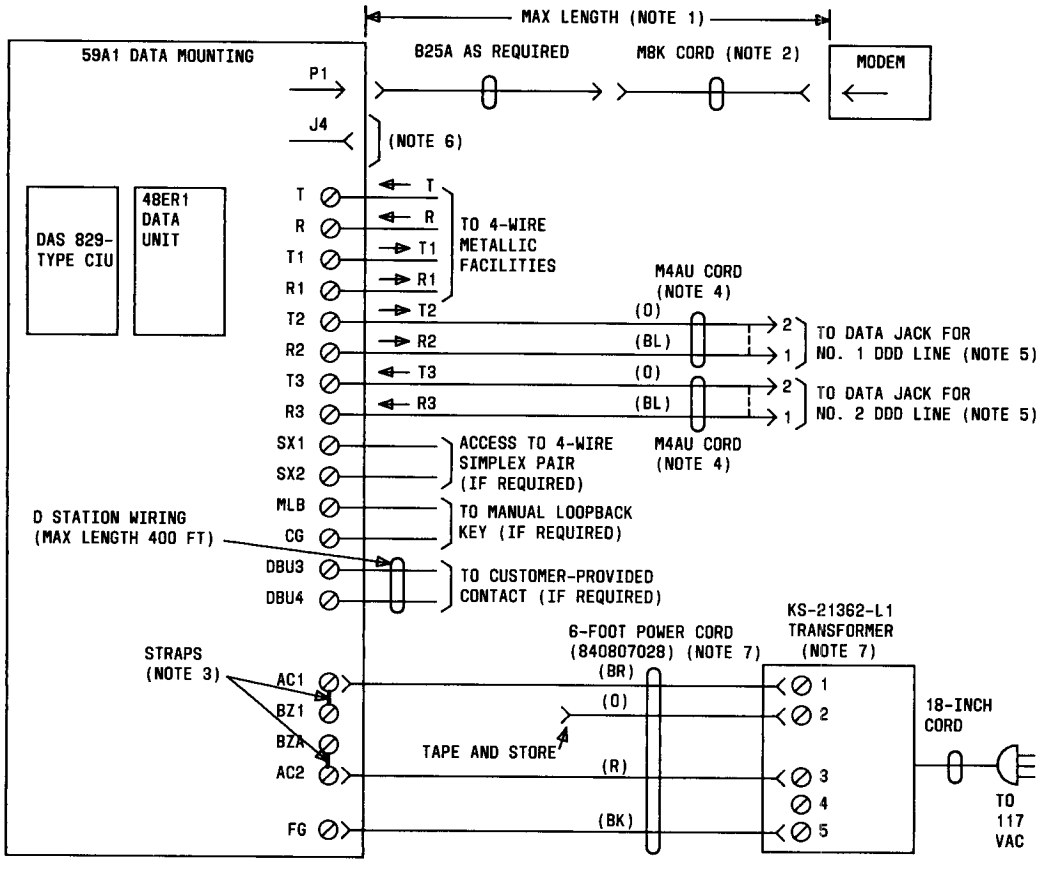
NOTES:

1. DATA SET — MAX LENGTH IN FT

201C-L1	1400
201C-L1D	1400
202D	500
202T	200
208A	1400
209A	1400

2. THE M8K CORD IS SUPPLIED AND USED WITH ALL DATA SETS EXCEPT 202D. USE D50AA-3 IN PLACE OF D6AA-61 SUPPLIED WITH DATA SET 202D
3. STRAPS PROVIDED AS PART OF 59A1 DATA MOUNTING. DO NOT REMOVE STRAPS
4. THE TWO M4AU CORDS MUST BE ORDERED SEPARATELY. TAPE AND STORE UNUSED LEADS
5. USE DATA JACK USOC RJ41S WITH SWITCH SET TO FLL. THE TWO DATA JACKS MUST BE ORDERED SEPARATELY
6. FOR AUTOMATIC DIALING, A SEPARATELY ORDERED 43A OR 53A STATION DIAL OR SEPARATELY ORDERED DAS 801/CR-L1/2 ACU IS CONNECTED TO J4 OF THE 59A1 DATA MOUNTING. IF A 43A OR 53A STATION DIAL IS USED, SEE FIG. 21 FOR CONNECTIONS. IF A DAS 801CR-L1/2 ACU IS USED, SEE FIG. 22 FOR CONNECTIONS
7. SUPPLIED WITH 59A1 DATA MOUNTING

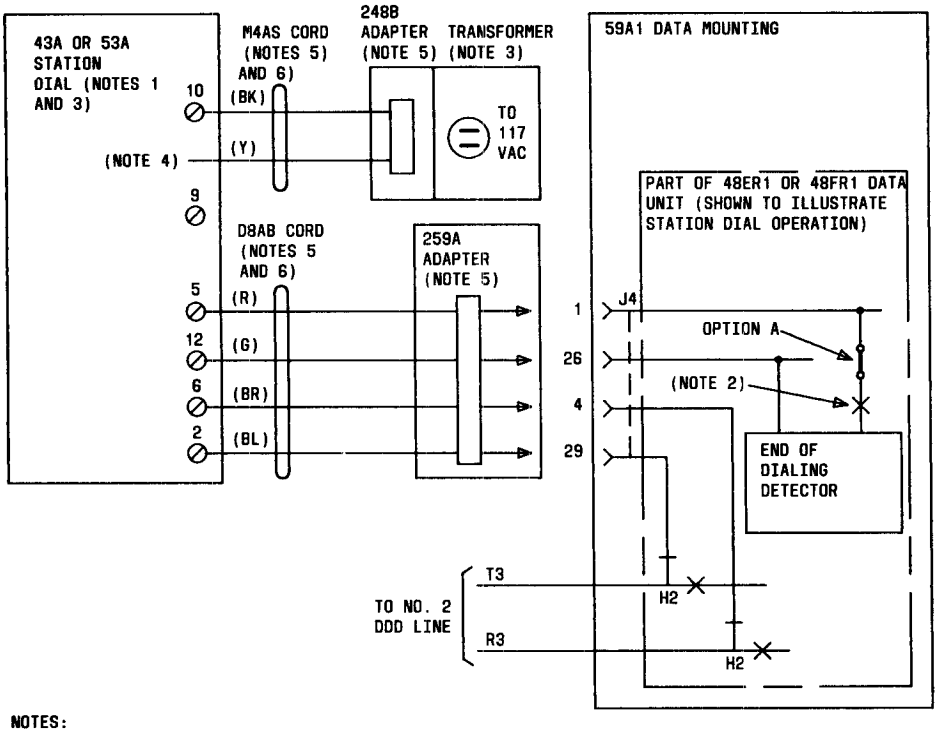
Fig. 19—59A1 Data Mounting—4-Wire Data With 4-Wire Dial Backup Service (Automatic Dialing)



NOTES:

1. DATA SET MAX LENGTH IN FT
   - 201C-L1 1400
   - 201C-L1D 1400
   - 202D 500
   - 202T 200
   - 208A 1400
   - 209A 1400
2. THE M8K CORD IS SUPPLIED AND USED WITH ALL DATA SETS EXCEPT 202D. USE D50AA-3 IN PLACE OF D6AA-61 SUPPLIED WITH DATA SET 202D
3. STRAPS PROVIDED AS PART OF 59A1 DATA MOUNTING. DO NOT REMOVE STRAPS
4. THE TWO M4AU CORDS MUST BE ORDERED SEPARATELY. TAPE AND STORE UNUSED LEADS
5. USE DATA JACK USOC RJ41S WITH SWITCH SET TO FLL. THE TWO DATA JACKS MUST BE ORDERED SEPARATELY
6. FOR AUTOMATIC ANSWERING WITH AUTOMATIC CALLBACK, A SEPARATELY ORDERED 43A OR 53A STATION DIAL IS CONNECTED TO J4 OF THE 59A1 DATA MOUNTING AS SHOWN IN FIG. 21. FOR AUTOMATIC ANSWERING WITH TWO CALLS ANSWERED, THE STATION DIAL IS NOT REQUIRED
7. SUPPLIED WITH 59A1 DATA MOUNTING

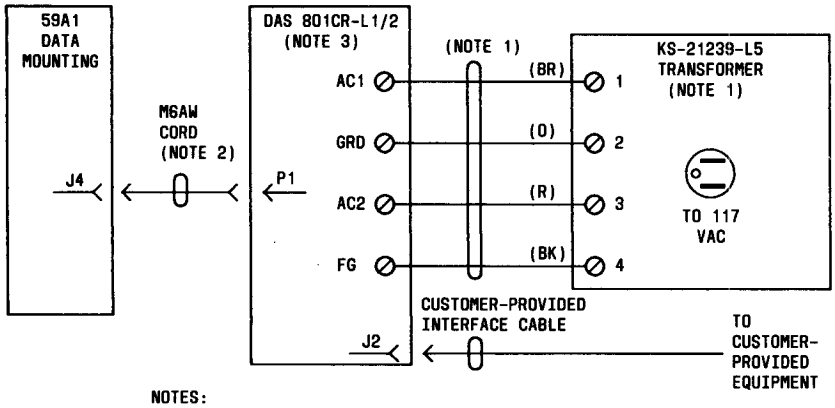
Fig. 20—59A1 Data Mounting—4-Wire Data With 4-Wire Dial Backup Service (Automatic Answering)



NOTES:
1. THE 43A OR 53A STATION DIAL MUST BE OPTIONED FOR RESTRICTED DIALING
2. THE RELAY CONTACT SHOWN IS DESIGNATED R WHEN THE 48ER1 DATA UNIT IS PROVIDED AND IS DESIGNATED OR WHEN THE 48FR1 DATA UNIT IS PROVIDED.
3. A 2012D TRANSFORMER IS REQUIRED WHEN THE 43A OR 53A STATION DIAL IS USED WITHOUT THE 1A350 TONE DETECTOR. A 2075A TRANSFORMER IS REQUIRED WHEN THE 43A OR 53A STATION DIAL IS USED WITH THE 1A350 TONE DETECTOR. THE 2012D TRANSFORMER OR THE 2075A TRANSFORMER AND THE 1A350 TONE DETECTOR MUST BE ORDERED SEPARATELY
4. WHEN A 43A STATION DIAL IS USED, CONNECT YELLOW (Y) LEAD OF M4AS CORD TO TERMINAL 9 OF STATION DIAL. WHEN A 53A STATION DIAL IS USED, CONNECT YELLOW (Y) LEAD OF M4AS CORD TO TERMINAL 6 OF STATION DIAL.
5. THE M4AS CORD, D8AB CORD, 248B ADAPTER, AND 259A ADAPTER MUST BE ORDERED SEPARATELY
6. TAPE AND STORE UNUSED LEADS.

Fig. 21—59A1 Data Mounting—Connections to 43A or 53A Station Dial

units that add alternate voice service to the 4-wire private lines. Each DAS 829-type CIU and 48A1 data unit is identified by a number (N) from 1 to 23. The Nth DAS 829-type CIU terminates the Nth 4-wire private line. The Nth 48A1 data unit adds alternate voice service to the 4-wire private line terminated by the Nth DAS 829-type CIU. The key leads controlling the 23 FDA arrangements are concentrated in connector J10 of each 46B1 data mounting. The key leads controlling FDA arrangements 1 through 8 are connected through connector P1, of the 48D1 data unit, to the keys designated 1 through 8 on the 30-button CALL DIRECTOR. Similarly, the key leads controlling FDA arrangements 9 through 16 and 17 through 23 are connected through connectors P2 and P3, respectively, of the 48D1 data unit, to the keys designated 9 through 16 and 17 through 23,



NOTES:
1. SUPPLIED WITH DAS 801CR-L1/2
2. THE M6AW CORD IS USED INSTEAD OF THE M15H CORD SUPPLIED WITH DAS 801CR-L1/2. THE M6AW CORD MUST BE ORDERED SEPARATELY. THE M15H CORD SHOULD BE RETURNED TO STOCK
3. DAS 801CR-L1/2 OPTIONS REQUIRED ARE SHOWN IN TABLE BELOW.

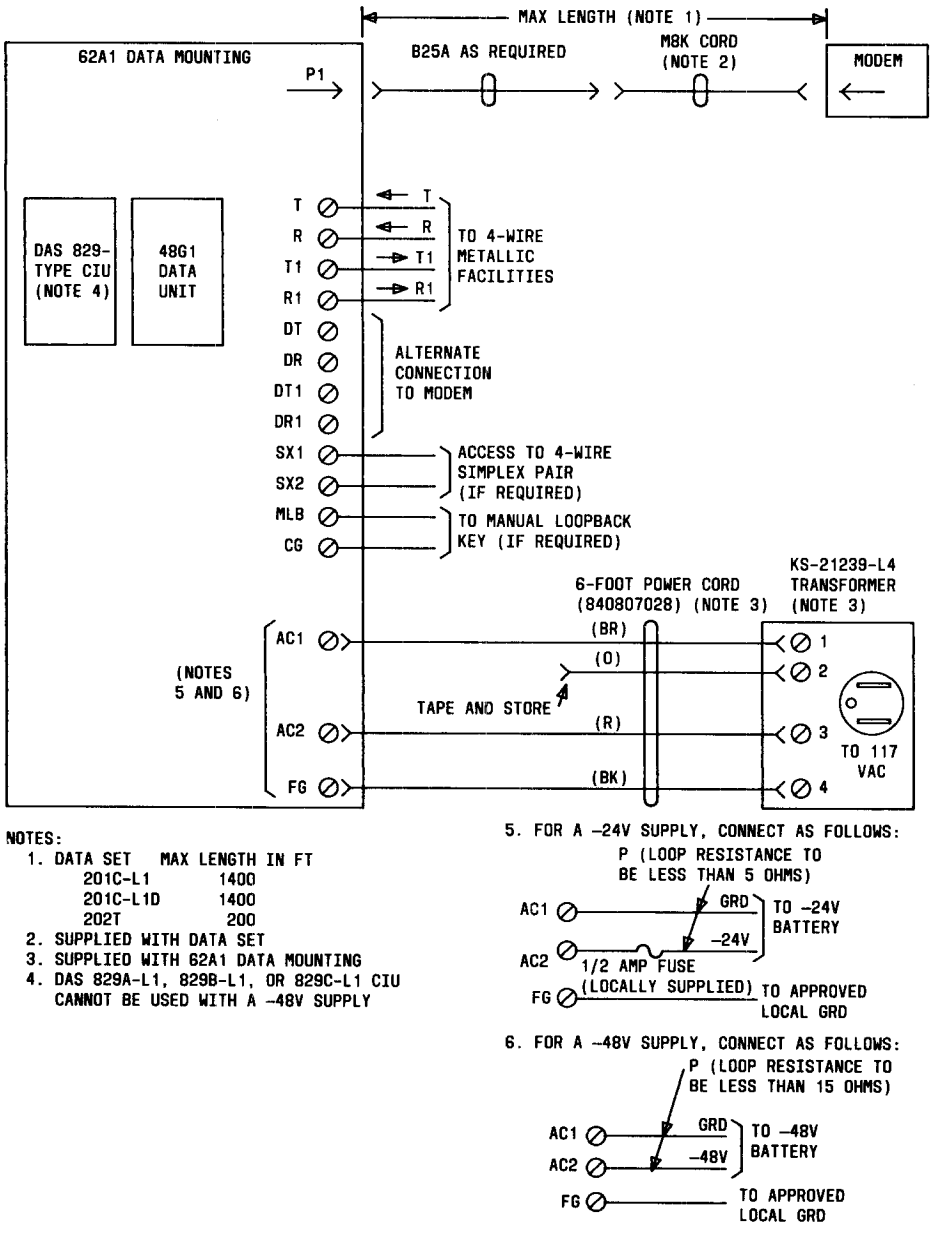
OPTION		SWITCH SETTINGS ON CP1	
DESCRIPTION	DESIG	CLOSED	OPEN
LOOP START	Y	S2-4, S4-1	S1-2, S2-1
DETECT BEGINNING OF ANSWER TONE	X	–	S3-3
DETECT 2225-HZ ANSWER TONE	T	S2-2	S2-3
DATA SET TO DATA MODE BY GROUNDED CONTACT	ZG	S1-1	S1-3
NO CLEAR SIGNAL; NO TK CONTACT	ZN	–	S1-4
TERMINATE CALL VIA DATA SET AFTER DSS ON	G	S4-2	–
STOP ACR TIMER WHEN DSS GOES ON	R	S3-1, S3-2	–
ACR TIMING INTERVAL 56 SEC	ZT	S3-4	S3-5
SIGNAL GRD CONNECTED TO FRAME GRD	ZU	CLOSE SCREW SWITCH ON 52A2 DATA MOUNTING.	

Fig. 22—59A1 Data Mounting—Connections to DAS 801CR-L1/2 ACU

respectively, on the 30-button CALL DIRECTOR. The pickup key controlling the Nth FDA arrangement is designated TALK-DBU N.

3.12 The interface leads for the 23 FDA arrangements and the interface leads for the 23 modems must be connected to the switching matrices controlled by the 30-button CALL DIRECTOR. The interface leads for the 23 FDA arrangements are concentrated in connector P1 of each 46B1 data mounting. The interface leads for FDA arrangements 1 through 8 are connected through connector J10, of the 46C-type data mounting, to the switching matrix provided by the pair of 48C1 data units installed in connectors J4 and J5 of the 46C-type data mounting. The interface leads for modems 1 through 8 are also connected to this matrix through connector P2 of the 46C-type data mounting. The key leads controlling this matrix are connected through connectors P4 and P5, of the 48D1 data unit, to the keys designated 1 through 8 on the 30-button CALL DIRECTOR. The FDA, modem, and key leads for circuits 9 through 16 and 17 through 23 are connected in a similar manner.

3.13 The interface leads for the 23 modems are concentrated in connectors P2, P3, and P4 of the 46C-type data mounting. The modems can



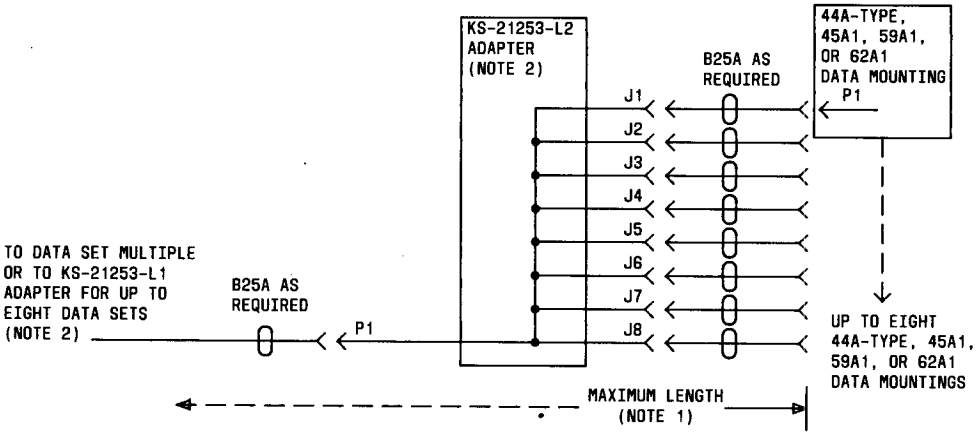
NOTES:

1. DATA SET MAX LENGTH IN FT
   - 201C-L1 1400
   - 201C-L1D 1400
   - 202T 200
2. SUPPLIED WITH DATA SET
3. SUPPLIED WITH 62A1 DATA MOUNTING
4. DAS 829A-L1, 829B-L1, OR 829C-L1 CIU CANNOT BE USED WITH A -48V SUPPLY

5. FOR A -24V SUPPLY, CONNECT AS FOLLOWS:

6. FOR A -48V SUPPLY, CONNECT AS FOLLOWS:

Fig. 23—62A1 Data Mounting—2-Wire Data Only Service



NOTES:

1. DATA SET — MAX LENGTH IN FT

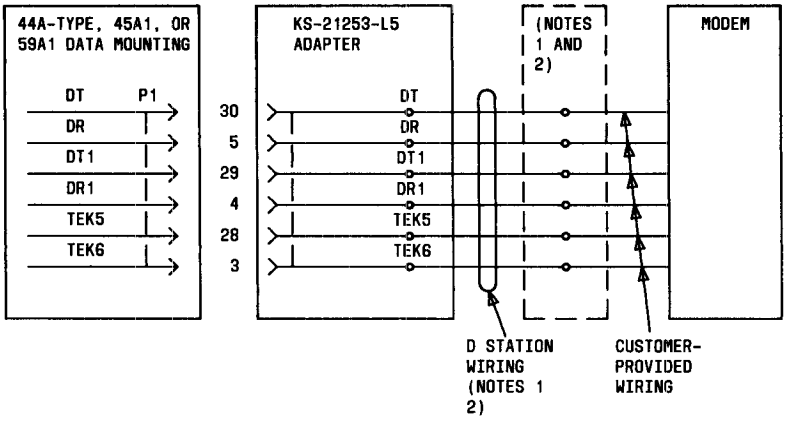
DATA SET	MAX LENGTH IN FT
201C-L1	1400
201C-L1D	1400
202D	500
202T	200
208A	1400
209A	1400

2. IF THE DATA SET REQUIRES A DIAL BACKUP STATUS INDICATION, AND/OR ACCESS TO THE DIAL BACKUP REQUEST PAIR, THIS ARRANGEMENT CANNOT BE USED

Fig. 24—44A-Type, 45A1, 59A1, or 62A1 Data Mounting—Multiple Arrangement

be terminated, as required, using the arrangements given in paragraph 3.02.

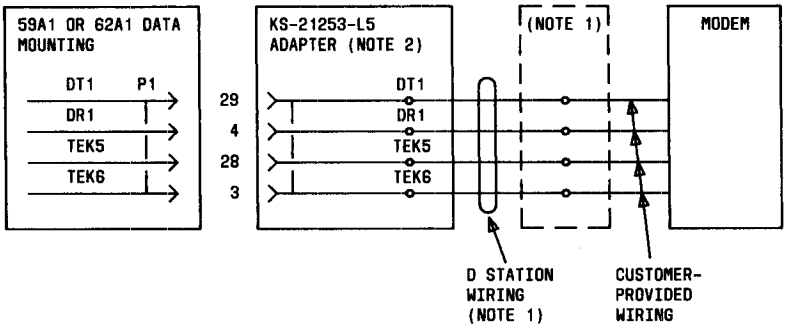
3.14 Dial backup channels A and B for the twenty-three FDA arrangements are provided by the two 48B1 or 48ER1 data units installed in connectors J2 and J3 of the 46C-type data mounting. The four direct distance dialing (DDD) lines required for dial backup channels A and B are connected to a terminal strip or connector J1 on the 46C-type data mounting. The key leads controlling the dial backup channels are connected through connector P1, of the 46C-type data mounting, and connector J6, of the 48D1 data unit, to the pickup keys designated DDD1A, DDD2A, DDD1B, DDD2B, and REL.



NOTES:

1. IF THE CUSTOMER-PROVIDED WIRING IS TOO SHORT, A 42A CONNECTING BLOCK CAN BE USED WITH D STATION WIRING TO CONNECT THE MODEM TO THE KS-21253-L5 ADAPTER. THE D STATION WIRING SHOULD NOT EXCEED 10 FEET IN LENGTH.
2. IF THE TEK5 AND TEK6 LEADS ARE REQUIRED, A 44A CONNECTING BLOCK MUST BE USED WITH THE D STATION WIRING.

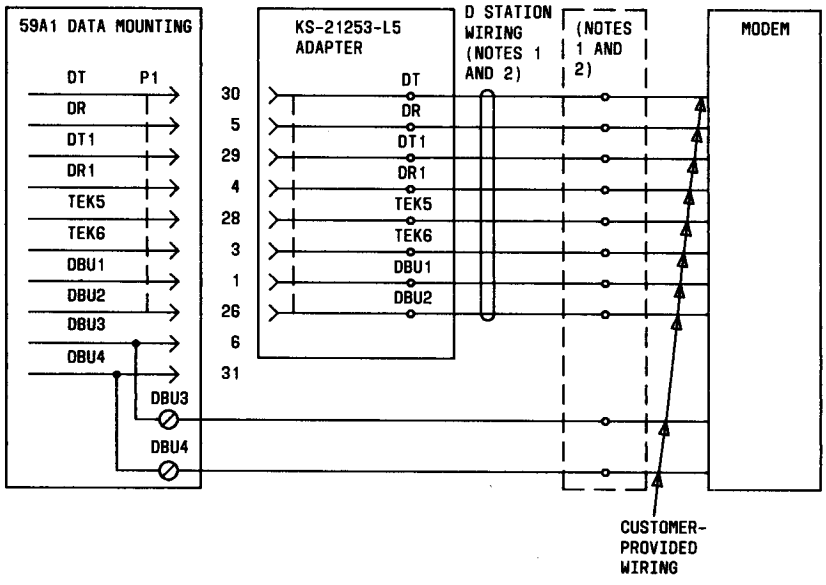
Fig. 25—Customer-Provided Modem—4-Wire Data Service (With or Without Alternate Voice Service)



NOTES:

1. IF THE CUSTOMER-PROVIDED WIRING IS TOO SHORT, A 42A CONNECTING BLOCK CAN BE USED WITH D STATION WIRING TO CONNECT THE MODEM TO THE KS-21253-L5 ADAPTER. THE D STATION WIRING SHOULD NOT EXCEED 10 FEET IN LENGTH.
2. IF THE TEK5 AND TEK6 LEADS ARE NOT REQUIRED FOR 2-WIRE DATA ONLY SERVICE, THE KS-21253-L5 ADAPTER CAN BE OMITTED AND THE DT1 AND DR1 LEADS CONNECTED TO SCREW TERMINALS DT1 AND DR1, RESPECTIVELY, OF THE 62A1 DATA MOUNTING.

Fig. 26—Customer-Provided Modem—2-Wire Data Service (With or Without Alternate Voice Service)



NOTES:
1. IF THE CUSTOMER-PROVIDED WIRING IS TOO SHORT, A 42A CONNECTING BLOCK CAN BE USED WITH D STATION WIRING TO CONNECT THE MODEM TO THE KS-21253-L5 ADAPTER. THE D STATION WIRING SHOULD NOT EXCEED 10 FEET IN LENGTH
2. IF THE TEK5 AND TEK6 LEADS AND/OR DBU1 AND DBU2 LEADS AND/OR DBU3 AND DBU4 LEADS ARE REQUIRED, A 44A CONNECTING BLOCK MUST BE USED WITH THE D STATION WIRING

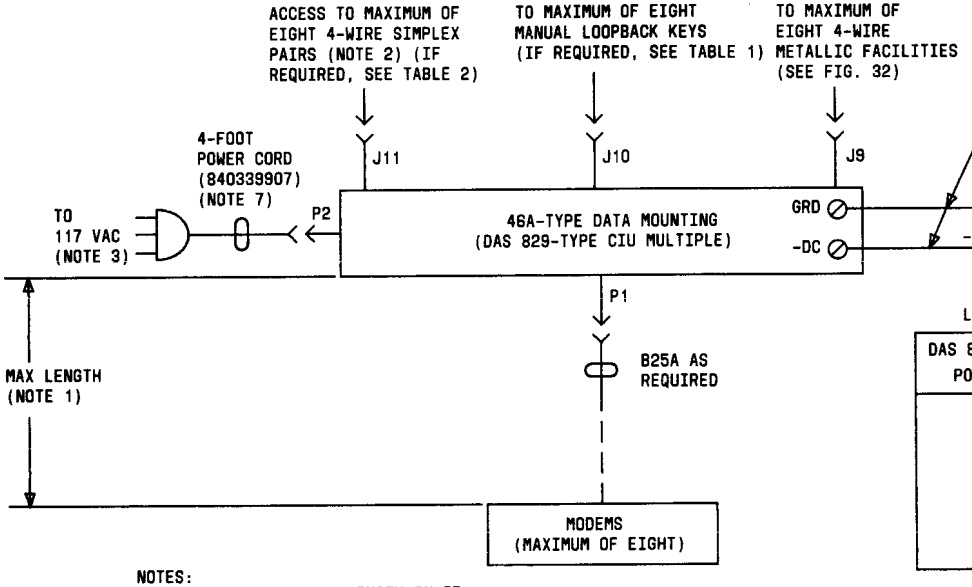
Fig. 27—Customer-Provided Modem—4-Wire Data With 4-Wire Dial Backup Service (With or Without Alternate Voice Service)

Second Example—Multiple FD and FDA Arrangements With and Without Switched Dial Backup Service

3.15 The second example (Fig. 44) is a multiple arrangement consisting of a variety of services controlled by one CALL DIRECTOR. In this example, 8 FD and 11 FDA arrangements are to be provided. Switched dial backup service using one dial backup channel is to be provided for 5 of the FD and 6 of the FDA arrangements.

3.16 Design rule No. 1 indicates that one 18-button CALL DIRECTOR can be used to control the 11 arrangements (5 FD and 6 FDA) that require switched dial backup service. However, 5 of the FDA arrangements to be provided do not require switched dial backup service. Design rule No. 2 and Table B indicate that when 11 FD and/or FDA arrangements are provided with switched dial backup service, there are up to 8 pickup keys available for control of additional FDA arrangements when a 30-button CALL DIRECTOR is provided. Therefore, for this example, the 631DAM or the 2631DAM 30-button CALL DIRECTOR key telephone set, with the wiring modifications given in Fig. 44, is used to control the entire multiple arrangement. The CALL DIRECTOR is connected to connectors J1 through J5 of the 48D1 data unit. Table B indicates that pickup keys 1 through 8 of the CALL DIRECTOR should be assigned to the FDA arrangements that do not require switched dial backup service. Pickup keys 9 through 23 should be assigned to the FD and/or FDA arrangements that require switched dial backup service.

3.17 The FDA arrangements that do not require switched dial backup service are provided



NOTES:
1. DATA SET — MAX LENGTH IN FT
   - 201C-L1 — 1400
   - 201C-L1D — 1400
   - 202D — 500
   - 202T — 200
   - 208A — 1400
   - 209A — 1400
2. NOT PROVIDED ON 46A1 DATA MOUNTING
3. FOR OPERATION FROM A 117 VAC SUPPLY, THE 46A2 DATA MOUNTING MUST BE EQUIPPED WITH THE AC OPTION
4. FOR OPERATION FROM A DC SUPPLY, THE 46A2 DATA MOUNTING MUST BE EQUIPPED WITH THE DC OPTION. THIS OPTION IS NOT PROVIDED ON THE 46A1 DATA MOUNTING
5. DAS 829A-L1, 829B-L1, OR 829C-L1 CIU CANNOT BE USED WITH A -48V SUPPLY
6. LOOP RESISTANCE TO BE LESS THAN 4 OHMS
7. SUPPLIED WITH DATA MOUNTING. NOT REQUIRED FOR OPERATION FROM A DC SUPPLY

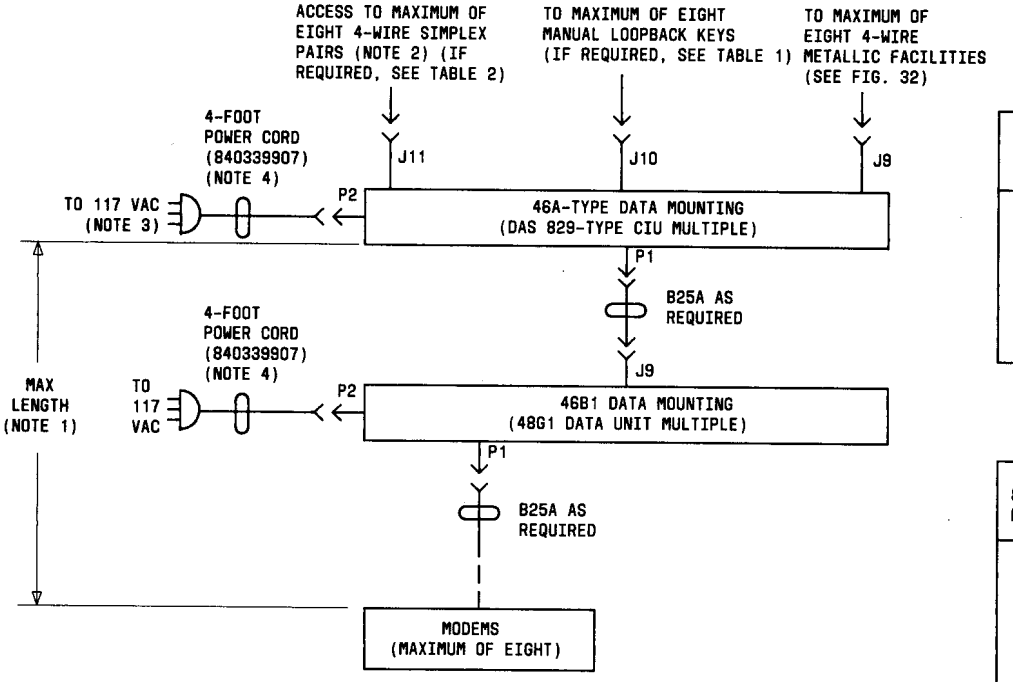
TABLE 1
LOCATION OF LOOPBACK PAIR

DAS 829-TYPE CIU POSITION NO.	J10 TERMINAL NO.	
	CG	MLB
1	3	28
2	6	31
3	9	34
4	12	37
5	15	40
6	18	43
7	21	46
8	24	49

TABLE 2
LOCATION OF SIMPLEX PAIR

DAS 829-TYPE CIU POSITION NO.	J11 TERMINAL NO.	
	SX1	SX2
1	1	26
2	2	27
3	3	28
4	4	29
5	5	30
6	6	31
7	7	32
8	8	33

Fig. 28—46A-Type Data Mounting—4-Wire Data Only Service



NOTES:
1. DATA SET — MAX LENGTH IN FT
   - 201C-L1 — 1400
   - 201C-L1D — 1400
   - 202T — 200
2. NOT PROVIDED ON 46A1 DATA MOUNTING
3. THE 46A2 DATA MOUNTING MUST BE EQUIPPED WITH THE AC OPTION
4. SUPPLIED WITH DATA MOUNTING

Fig. 29—46A-Type and 46B1 Data Mountings—2-Wire Data Only Service

TABLE 1
LOCATION OF LOOPBACK PAIR

DAS 829-TYPE CIU POSITION NO.	J10 TERMINAL NO.	
	CG	MLB
1	3	28
2	6	31
3	9	34
4	12	37
5	15	40
6	18	43
7	21	46
8	24	49

TABLE 2
LOCATION OF SIMPLEX PAIR

DAS 829-TYPE CIU POSITION NO.	J11 TERMINAL NO.	
	SX1	SX2
1	1	26
2	2	27
3	3	28
4	4	29
5	5	30
6	6	31
7	7	32
8	8	33

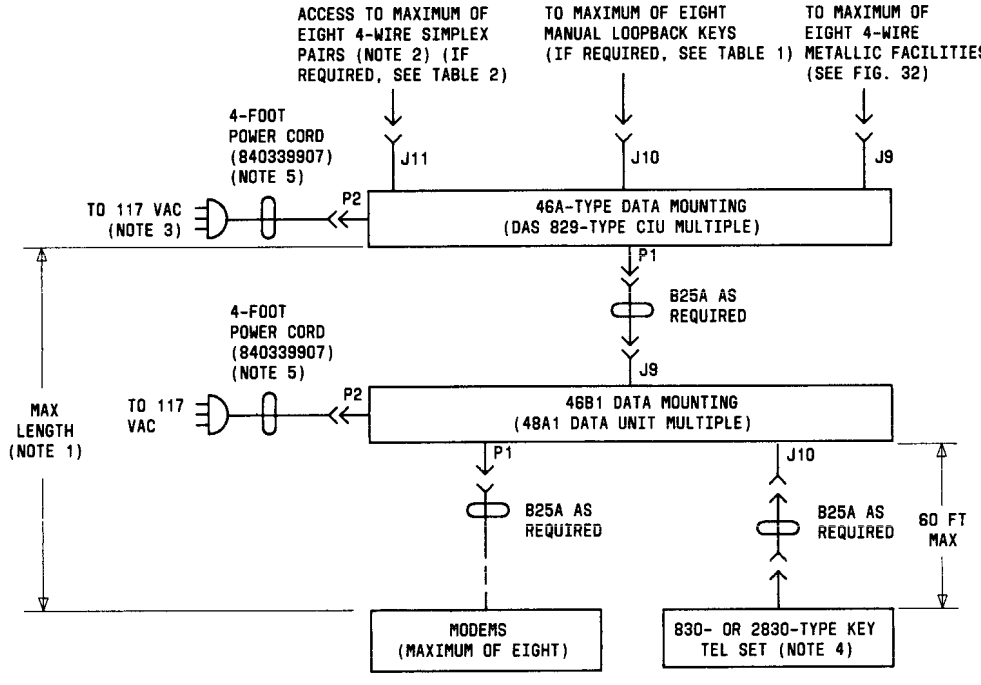


TABLE 1
LOCATION OF LOOPBACK PAIR

DAS 829-TYPE CIU POSITION NO.	J10 TERMINAL NO.	
	CG	MLB
1	3	28
2	6	31
3	9	34
4	12	37
5	15	40
6	18	43
7	21	46
8	24	49

TABLE 2
LOCATION OF SIMPLEX PAIR

DAS 829-TYPE CIU POSITION NO.	J11 TERMINAL NO.	
	SX1	SX2
1	1	26
2	2	27
3	3	28
4	4	29
5	5	30
6	6	31
7	7	32
8	8	33

NOTES:
1. DATA SET — MAX LENGTH IN FT

DATA SET	MAX LENGTH IN FT
201C-L1	1400
201C-L1D	1400
202D	500
202T	200
208A	1400
209A	1400

2. NOT PROVIDED ON 46A1 DATA MOUNTING
3. THE 46A2 DATA MOUNTING MUST BE EQUIPPED WITH THE AC OPTION
4. DESIGNATE KEY STRIP AS SHOWN. CONVERT RING BUTTON TO NONLOCKING

HOLD	PL TALK1	PL TALK2	PL TALK3	PL TALK4	PL TALK5	PL TALK6	PL TALK7	PL TALK8	RING

5. SUPPLIED WITH DATA MOUNTING

Fig. 30—46A-Type and 46B1 Data Mountings—4-Wire Data With Alternate Voice Service

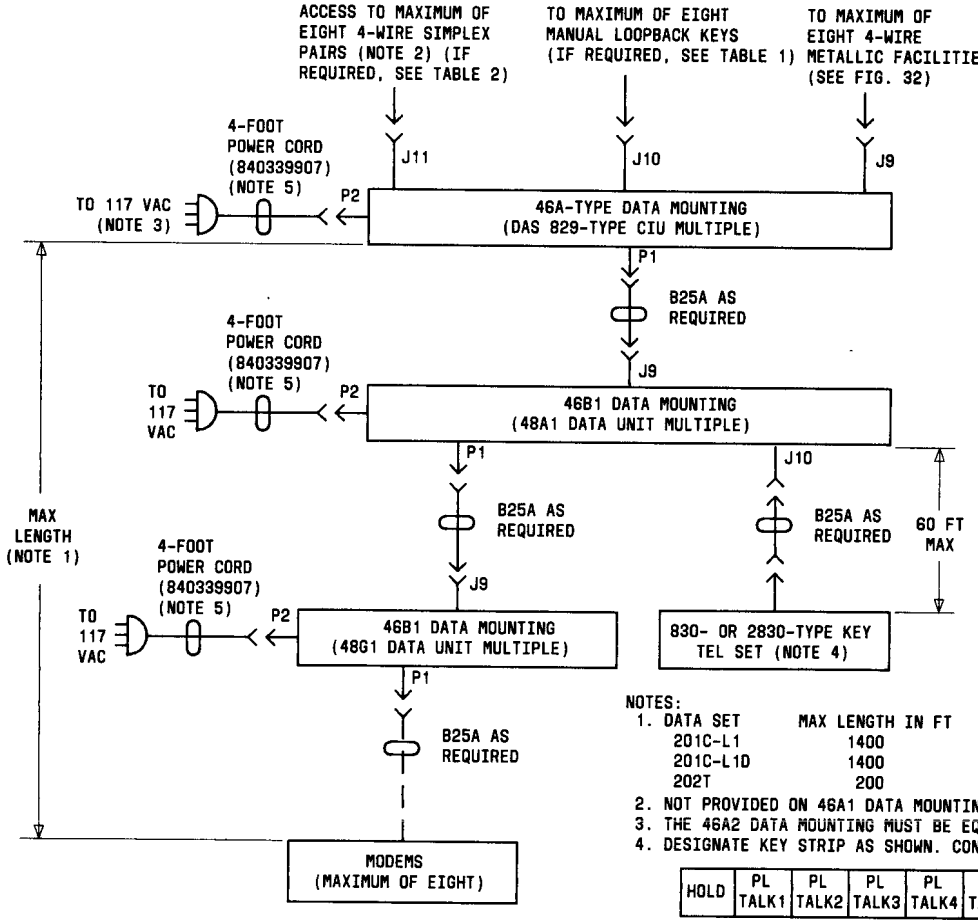


TABLE 1
LOCATION OF LOOPBACK PAIR

DAS 829-TYPE CIU POSITION NO.	J10 TERMINAL NO.	
	CG	MLB
1	3	28
2	6	31
3	9	34
4	12	37
5	15	40
6	18	43
7	21	46
8	24	49

TABLE 2
LOCATION OF SIMPLEX PAIR

DAS 829-TYPE CIU POSITION NO.	J11 TERMINAL NO.	
	SX1	SX2
1	1	26
2	2	27
3	3	28
4	4	29
5	5	30
6	6	31
7	7	32
8	8	33

NOTES:
1. DATA SET — MAX LENGTH IN FT
   - 201C-L1 — 1400
   - 201C-L1D — 1400
   - 202T — 200
2. NOT PROVIDED ON 46A1 DATA MOUNTING.
3. THE 46A2 DATA MOUNTING MUST BE EQUIPPED WITH THE AC OPTION.
4. DESIGNATE KEY STRIP AS SHOWN. CONVERT RING BUTTON TO NONLOCKING.

HOLD	PL TALK1	PL TALK2	PL TALK3	PL TALK4	PL TALK5	PL TALK6	PL TALK7	PL TALK8	RING

5. SUPPLIED WITH DATA MOUNTING

Fig. 31—46A-Type and 46B1 Data Mountings—2-Wire Data With Alternate Voice Service

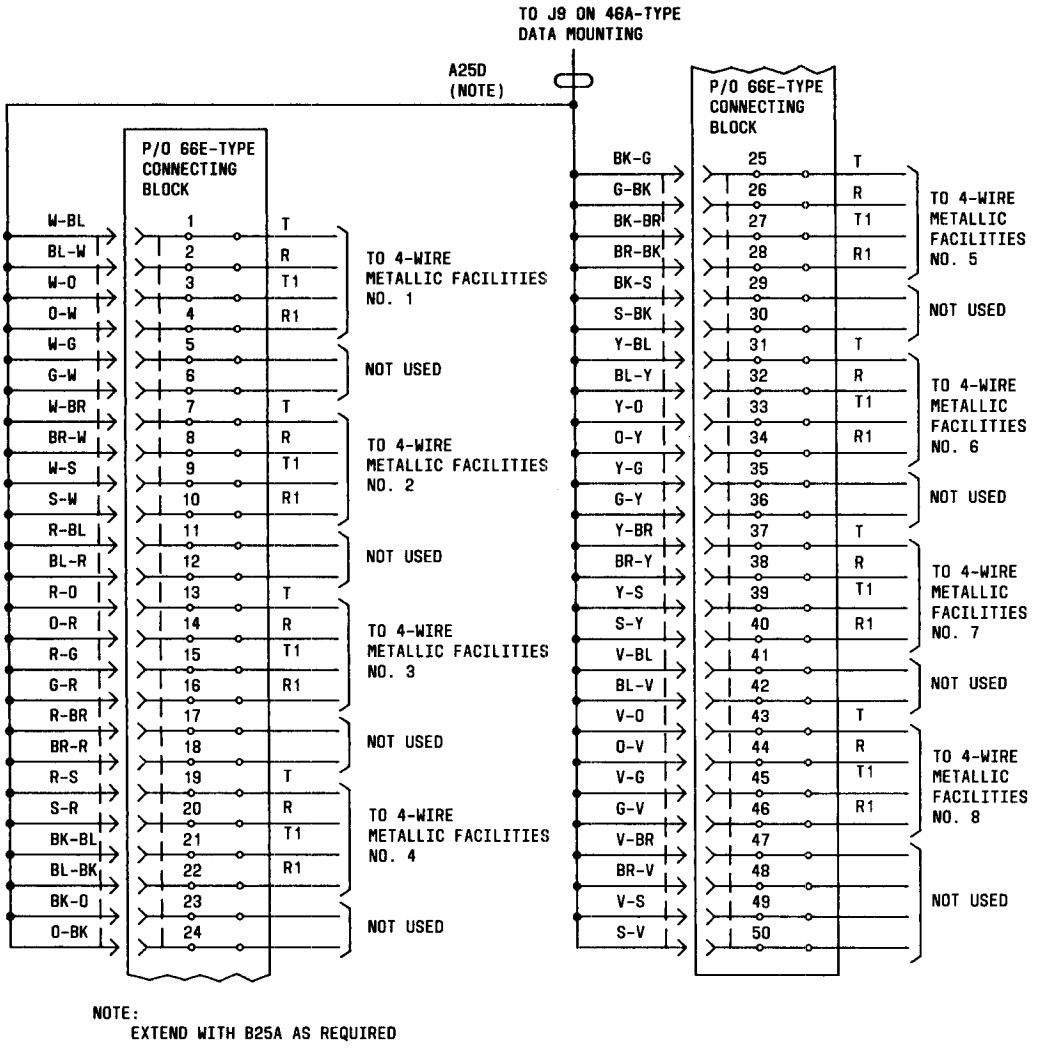


Fig. 32—46A-Type Data Mounting Connections to 4-Wire Metallic Facilities

by the 46A-type and 46B1 data mountings that terminate the 4-wire private lines 1 through 8. Positions 1 through 5 are used for the required 5 FDA arrangements. Positions 6 through 8 are used for the 3 FD arrangements that do not require switched dial backup service (design rule No. 3). The modems for circuits 1 through 8 are connected to connector P1 of the 46B1 data mounting for circuits 1 through 8. The key leads controlling circuits 1 through 8 are connected through connector P1 of the 48D1 data unit.

Note: The 48C1 data units are not installed in connectors J4 and J5 of the 46C-type data

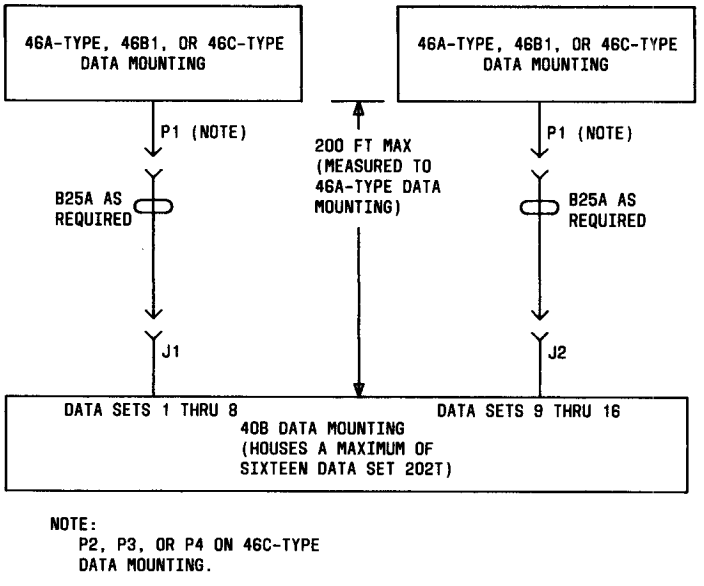


Fig. 33—Data Set 202T—4-Wire Multiple Arrangement

mounting. These connectors are left unterminated as switched dial backup service is not required for circuits 1 through 8.

3.18 The pickup keys for positions 1 through 5 control FDA arrangements and are designated TALK 1 through TALK 5, respectively. The pickup keys for positions 6 through 8 are left blank as these positions do not require key lead control.

3.19 The FDA arrangements that require switched dial backup service are provided by the 46A-type and 46B1 data mountings that terminate the 4-wire private lines 9 through 16. Positions 9 through 14 are used for the required 6 FDA arrangements. Positions 15 and 16 are used for 2 of the 5 FD arrangements that require switched dial backup service. The key leads controlling circuits 9 through 16 are connected through connector P2 of the 48D1 data unit.

3.20 The interface leads for FD and/or FDA arrangements 9 through 16 are connected through connector J11, of the 46C-type data mounting, to the switching matrix provided by the pair of 48C1 data units installed in connectors J6 and J7 of the 46C-type data mounting. The interface leads for modems 9 through 16 are also connected to this matrix through connector P3 of the 46C-type data mounting.

3.21 The pickup keys for positions 9 through 14 control FDA arrangements with switched dial backup service and are designated TALK-DBU 9 through TALK-DBU 14, respectively. The pickup keys for positions 15 and 16 control FD arrangements with switched dial backup service and are designated DBU 15 and DBU 16, respectively.

3.22 The remaining FD arrangements that require switched dial backup service are provided by the 46A-type data mounting that terminates 4-wire private lines 17 through 23. Positions 17 through 19 are used for the remaining 3 FD arrangements. Positions 20 through 23 are not used.

3.23 The interface leads for FD arrangements 17 through 23 are connected through connector J12, of the 46C-type data mounting, to switching matrix connectors J8 and J9 of the 46C-type data mounting. The interface leads for modems 17

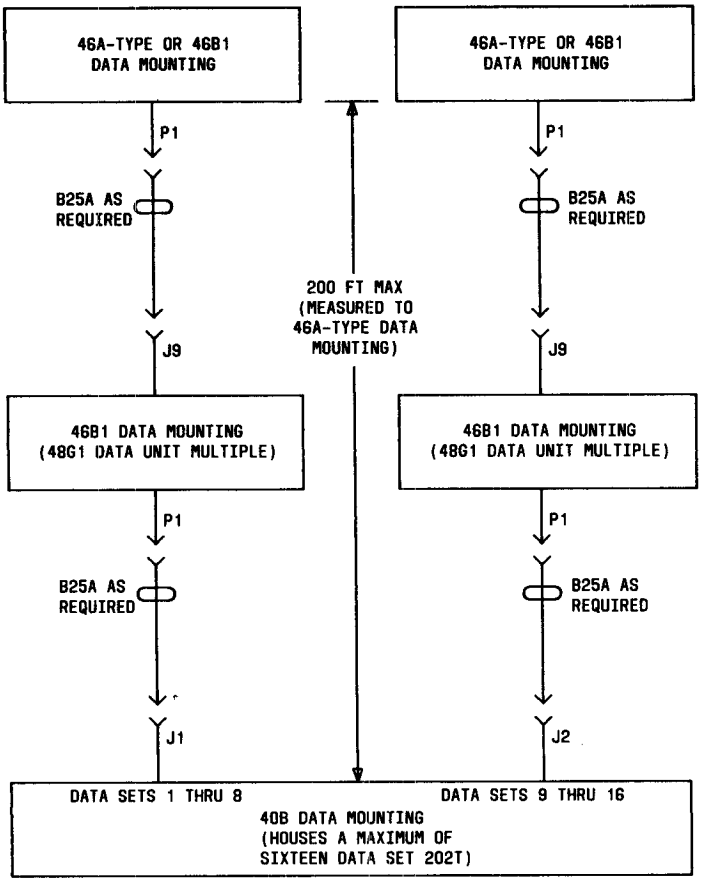


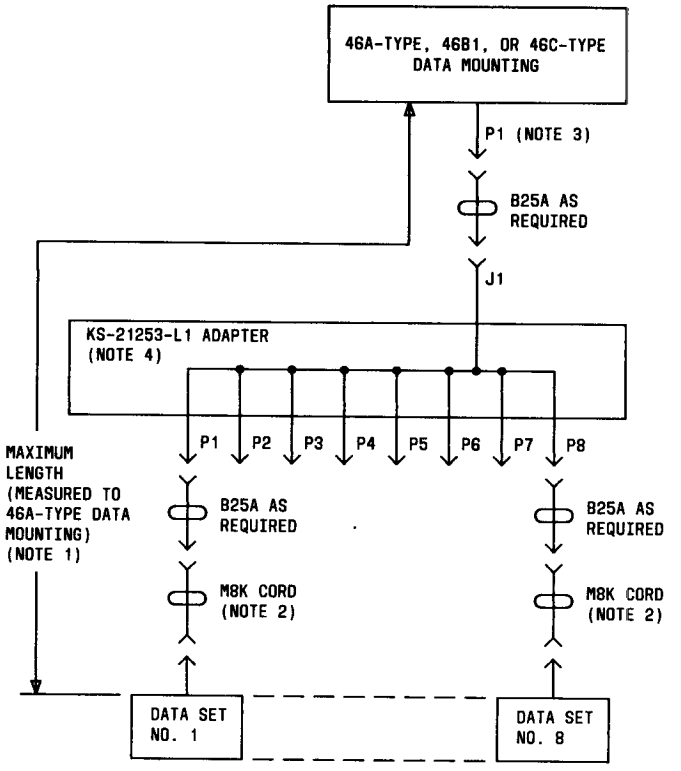
Fig. 34—Data Set 202T—2-Wire Multiple Arrangement

through 23 are also connected to connectors J8 and J9 through connector P4 of the 46C-type data mounting. The 48C1 data unit installed in connector J8 provides the switching matrix for circuits 17 through 20. Since circuits 21 through 23 do not require switched dial backup service, connector J9 is not terminated by a 48C1 data unit.

Note: Connectors J4 through J9 of the 46C-type data mounting, when unterminated, do not provide a through connection for the modem interface leads. Hence, in this example, positions 21 through 23 cannot be used to provide FD arrangements.

3.24 The pickup keys for positions 17 through 19 control FD arrangements with switched dial backup service and are designated DBU 17 through DBU 19, respectively. The pickup keys for positions 20 through 23 are left blank as these positions are not used.

3.25 Dial backup channel A, the only dial backup channel required in this example, is provided by the 48B1 or 48ER1 data unit installed in connector



NOTES:

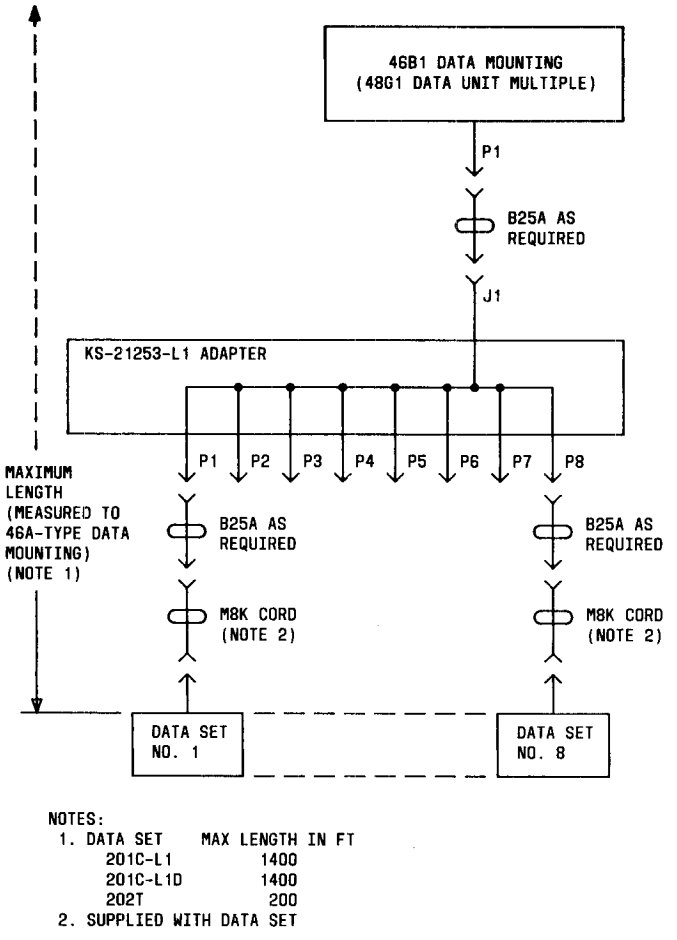
1. DATA SET — MAX LENGTH IN FT

DATA SET	MAX LENGTH IN FT
201C-L1	1400
201C-L1D	1400
202D	500
202T	200
208A	1400
209A	1400

2. THE M8K CORD IS SUPPLIED AND USED WITH ALL DATA SETS EXCEPT 202D. USE D5OAA-3 IN PLACE OF D6AA-61 SUPPLIED WITH DATA SET 202D
3. P2, P3, OR P4 ON 46C-TYPE DATA MOUNTING
4. IF THE DATA SET REQUIRES A DIAL BACKUP STATUS INDICATION, THE KS-21253-L4 ADAPTER MUST BE USED AS SHOWN IN FIG. 47

Fig. 35—Data Set 201C, 202D, 202T, 208A, or 209A—4-Wire Multiple Arrangement

J2 of the 46C-type data mounting. The two DDD lines required for dial backup channel A are connected to a terminal strip on the 46C-type data mounting. The two DDD lines and the 48B1 or 48ER1 data unit required for dial backup channel B are not provided. The key leads controlling the dial backup channels are connected through connector P1, of the 46C-type data mounting, and connector J6, of the 48D1 data unit, to the pickup keys designated DDD1A, DDD2A, and REL. The 4th and 5th pickup



NOTES:
1. DATA SET MAX LENGTH IN FT
201C-L1 1400
201C-L1D 1400
202T 200
2. SUPPLIED WITH DATA SET

Fig. 36—Data Set 201C or 202T—2-Wire Multiple Arrangement

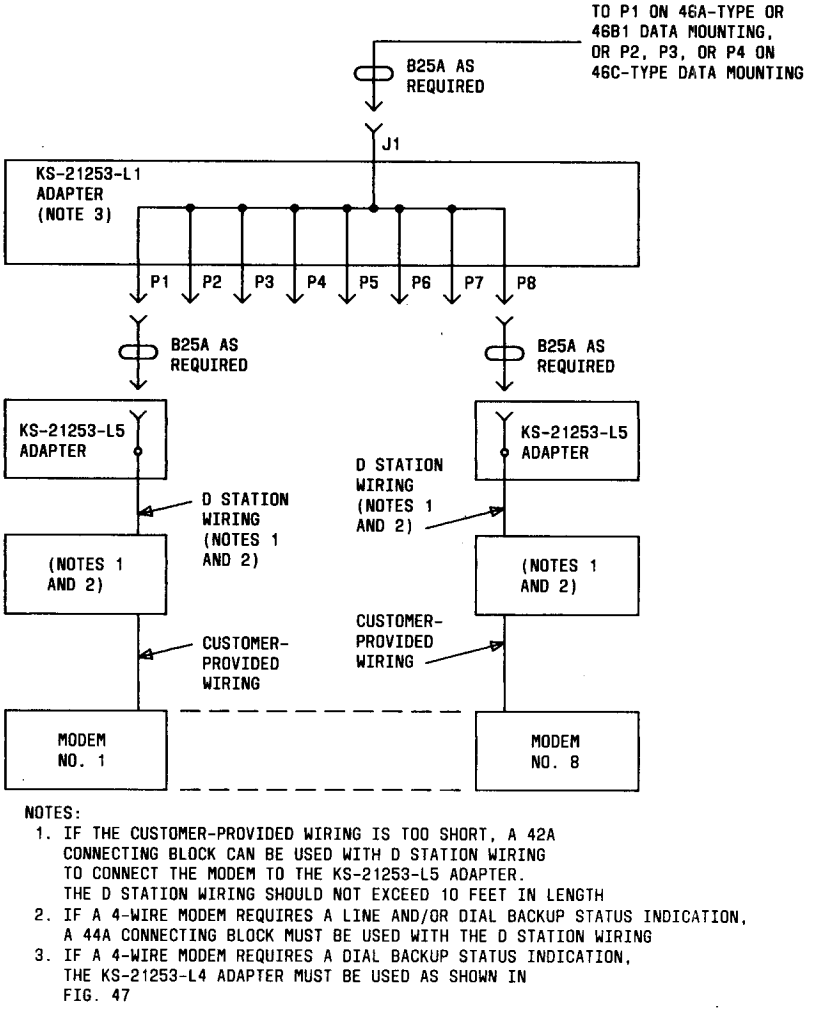
keys of the 1st key module that provide key lead control for the DDD1B and DDD2B lines are not required and are left blank.

4. OPTIONS AND ADJUSTMENTS

A. DAS 829A-L1 CIU

4.01 A sealing current option (Fig. 48) is provided on the DAS 829A-L1 CIU. If this option is specified on the service order, a plug-in strap should be placed in the sealing current option (SC) position. If the option is not specified on the service order, the plug-in strap should be placed in the sealing current storage (ST) position.

4.02 A line impedance option (Fig. 48) on the DAS 829A-L1 CIU provides a 600- or 1200-ohm line termination. The two plug-in straps used for line termination should be placed in the 600-ohm or 1200-ohm option positions as specified on the service order.

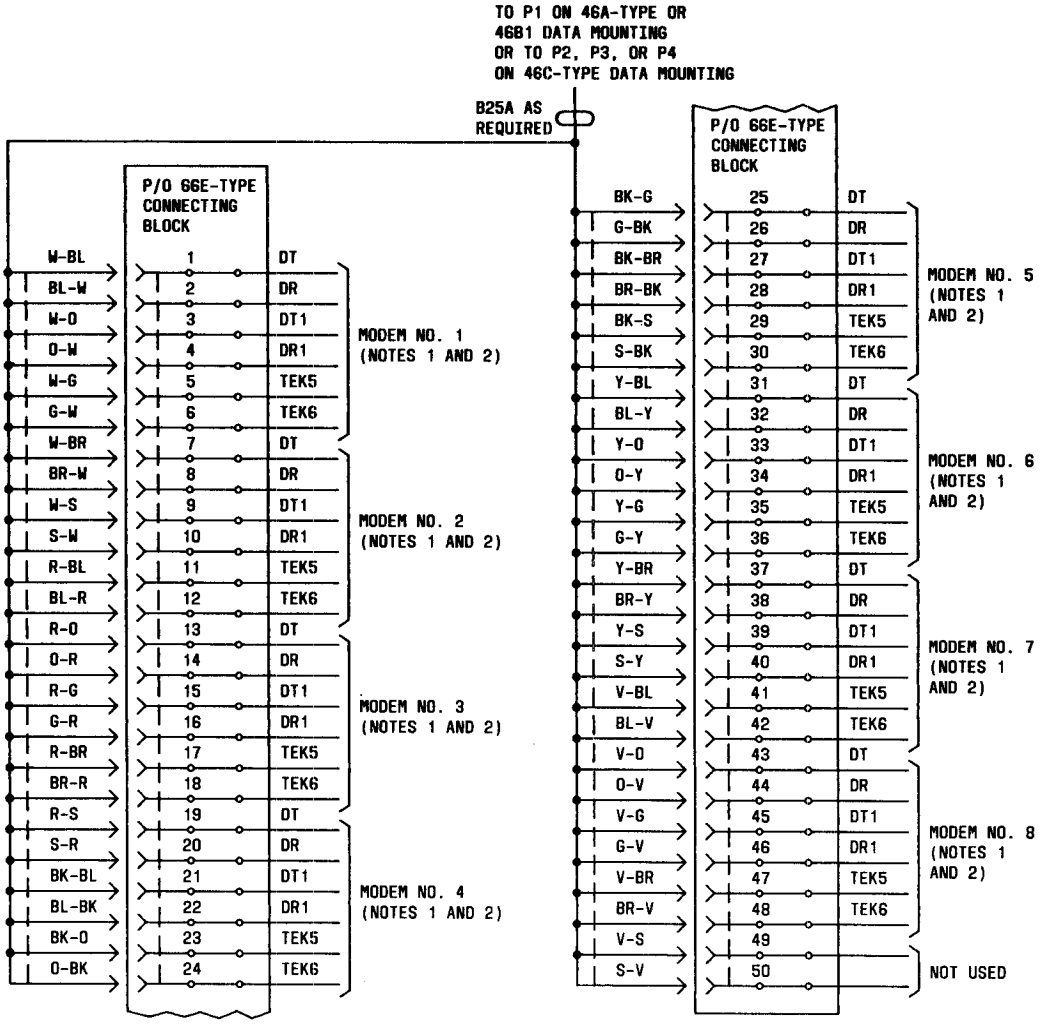


NOTES:
1. IF THE CUSTOMER-PROVIDED WIRING IS TOO SHORT, A 42A CONNECTING BLOCK CAN BE USED WITH D STATION WIRING TO CONNECT THE MODEM TO THE KS-21253-L5 ADAPTER. THE D STATION WIRING SHOULD NOT EXCEED 10 FEET IN LENGTH
2. IF A 4-WIRE MODEM REQUIRES A LINE AND/OR DIAL BACKUP STATUS INDICATION, A 44A CONNECTING BLOCK MUST BE USED WITH THE D STATION WIRING
3. IF A 4-WIRE MODEM REQUIRES A DIAL BACKUP STATUS INDICATION, THE KS-21253-L4 ADAPTER MUST BE USED AS SHOWN IN FIG. 47

Fig. 37—Customer-Provided Modem—Multiple Arrangement Using KS-21253-L1 Adapter

4.03 The transmit (TRANS) attenuator (Fig. 48) and the receive (REC) attenuator on the DAS 829A-L1 CIU should be set to the attenuation values specified on the service order. Four slide switches on each attenuator control 1.0-, 2.0-, 4.0-, and 8.0-dB pads. The attenuation value for each attenuator is variable from 0 to 15 dB in 1-dB steps and is the sum of the exposed numbers. A setting example follows:

- Service order specifies 12-dB attenuation in transmit path—set slide switches on TRANS attenuator so that numbers 4.0 and 8.0 are exposed.



NOTES:
1. THE DT AND DR LEADS ARE NOT REQUIRED FOR 2-WIRE MODEMS.
2. THE TEK5 AND TEK6 LEADS ARE NORMALLY NOT REQUIRED.

Fig. 38—Customer-Provided Modem—Multiple Arrangement Using 66E-Type Connecting Block

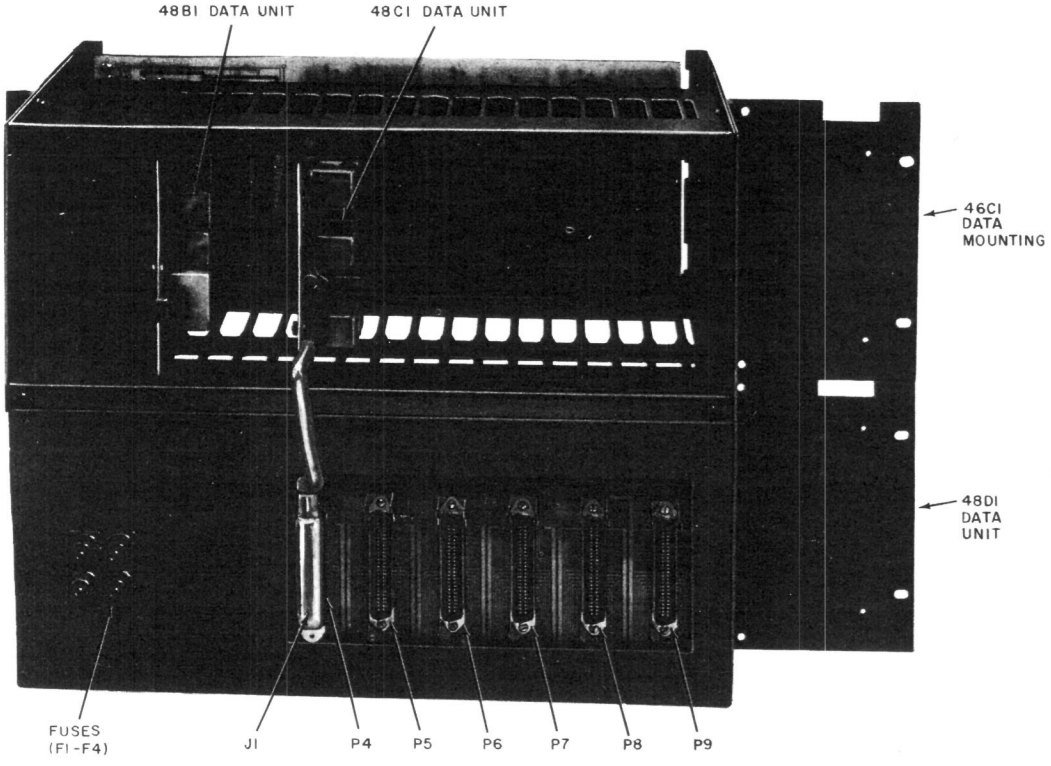


Fig. 39—46C1 Data Mounting and 48D1 Data Unit—Front View

- Service order specifies 11-dB attenuation in receive path—set slide switches on REC attenuator so that numbers 1.0, 2.0, and 8.0 are exposed.

B. DAS 829B-L1 CIU

4.04 A sealing current option (Fig. 49) is provided on the DAS 829B-L1 CIU. If this option is specified on the service order, a plug-in strap should be placed in the sealing current option (SC) position. If the option is not specified on the service order, the plug-in strap should be placed in the sealing current storage (ST) position.

4.05 A line impedance option (Fig. 49) on the DAS 829B-L1 CIU provides a 150-, 600-, or 1200-ohm line termination. The four plug-in straps used for line termination should be placed in the 150-ohm, 600-ohm, or 1200-ohm option positions as specified on the service order.

4.06 The transmit (TRANS) attenuator (Fig. 49) on the DAS 829B-L1 CIU should be set to the attenuation value specified on the service order, as described in paragraph 4.03.

4.07 A coarse gain option (Fig. 49) and a fine gain control on the DAS 829B-L1 CIU provide adjustment for the output level of the CIU receive amplifier. A plug-in strap should be placed in the receive coarse gain option position (GAIN—+10, 0, -10, -20) specified on the service order. The receive fine gain control is variable from 0 to 10

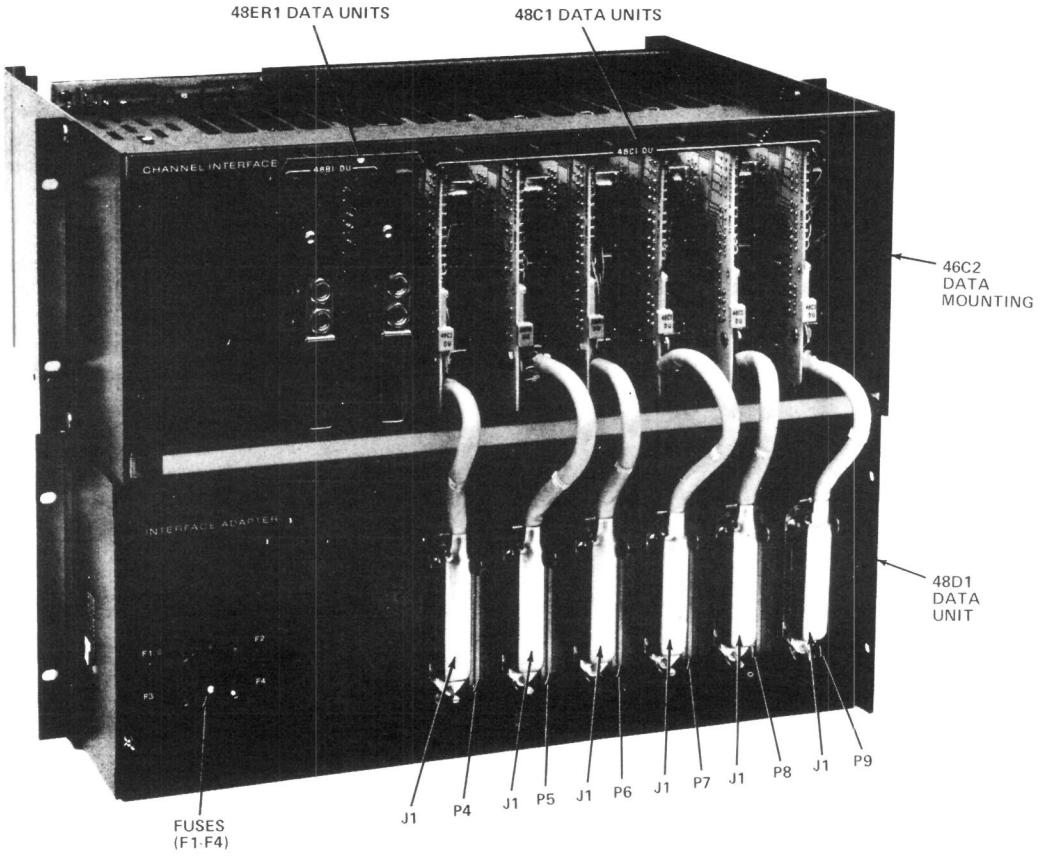


Fig. 40—46C2 Data Mounting and 48D1 Data Unit—Front View

dB and is accessible through a hole in the faceplate of the CIU. Adjustment of the fine gain control is described in Section 598-082-500.

C. DAS 829C-L1 CIU

4.08 A sealing current option (Fig. 50) is provided on the DAS 829C-L1 CIU. If this option is specified on the service order, a plug-in strap should be placed in the sealing current option (SC) position. If the option is not specified on the service order, the plug-in strap should be placed in the sealing current storage (ST) position.

4.09 A 359A or 359K equalizer equivalent option (Fig. 50) is provided on the DAS 829C-L1 CIU. This equalizer equivalent consists of a slope equalizer circuit and a line termination (1200-ohm for 359A and 600-ohm for 359K). Either the 359A or 359K equalizer equivalent should be selected as specified on the service order. The 359A equalizer equivalent is selected by inserting two plug-in straps in column 359 adjacent to the designation A. The 359K equalizer equivalent is selected by inserting two plug-in straps in column 359 adjacent to the designation K. After the equalizer is selected, the required equalizer characteristics are provided by inserting plug-in straps in the positions specified

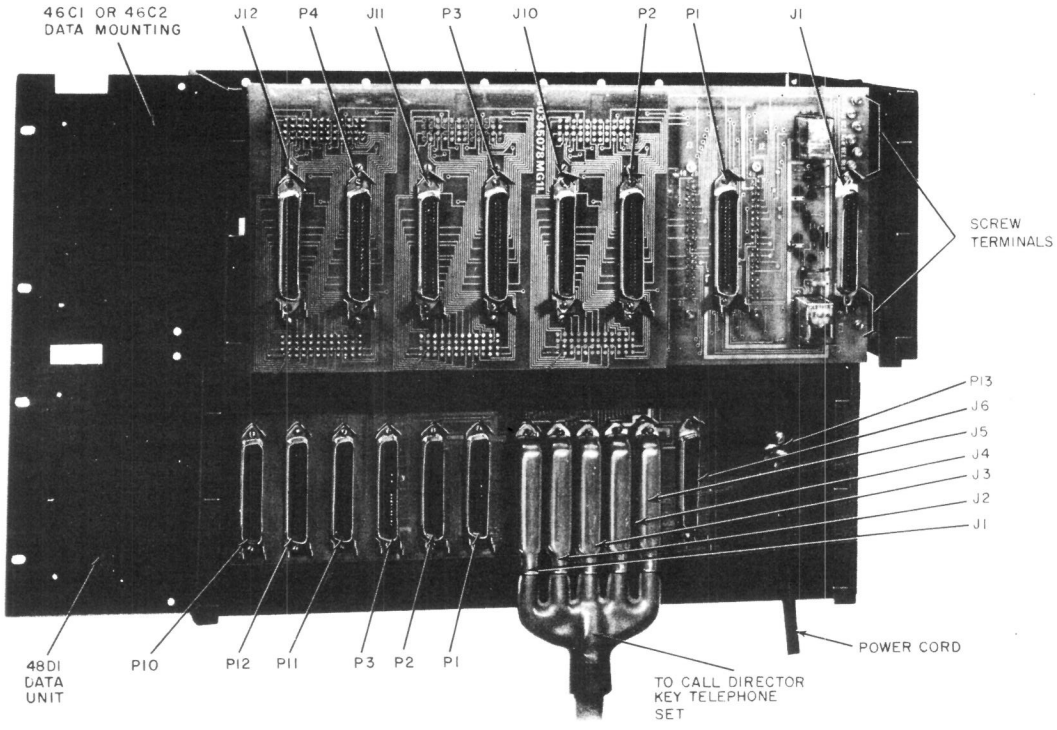


Fig. 41—46C1 or 46C2 Data Mounting and 48D1 Data Unit—Rear View

on the service order or the circuit layout record (CLR). The straps should be inserted in positions identified by columns A, B, C, and D and rows 1, 2, 3, and 4. Strap storage is provided to the left of columns A, B, C, and D in the four ST columns. Additional information is provided in Sections 332-104-500 and 332-116-201.

4.10 The transmit (TRANS) attenuator (Fig. 50) on the DAS 829C-L1 CIU should be set to the attenuation value specified on the service order, as described in paragraph 4.03.

4.11 A coarse gain option (Fig. 50) and a fine gain control on the DAS 829C-L1 CIU provide adjustment for the output level of the CIU receive amplifier. A plug-in strap should be placed in the receive coarse gain option position (GAIN—+20, +10, 0, -10, -20) specified on the service order. The receive fine gain control is variable from 0 to 10 dB and is accessible through a hole in the faceplate of the CIU. Adjustment of the fine gain control is described in Section 598-082-500.

D. DAS 829A-L1A CIU

4.12 A power supply option (Fig. 51) on the DAS 829A-L1A CIU permits operation from a 24 Vac, -24 Vdc, or -48 Vdc power source. A plug-in strap should be placed in the option position specified on the service order (N position for 24 Vac or -24 Vdc, and -48 position for -48 Vdc).

4.13 A loopback amplifier gain option (Fig. 51) on the DAS 829A-L1A CIU permits the CIU to terminate channels with an end-to-end loss of either 8 or 16 dB. A plug-in strap should be placed in the option position specified on the service order (8 position for 8-dB channels and 16 position for 16-dB channels).

TABLE A

CALL DIRECTOR KEY ASSIGNMENT

Key Assignment for 30-button Call Director

Key Assignment for 18-button Call Director

REL (NOTE 1)	RING (NOTE 4)	6	12	18
DDD1A (NOTE 2)	1 (NOTE 5)	7	13	19
DDD2A (NOTE 2)	2	8	14	20
DDD1B (NOTE 3)	3	9	15	21
DDD2B (NOTE 3)	4	10	16	22
HOLD	5	11	17	23

Note 1: When switched dial backup service is provided, the 1st pickup key of the 1st key module will be nonlocking and will be designated REL.

Note 2: When dial backup channel A is provided, designations DDD1A and DDD2A will be provided as shown.

Note 3: When dial backup channel B is provided, designations DDD1B and DDD2B will be provided as shown.

Note 4: When alternate voice service is provided, the 1st pickup key of the 2nd key module will be nonlocking and will be designated RING.

Note 5: Pickup keys numbered 1 to 23 are used to control alternate voice arrangements and/or switched dial backup arrangements provided for 4-wire private lines designated 1 through 23. The numbered pickup keys will be identified in one of the following four ways:

(a) BLANK KEY — Provided when key is not used to control alternate voice or switched dial backup service.

(b) TALK N — Provided when key is used to control the alternate voice arrangement for 4-wire private line designated N.

(c) DBU N — Provided when key is used to control the switched dial backup arrangement for 4-wire private line designated N.

(d) TALK-DBU N — Provided when key is used to control the alternate voice and the switched dial backup arrangement for 4-wire private line designated N.

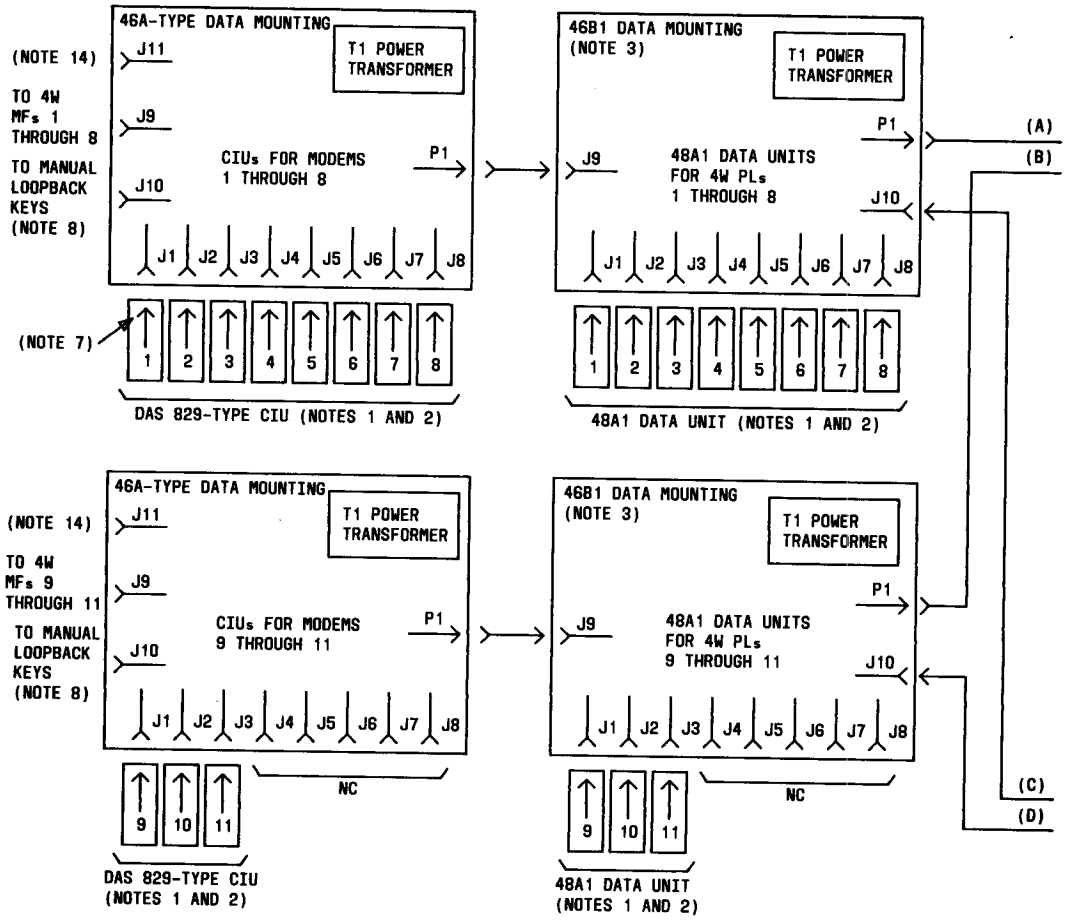


Fig. 42—Multiple 4-Wire FD or FDA Arrangement With Switched 4-Wire Dial Backup Service for 11 Modems or Less (Sheet 1 of 3)

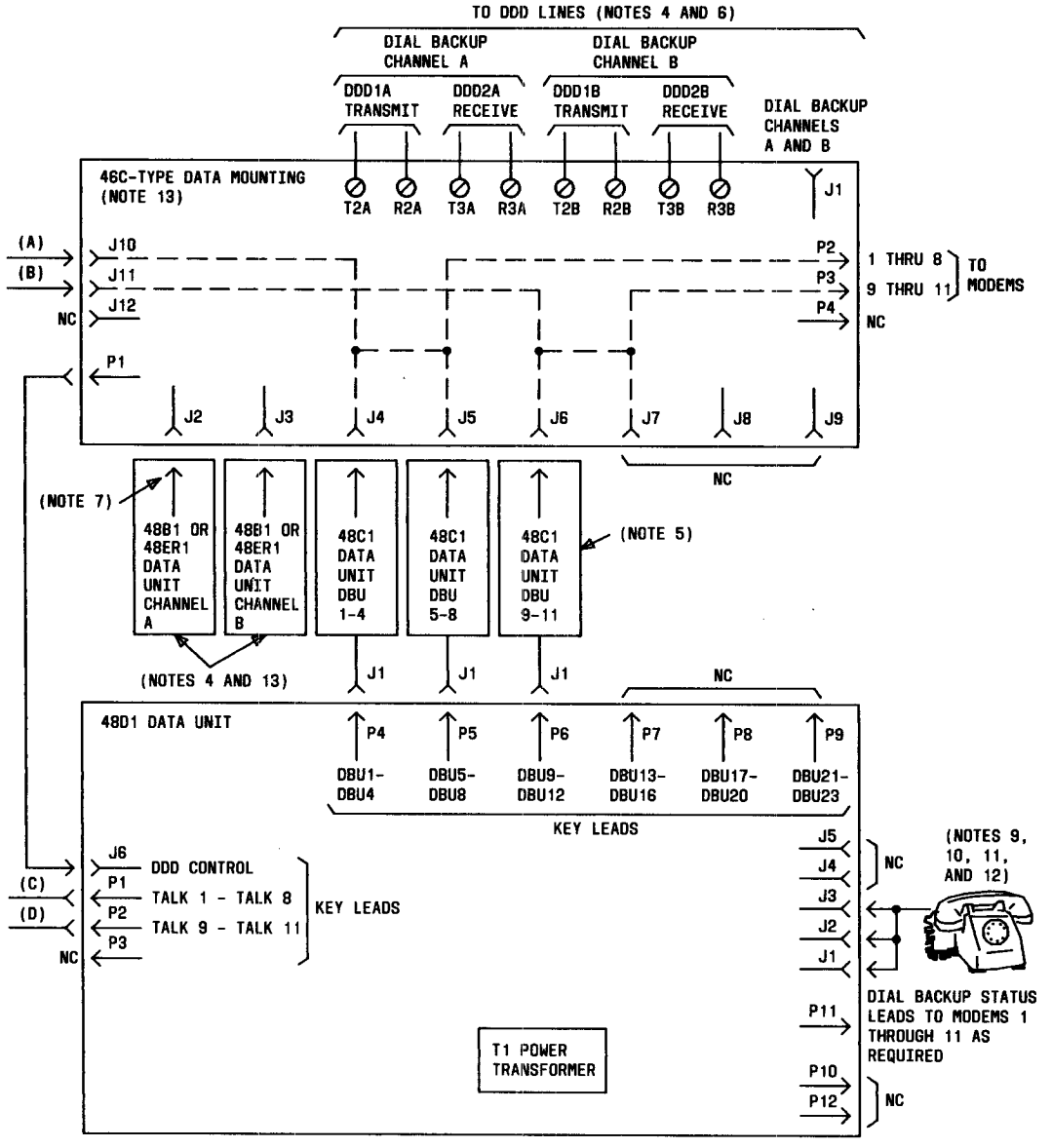


Fig. 42—Multiple 4-Wire FD or FDA Arrangement With Switched 4-Wire Dial Backup Service for 11 Modems or Less (Sheet 2 of 3)

NOTES:

1. A MAXIMUM OF ELEVEN FDA ARRANGEMENTS WITH SWITCHED DIAL BACKUP SERVICE TO EITHER ONE OF TWO DIAL BACKUP CHANNELS CAN BE PROVIDED AS SHOWN. AN FDA ARRANGEMENT IS PROVIDED FOR THE NTH 4W PL WHEN THE NTH DAS 829-TYPE CIU AND 48A1 DATA UNIT ARE PROVIDED. UNUSED POSITIONS IN BOTH THE 46A-TYPE AND THE 46B1 DATA MOUNTINGS ARE LEFT UNTERMINATED.
2. AN FD ARRANGEMENT IS PROVIDED FOR THE NTH 4W PL WHEN THE NTH DAS 829-TYPE CIU IS PROVIDED AND THE NTH 48A1 DATA UNIT IS NOT PROVIDED. UNUSED POSITIONS IN THE 46B1 DATA MOUNTING ARE LEFT UNTERMINATED.
3. WHEN ALTERNATE VOICE SERVICE IS NOT REQUIRED, OR ONLY REQUIRED ON SOME PORTION OF THE 4W PLs PROVIDED, IT MAY BE POSSIBLE TO ELIMINATE ALL, OR PART, OF THE INDICATED 46B1 DATA MOUNTINGS.
4. THE ARRANGEMENT SHOWN PROVIDES TWO DIAL BACKUP CHANNELS. WHEN ONE OF THE BACKUP CHANNELS IS NOT REQUIRED, THE 48B1 OR 48ER1 DATA UNIT ASSOCIATED WITH THAT CHANNEL AND THE DDD LINES REQUIRED FOR THAT CHANNEL ARE NOT PROVIDED.
5. WHEN SWITCHED DIAL BACKUP SERVICE IS NOT REQUIRED ON SOME PORTION OF THE SERVICE, IT MAY BE POSSIBLE TO REDUCE THE NUMBER OF 48C1 DATA UNITS REQUIRED.
6. FOR NONREGISTERED ARRANGEMENTS, THE DDD LINES MAY BE TERMINATED THROUGH USE OF THE SCREW TERMINALS OR CONNECTOR J1. FOR REGISTERED ARRANGEMENTS, THE SCREW TERMINALS MUST BE USED. THE REQUIRED CONNECTIONS ARE SHOWN IN FIG. 45.
7. PLUG SHOWN FOR EITHER THE DAS 829-TYPE CIU OR THE 48-TYPE DATA UNIT IS THE 40-PIN PLUG FORMED BY THE TERMINATIONS ON THE EDGE OF THE PRINTED WIRING BOARD.
8. MANUAL LOOPBACK KEYS ARE NORMALLY NOT PROVIDED.
9. A 630DAM OR 2630DAM 18-BUTTON KEY TELEPHONE SET MUST BE PROVIDED FOR CONTROL OF THE 2 BY 11 SWITCHING MATRIX AND ALTERNATE VOICE CIRCUITS. CONVERT THE TELEPHONE SET AS FOLLOWS:

SCREW TERMINAL LEADS				
COLOR	W-O	V-G	O-W	O-BK
REMOVE FROM	7	5	5	24
CONNECT TO	TAPE AND STORE	7	7	7

10. TO PROVIDE THE SERVICE SHOWN THE TELEPHONE KEY STRIP SHALL BE AS FOLLOWS:

REL	RING	TALK-DBU6
DDD1A	TALK-DBU1	TALK-DBU7
DDD2A	TALK-DBU2	TALK-DBU8
DDD1B	TALK-DBU3	TALK-DBU9
DDD2B	TALK-DBU4	TALK-DBU10
HOLD	TALK-DBU5	TALK-DBU11

WHEN SOME PORTION OF THE SERVICE IS NOT PROVIDED THE KEY STRIPS SHALL BE MODIFIED ACCORDINGLY.

11. CONVERT THE 1ST PICKUP KEY OF THE 1ST KEY MODULE (REL) TO A NONLOCKING KEY.
12. CONVERT THE 1ST PICKUP KEY OF THE 2ND KEY MODULE (RING) TO A NONLOCKING KEY.
13. FOR REGISTERED ARRANGEMENTS, THE 48ER1 DATA UNIT INSTALLED IN A 46C2 DATA MOUNTING IS REQUIRED.
14. CONNECTOR J1 PROVIDES ACCESS TO THE SIMPLEX PAIR SX1 AND SX2 OF THE DAS 829-TYPE CIU. THIS CONNECTOR IS NOT PROVIDED ON THE 46A1 DATA MOUNTING.

Fig. 42—Multiple 4-Wire FD or FDA Arrangement With Switched 4-Wire Dial Backup Service for 11 Modems or Less (Sheet 3 of 3)

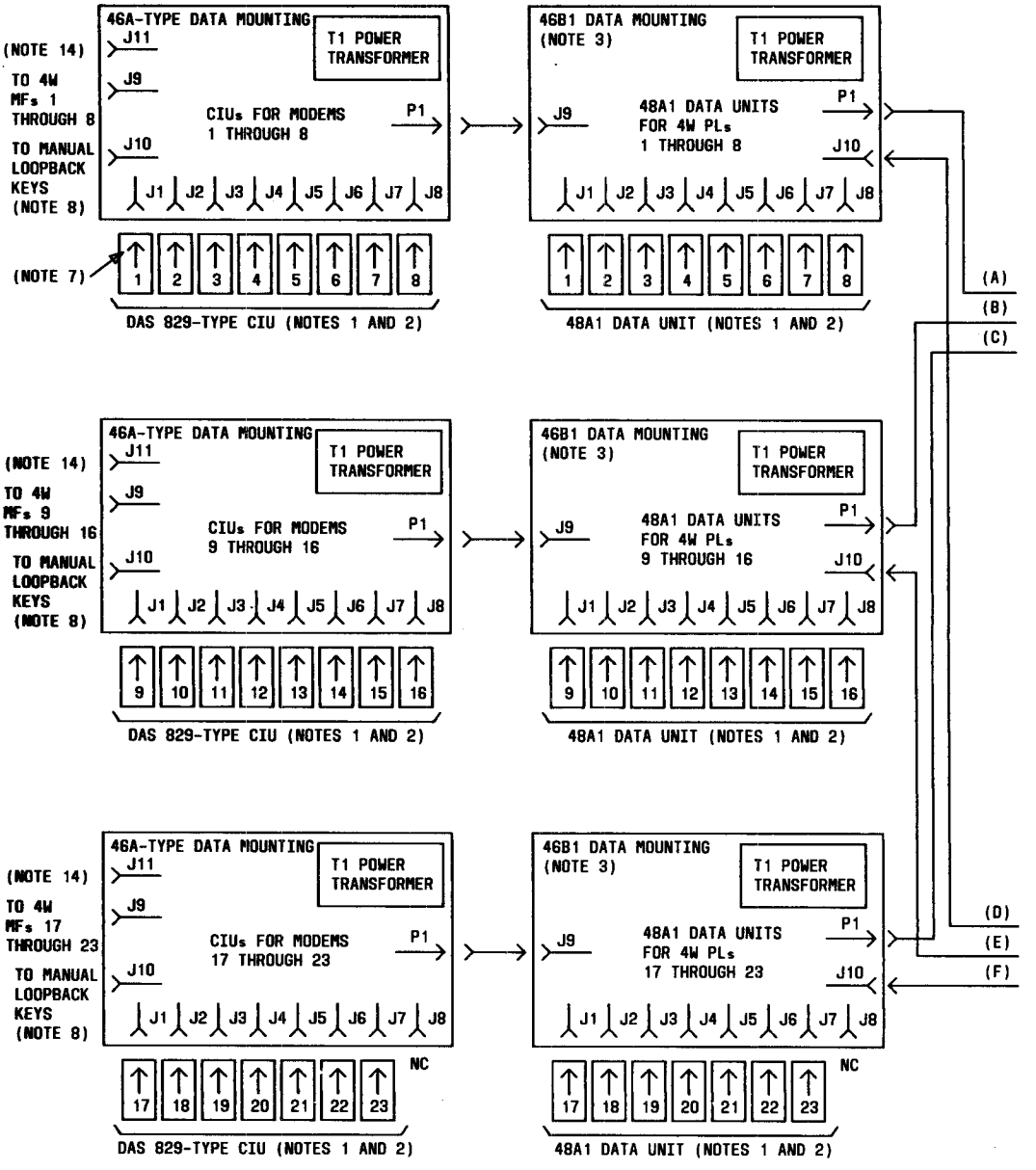


Fig. 43—Multiple 4-Wire FD or FDA Arrangement With Switched 4-Wire Dial Backup Service for 23 Modems or Less (Sheet 1 of 3)

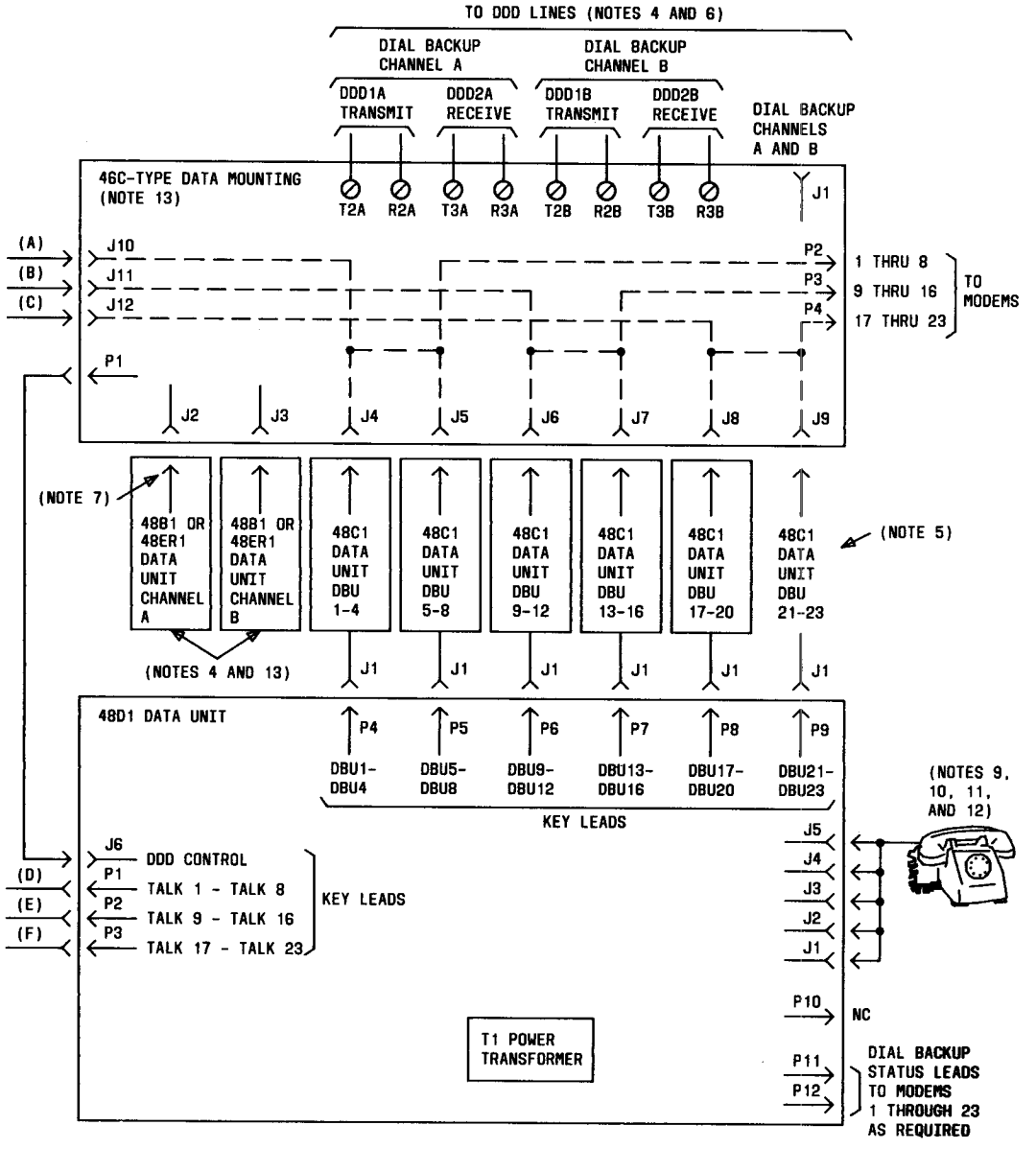


Fig. 43—Multiple 4-Wire FD or FDA Arrangement With Switched 4-Wire Dial Backup Service for 23 Modems or Less (Sheet 2 of 3)

NOTES:

1. A MAXIMUM OF TWENTY-THREE FDA ARRANGEMENTS WITH SWITCHED DIAL BACKUP SERVICE TO EITHER ONE OF TWO DIAL BACKUP CHANNELS CAN BE PROVIDED AS SHOWN. AN FDA ARRANGEMENT IS PROVIDED FOR THE NTH 4W PL WHEN THE NTH DAS 829-TYPE CIU AND 48A1 DATA UNIT ARE PROVIDED. UNUSED POSITIONS IN BOTH THE 46A-TYPE AND THE 46B1 DATA MOUNTINGS ARE LEFT UNTERMINATED.
2. AN FD ARRANGEMENT IS PROVIDED FOR THE NTH 4W PL WHEN THE NTH DAS 829-TYPE CIU IS PROVIDED AND THE NTH 48A1 DATA UNIT IS NOT PROVIDED. UNUSED POSITIONS IN THE 46B1 DATA MOUNTING ARE LEFT UNTERMINATED.
3. WHEN ALTERNATE VOICE SERVICE IS NOT REQUIRED, OR ONLY REQUIRED ON SOME PORTION OF THE 4W PLs PROVIDED, IT MAY BE POSSIBLE TO ELIMINATE ALL, OR PART, OF THE INDICATED 46B1 DATA MOUNTINGS.
4. THE ARRANGEMENT SHOWN PROVIDES TWO DIAL BACKUP CHANNELS. WHEN ONE OF THE BACKUP CHANNELS IS NOT REQUIRED, THE 48B1 OR 48ER1 DATA UNIT ASSOCIATED WITH THAT CHANNEL AND THE DDD LINES REQUIRED FOR THAT CHANNEL ARE NOT PROVIDED.
5. WHEN SWITCHED DIAL BACKUP SERVICE IS NOT REQUIRED ON SOME PORTION OF THE SERVICE, IT MAY BE POSSIBLE TO REDUCE THE NUMBER OF 48C1 DATA UNITS REQUIRED.
6. FOR NONREGISTERED ARRANGEMENTS, THE DDD LINES MAY BE TERMINATED THROUGH USE OF THE SCREW TERMINALS OR CONNECTOR J1. FOR REGISTERED ARRANGEMENTS, THE SCREW TERMINALS MUST BE USED. THE REQUIRED CONNECTIONS ARE SHOWN IN FIG. 45.
7. PLUG SHOWN FOR EITHER THE DAS 829-TYPE CIU OR THE 48-TYPE DATA UNIT IS THE 40-PIN PLUG FORMED BY THE TERMINATIONS ON THE EDGE OF THE PRINTED WIRING BOARD.
8. MANUAL LOOPBACK KEYS ARE NORMALLY NOT PROVIDED.
9. A 631DAM OR 2631DAM 30-BUTTON KEY TELEPHONE SET MUST BE PROVIDED FOR CONTROL OF THE 2 BY 23 SWITCHING MATRIX AND ALTERNATE VOICE CIRCUITS. CONVERT THE TELEPHONE SET AS FOLLOWS:

SCREW TERMINAL LEADS				
COLOR	W-O	V-G	O-W	O-BK
REMOVE FROM	7	5	5	24
CONNECT TO	TAPE AND STORE	7	7	7

10. TO PROVIDE THE SERVICE SHOWN THE TELEPHONE KEY STRIP SHALL BE AS FOLLOWS:

REL	RING	TALK-DBU6	TALK-DBU12	TALK-DBU18
DDD1A	TALK-DBU1	TALK-DBU7	TALK-DBU13	TALK-DBU19
DDD2A	TALK-DBU2	TALK-DBU8	TALK-DBU14	TALK-DBU20
DDD1B	TALK-DBU3	TALK-DBU9	TALK-DBU15	TALK-DBU21
DDD2B	TALK-DBU4	TALK-DBU10	TALK-DBU16	TALK-DBU22
HOLD	TALK-DBU5	TALK-DBU11	TALK-DBU17	TALK-DBU23

WHEN SOME PORTION OF THE SERVICE IS NOT PROVIDED THE KEY STRIPS SHALL BE MODIFIED ACCORDINGLY.

11. CONVERT THE 1ST PICKUP KEY OF THE 1ST KEY MODULE (REL) TO A NONLOCKING KEY.
12. CONVERT THE 1ST PICKUP KEY OF THE 2ND KEY MODULE (RING) TO A NONLOCKING KEY.
13. FOR REGISTERED ARRANGEMENTS, THE 48ER1 DATA UNIT INSTALLED IN A 46C2 DATA MOUNTING IS REQUIRED.
14. CONNECTOR J11 PROVIDES ACCESS TO THE SIMPLEX PAIR SX1 AND SX2 OF THE DAS 829-TYPE CIU. THIS CONNECTOR IS NOT PROVIDED ON THE 46A1 DATA MOUNTING.

Fig. 43—Multiple 4-Wire FD or FDA Arrangement With Switched 4-Wire Dial Backup Service for 23 Modems or Less (Sheet 3 of 3)

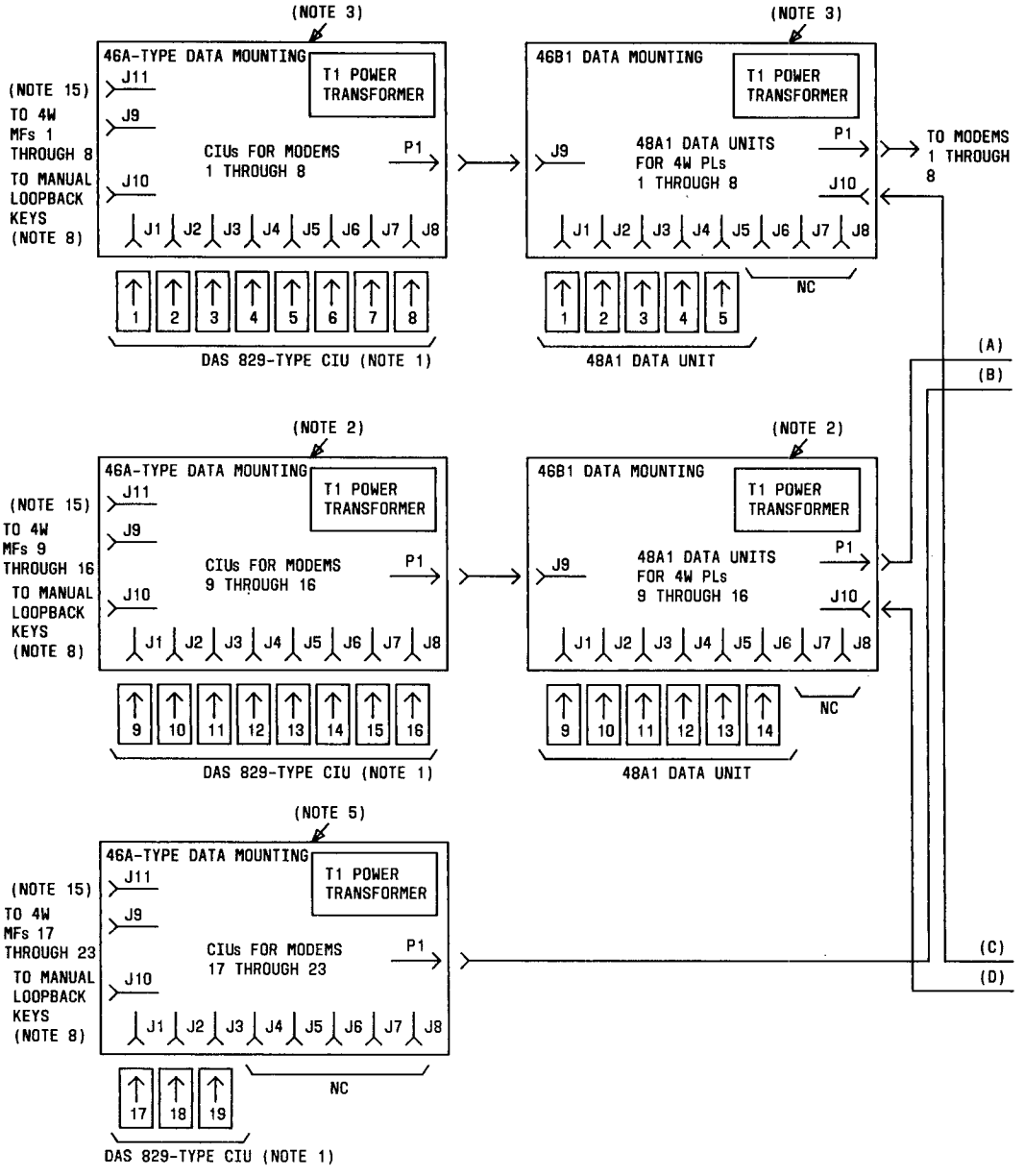


Fig. 44—Multiple 4-Wire FD and FDA Arrangements With and Without Switched 4-Wire Dial Backup Service (Sheet 1 of 3)

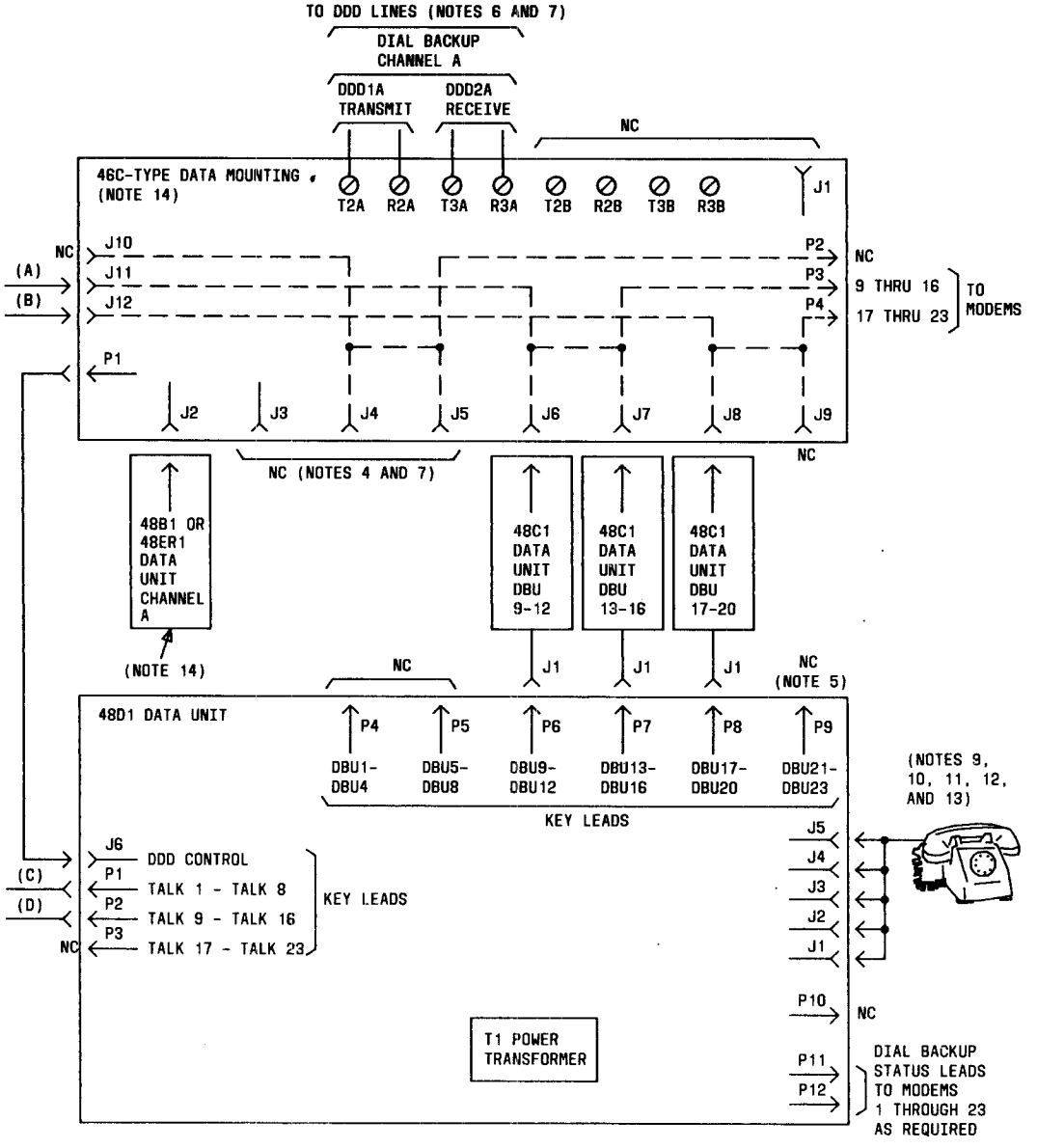


Fig. 44—Multiple 4-Wire FD and FDA Arrangements With and Without Switched 4-Wire Dial Backup Service (Sheet 2 of 3)

NOTES:

1. THE ARRANGEMENT SHOWN ILLUSTRATES THE VARIETY OF SERVICES THAT CAN BE CONTROLLED THROUGH USE OF A 30-BUTTON KEY TELEPHONE SET. THE ARRANGEMENT SHOWN PROVIDES ELEVEN FDA ARRANGEMENTS AND EIGHT FD ARRANGEMENTS. SWITCHED DIAL BACKUP SERVICE, TO ONE DIAL BACKUP CHANNEL, IS PROVIDED FOR SIX OF THE FDA ARRANGEMENTS AND FIVE OF THE FD ARRANGEMENTS.
2. A MAXIMUM OF EIGHT FDA ARRANGEMENTS WITH SWITCHED DIAL BACKUP SERVICE TO ONE DIAL BACKUP CHANNEL CAN BE PROVIDED FOR 4W PLs 9 THROUGH 16 WITH THE INDICATED 46A-TYPE AND 46B1 DATA MOUNTINGS. POSITIONS 15 AND 16 OF THE 46B1 DATA MOUNTING ARE LEFT UNTERMINATED. THESE POSITIONS PROVIDE FD ARRANGEMENTS.
3. A MAXIMUM OF EIGHT FDA ARRANGEMENTS CAN BE PROVIDED FOR 4W PLs 1 THROUGH 8 WITH THE INDICATED 46A-TYPE AND 46B1 DATA MOUNTINGS. POSITIONS 6, 7 AND 8 OF THE 46B1 DATA MOUNTING ARE LEFT UNTERMINATED. THESE POSITIONS PROVIDE FD ARRANGEMENTS. THESE DATA MOUNTINGS ARE NOT CONNECTED TO THE 46C-TYPE DATA MOUNTING AS SWITCHED DIAL BACKUP SERVICE IS NOT REQUIRED. THE 46B1 DATA MOUNTING IS CONNECTED TO THE 48D1 DATA UNIT TO PROVIDE FOR KEY CONTROL OF THE FDA ARRANGEMENTS ON 4W PLs 1 THROUGH 5.
4. THE 48C1 DATA UNITS PROVIDING SWITCHING MATRICES FOR MODEMS 1 THROUGH 4 AND 5 THROUGH 8 ARE NOT PROVIDED AS SWITCHED DIAL BACKUP SERVICE IS NOT REQUIRED FOR THESE 4W PLs.
5. A MAXIMUM OF SEVEN FD ARRANGEMENTS WITH SWITCHED DIAL BACKUP SERVICE TO ONE DIAL BACKUP CHANNEL CAN BE PROVIDED FOR 4W PLs 17 THROUGH 23 WITH THE INDICATED 46A-TYPE DATA MOUNTING. POSITIONS 17, 18 AND 19 OF THE 46A-TYPE DATA MOUNTING PROVIDE FOR THREE FD ARRANGEMENTS. THE SWITCHING MATRIX (48C1 DATA UNIT) REQUIRED TO PROVIDE SWITCHED DIAL BACKUP SERVICE FOR POSITIONS 17 THROUGH 20 IS PROVIDED. THE SWITCHING MATRIX FOR POSITIONS 21 THROUGH 23 IS NOT PROVIDED AS THESE LINES ARE NOT TERMINATED. IF LINES 21 THROUGH 23 ARE TO BE TERMINATED THE SWITCHING MATRIX FOR THESE POSITIONS IS REQUIRED.
6. THE SCREW TERMINALS ARE USED TO TERMINATE THE PAIR OF DDD LINES REQUIRED TO PROVIDE DIAL BACKUP CHANNEL A. THE REQUIRED CONNECTIONS ARE SHOWN IN FIG. 45. THE 48B1 OR 48ER1 DATA UNIT REQUIRED FOR CHANNEL A IS PROVIDED.
7. DIAL BACKUP CHANNEL B IS NOT PROVIDED; HENCE THE 48B1 OR 48ER1 DATA UNIT REQUIRED FOR CHANNEL B IS NOT PROVIDED.
8. MANUAL LOOPBACK KEYS ARE NORMALLY NOT PROVIDED.
9. A 631DAM OR 2631DAM 30-BUTTON KEY TELEPHONE SET MUST BE PROVIDED FOR CONTROL OF THE SWITCHING MATRIX AND ALTERNATE VOICE CIRCUITS. CONVERT THE TELEPHONE SET AS FOLLOWS:

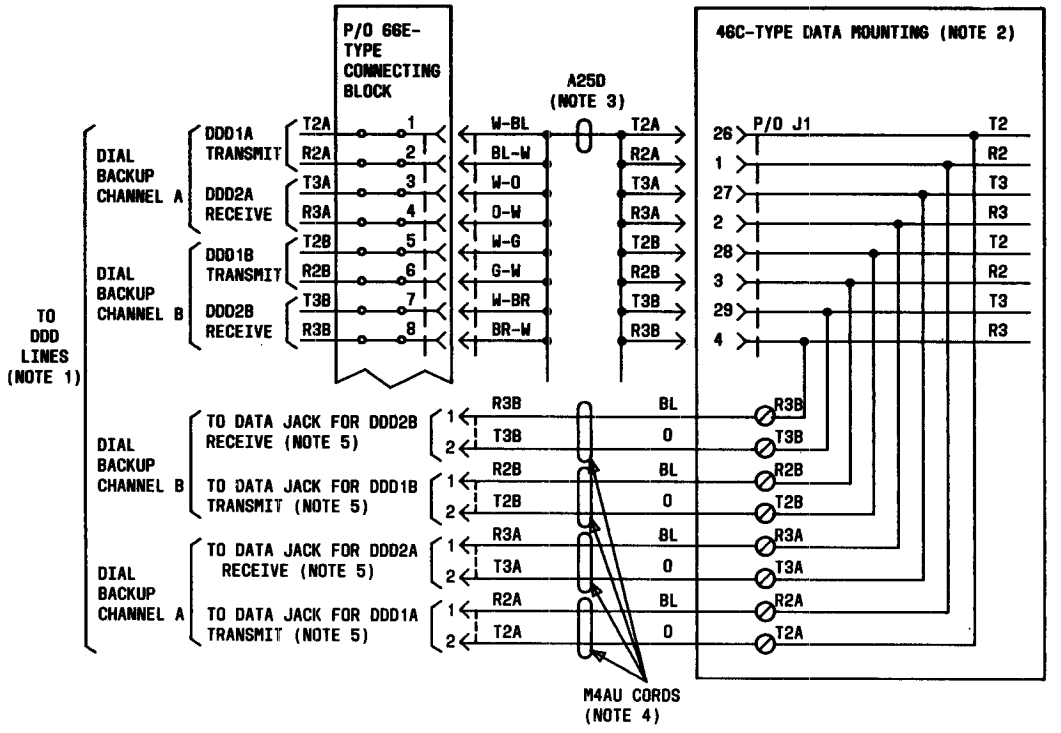
SCREW TERMINAL LEADS				
COLOR	W-O	V-G	O-W	O-BK
REMOVE FROM	7	5	5	24
CONNECT TO	TAPE AND STORE	7	7	7

10. TO PROVIDE THE SERVICE SHOWN THE TELEPHONE KEY STRIP SHALL BE AS FOLLOWS:

REL	RING		TALK-DBU12	DBU18
DDD1A	TALK 1		TALK-DBU13	DBU19
DDD2A	TALK 2		TALK-DBU14	
	TALK 3	TALK-DBU9	DBU15	
	TALK 4	TALK-DBU10	DBU16	
HOLD	TALK 5	TALK-DBU11	DBU17	

11. THE PICKUPS KEYS PROVIDING CONTROL OF 4W PLs ARE IDENTIFIED AS FOLLOWS:
    DBU N - CONTROLS THE SWITCHING MATRIX FOR POSITION N.
    TALK N - CONTROLS THE ALTERNATE VOICE CIRCUIT FOR POSITION N.
    TALK-DBU N - CONTROLS THE ALTERNATE VOICE AND SWITCHING MATRIX FOR POSITION N.
    BLANK - ALTERNATE VOICE CIRCUIT NOT PROVIDED AND SWITCHING MATRIX IS NOT PROVIDED OR IS NOT USED.
12. CONVERT THE 1ST PICKUP KEY OF THE 1ST KEY MODULE (REL) TO A NONLOCKING KEY.
13. CONVERT THE 1ST PICKUP KEY OF THE 2ND KEY MODULE (RING) TO A NONLOCKING KEY.
14. FOR REGISTERED ARRANGEMENTS, THE 48ER1 DATA UNIT INSTALLED IN A 46C2 DATA MOUNTING IS REQUIRED.
15. CONNECTOR J11 PROVIDES ACCESS TO THE SIMPLEX PAIR SX1 AND SX2 OF THE DAS 829-TYPE CIU. THIS CONNECTOR IS NOT PROVIDED ON THE 46A1 DATA MOUNTING.

Fig. 44—Multiple 4-Wire FD and FDA Arrangements With and Without Switched 4-Wire Dial Backup Service (Sheet 3 of 3)



NOTES:
1. FOR NONREGISTERED ARRANGEMENTS, THE DDD LINES MAY BE TERMINATED THROUGH USE OF THE SCREW TERMINALS OR CONNECTOR J1. FOR REGISTERED ARRANGEMENTS, THE SCREW TERMINALS MUST BE USED.
2. FOR NONREGISTERED ARRANGEMENTS, THE 46C1 OR 46C2 DATA MOUNTING MAY BE USED. FOR REGISTERED ARRANGEMENTS, THE 46C2 DATA MOUNTING MUST BE USED.
3. EXTEND WITH B25A AS REQUIRED.
4. TAPE AND STORE UNUSED LEADS.
5. USE DATA JACK USOC RJ41S WITH SWITCH SET TO FLL.

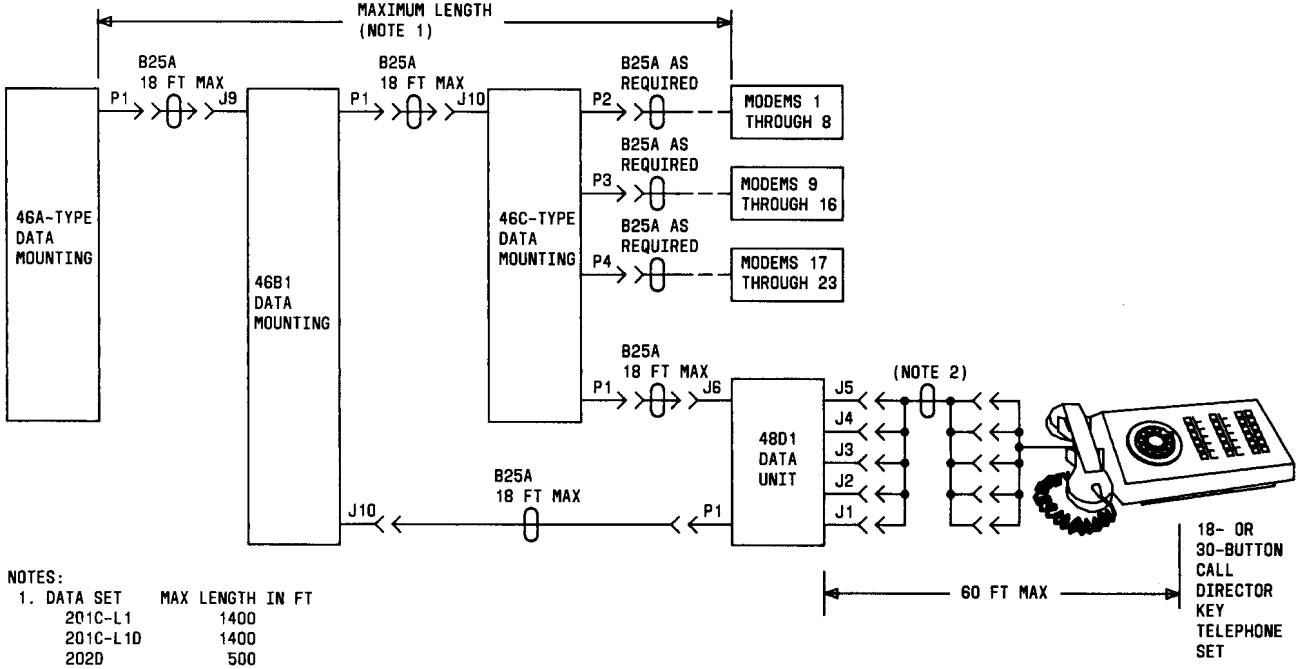
Fig. 45—46C-Type Data Mounting—Connections to DDD Lines

Note: Alternate voice and/or dial backup service cannot be provided for CIUs that terminate 8-dB channels.

4.14 A sealing current option (Fig. 51) is provided on the DAS 829A-L1A CIU. If this option is specified on the service order, a plug-in strap should be placed in the sealing current option (SC) position. If the option is not specified on the service order, the plug-in strap should be placed in the sealing current storage (ST) position.

4.15 A line impedance option (Fig. 51) on the DAS 829A-L1A CIU provides a 600- or 1200-ohm line termination. The two plug-in straps used for line termination should be placed in the 600-ohm or 1200-ohm option positions as specified on the service order.

4.16 The transmit (TRANS) attenuator (Fig. 51) and the receive (REC) attenuator on the DAS 829A-L1A CIU should be set to the attenuation values specified on the service order, as described in paragraph 4.03.



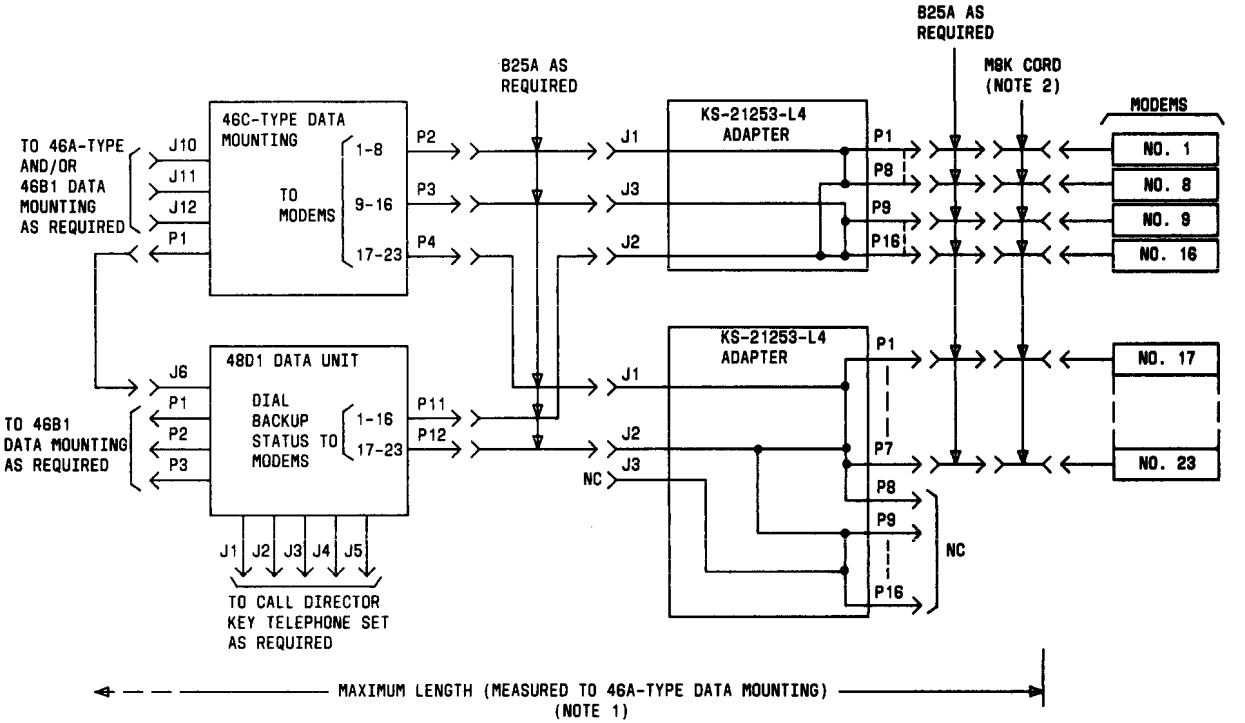
NOTES:

1. DATA SET — MAX LENGTH IN FT

DATA SET	MAX LENGTH IN FT
201C-L1	1400
201C-L1D	1400
202D	500
202T	200
208A	1400
209A	1400

2. FOR THE 18-BUTTON CALL DIRECTOR, USE B75A CABLE AS REQUIRED AND CONNECT TO J1 THROUGH J3 ON THE 48D1 DATA UNIT.
   FOR THE 30-BUTTON CALL DIRECTOR, USE B75A AND B50A CABLES AS REQUIRED AND CONNECT TO J1 THROUGH J5 ON THE 48D1 DATA UNIT.

Fig. 46—Multiple Arrangement Showing Cable Length Restrictions



NOTES:

1. DATA SET — MAX LENGTH IN FT

DATA SET	MAX LENGTH IN FT
201C-L1	1400
201C-L1D	1400
202D	500
202T	200
208A	1400
209A	1400

2. THE M8K CORD IS SUPPLIED AND USED WITH ALL DATA SETS EXCEPT 202D. USE D50AA-3 IN PLACE OF D6AA-61 SUPPLIED WITH DATA SET 202D.

Fig. 47—Multiple Arrangement Using KS-21253-L4 Adapter for Dial Backup Status to Modems

TABLE B

COMMON CONTROL OF FDA ARRANGEMENTS PROVIDED THROUGH USE OF A 30-BUTTON CALL DIRECTOR, WITH AND WITHOUT SWITCHED DIAL BACKUP SERVICE

NUMBER OF FD AND/OR FDA ARRANGEMENTS PROVIDED WITH SWITCHED DIAL BACKUP SERVICE	NUMBER OF PICKUP KEYS AVAILABLE FOR CONTROL OF FDA ARRANGEMENTS	PICKUP KEY ASSIGNMENT (SEE TABLE A)	
		FOR SWITCHED DIAL BACKUP SERVICE. KEYS DESIGNATED DBU OR TALK-DBU	FOR FDA SERVICE. KEYS DESIGNATED TALK
1 through 7	1 through 16	17 through 23	1 through 16
8 through 15	1 through 8	9 through 23	1 through 8
16	1 through 7	1 through 16	17 through 23
17 through 23	none	1 through 23	none

E. DAS 829B-L1A CIU

4.17 A power supply option (Fig. 52) on the DAS 829B-L1A CIU permits operation from a 24 Vac, -24 Vdc, or -48 Vdc power source. A plug-in strap should be placed in the option position specified on the service order (N position for 24 Vac or -24 Vdc, and -48 position for -48 Vdc).

4.18 A loopback amplifier gain option (Fig. 52) on the DAS 829B-L1A CIU permits the CIU to terminate channels with an end-to-end loss of either 8 or 16 dB. A plug-in strap should be placed in the option position specified on the service order (8 position for 8-dB channels and 16 position for 16-dB channels).

> ***Note:*** Alternate voice and/or dial backup service cannot be provided for CIUs that terminate 8-dB channels.

4.19 A sealing current option (Fig. 52) is provided on the DAS 829B-L1A CIU. If this option is specified on the service order, a plug-in strap should be placed in the sealing current option (SC) position. If the option is not specified on the service order, the plug-in strap should be placed in the sealing current storage (ST) position.

4.20 A line impedance option (Fig. 52) on the DAS 829B-L1A CIU provides a 150-, 600-, or 1200-ohm line termination. The four plug-in straps used for line termination should be placed in the 150-ohm, 600-ohm, or 1200-ohm positions as specified on the service order.

4.21 The transmit (TRANS) attenuator (Fig. 52) on the DAS 829B-L1A CIU should be set to the attenuation value specified on the service order, as described in paragraph 4.03.

4.22 A coarse gain option (Fig. 52) and a fine gain control on the DAS 829B-L1A CIU provide adjustment for the output level of the CIU receive amplifier. A plug-in strap should be placed in the receive coarse gain option position (GAIN—+10, 0, -10, -20) specified on the service order. The receive fine gain control is variable from 0 to 10 dB and is accessible through a hole in the faceplate of the CIU. Adjustment of the fine gain control is described in Section 598-082-500.

F. DAS 829C-L1A CIU

4.23 A power supply option (Fig. 53) on the DAS 829C-L1A CIU permits operation from a 24 Vac, -24 Vdc, or -48 Vdc power source. A plug-in strap should be placed in the option position specified on the service order (N position for 24 Vac or -24 Vdc, and -48 position for -48 Vdc).

4.24 A loopback amplifier gain option (Fig. 53) on the DAS 829C-L1A CIU permits the CIU to terminate channels with an end-to-end loss of either 8 or 16 dB. A plug-in strap should be placed in the option position specified on the service order

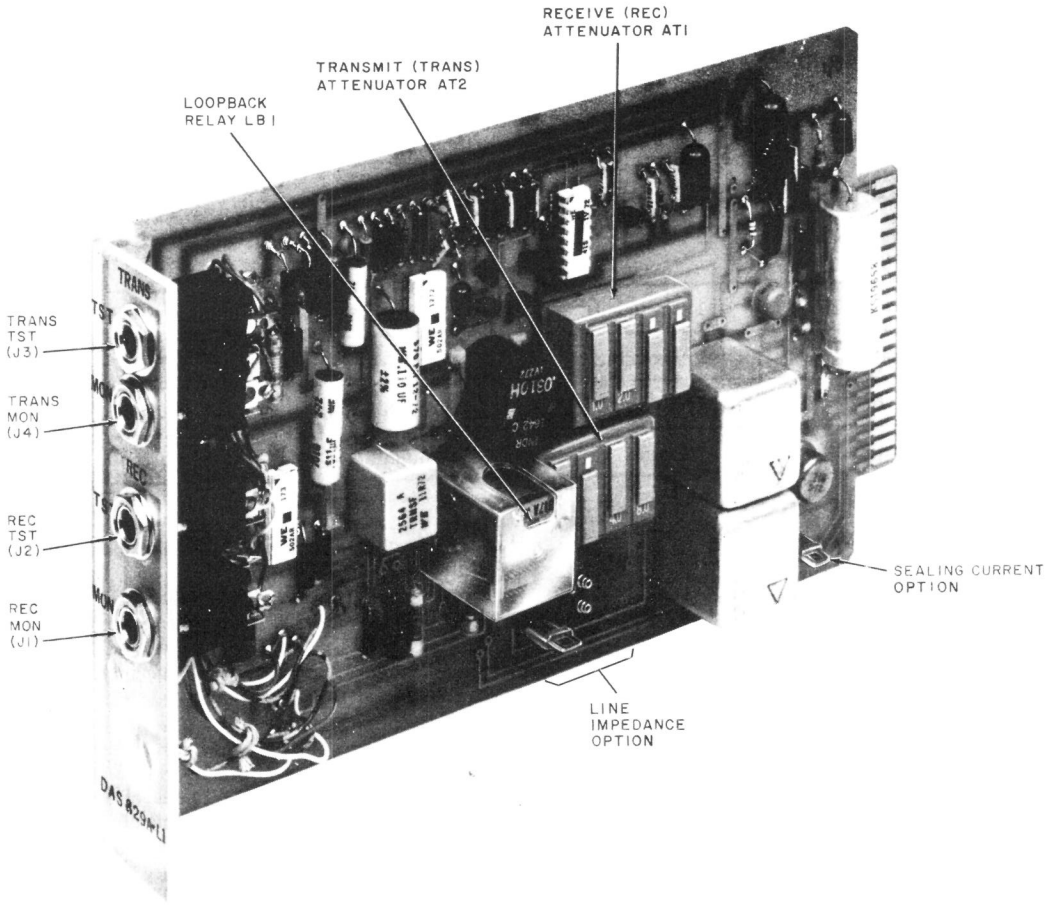


Fig. 48—DAS 829A-L1 CIU

(8 position for 8-dB channels and 16 position for 16-dB channels).

Note: Alternate voice and/or dial backup service cannot be provided for CIUs that terminate 8-dB channels.

4.25 A sealing current option (Fig. 53) is provided on the DAS 829C-L1A CIU. If this option is specified on the service order, a plug-in strap should be placed in the sealing current option (SC) position. If the option is not specified on the service order, the plug-in strap should be placed in the sealing current storage (ST) position.

4.26 A 359A or 359K equalizer equivalent option (Fig. 53) is provided on the DAS 829C-L1A CIU. This equalizer equivalent consists of a slope equalizer circuit and a line termination (1200-ohm for 359A and 600-ohm for 359K). Either the 359A or 359K equalizer equivalent should be selected as specified on the service order. The 359A equalizer equivalent is selected by inserting two plug-in straps in column 359 adjacent to the designation A. The 359K equalizer equivalent is selected by inserting

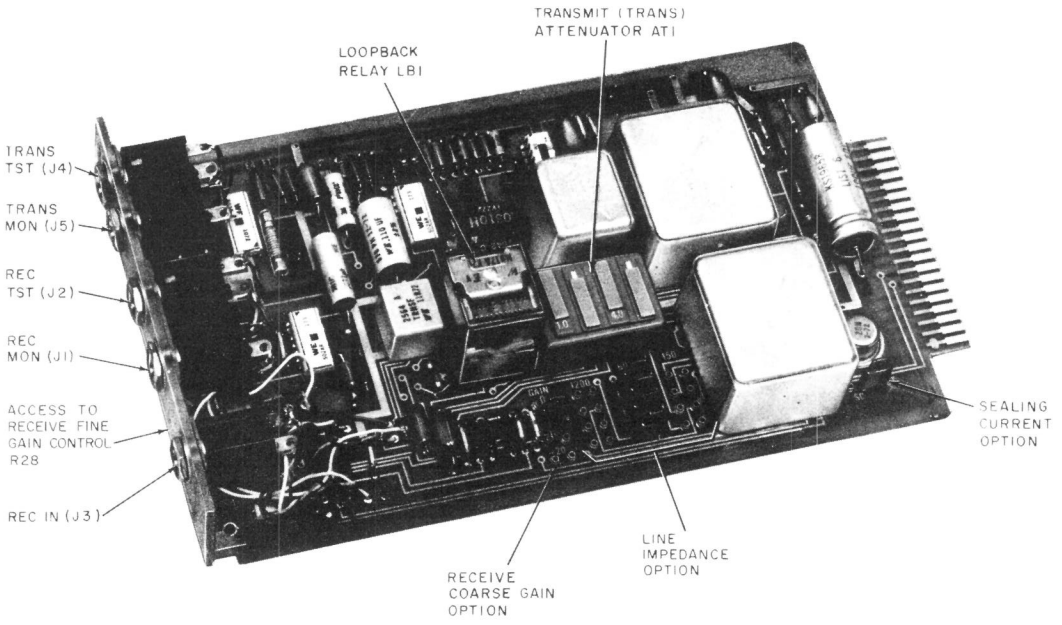


Fig. 49—DAS 829B-L1 CIU

two plug-in straps in column 359 adjacent to the designation K. After the equalizer is selected, the required equalizer characteristics are provided by inserting plug-in straps in the positions specified on the service order or the circuit layout record (CLR). The straps should be inserted in positions identified by columns A, B, C, and D and rows 1, 2, 3, and 4. Strap storage is provided to the left of columns A, B, C, and D in the four ST columns. Additional information is provided in Sections 332-104-500 and 332-116-201.

4.27 The transmit (TRANS) attenuator (Fig. 53) on the DAS 829C-L1A CIU should be set to the attenuation value specified on the service order, as described in paragraph 4.03.

4.28 A coarse gain option (Fig. 53) and a fine gain control on the DAS 829C-L1A CIU provide adjustment for the output level of the CIU receive amplifier. A plug-in strap should be placed in the receive coarse gain option position (GAIN—+20, +10, 0, -10, -20) specified on the service order. The receive fine gain control is variable from 0 to 10 dB and is accessible through a hole in the faceplate of the CIU. Adjustment of the fine gain control is described in Section 598-082-500.

G. 46A2 Data Mounting

4.29 A power supply option (Fig. 54) on the 46A2 data mounting permits operation from a 24 Vac, -24 Vdc, or -48 Vdc power source. Two plug-in straps should be placed in the option position specified on the service order (AC position for 24 Vac and DC position for -24 Vdc or -48Vdc).

H. 46B1 Data Mounting

4.30 A ringing supply option (Fig. 55) on the 46B1 data mounting uses a plug-in strap to select an internal ringing supply (plug-in strap in INT position) or an external ringing supply (plug-in strap in EXT position). When the 46B1 data mounting is used with an 830- or 2830-type key telephone set, the plug-in strap must be in the INT position. When the 46B1 data mounting is used with a 48D1 data unit or a locally engineered

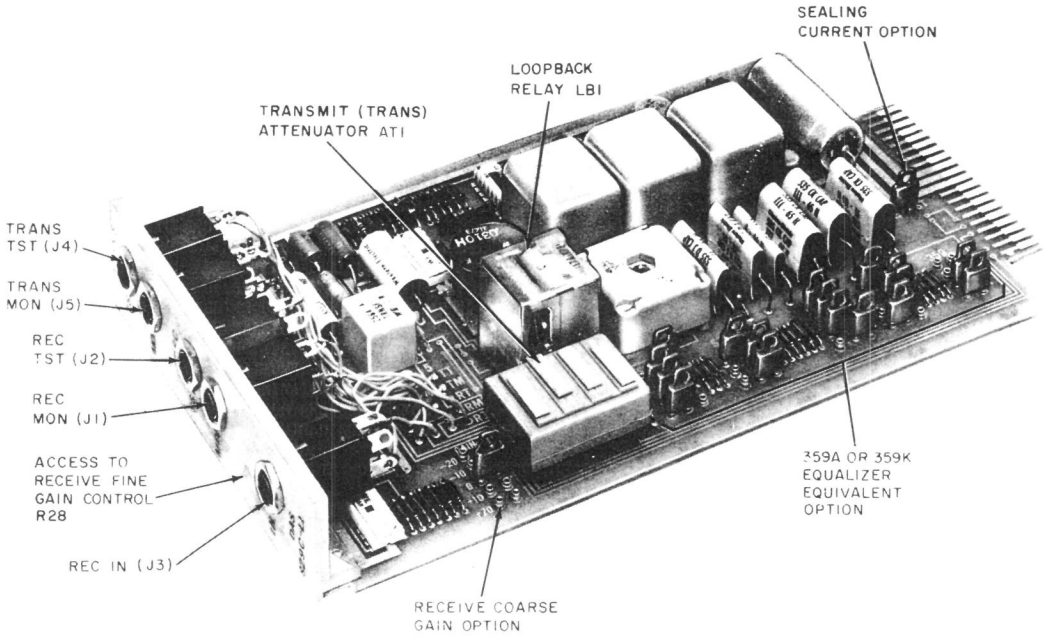


Fig. 50—DAS 829C-L1 CIU

key system, the plug-in strap must be in the EXT position.

I. 48B1 Data Unit

4.31 A slope equalizer option (Fig. 56) that inserts 4 dB of slope equalization into the receive path is provided on the 48B1 data unit. If this option is specified on the service order, a plug-in strap should be placed in the 4 position. If the option is not specified on the service order, the plug-in strap should be placed in the 0 position.

4.32 Receive gain control R9 (Fig. 56) on the 48B1 data unit provides adjustment for the output level of the receive amplifier in the data unit. Adjustment of R9 is described in Section 598-082-500.

4.33 Transmit attenuator AT1 (Fig. 56) on the 48B1 data unit is used to set the transmit signal level at the central office. This level is set as described in Section 598-082-500.

J. 48ER1 Data Unit

4.34 The 48ER1 data unit (Fig. 57) has options that must be installed prior to placing the data unit in operation. The options to be installed should be specified on the service order. Refer to Table C for a summary of the options.

4.35 ***Call Control:*** The calls required to enable the 48ER1 data unit to establish a 4-wire dial backup channel are initiated by either manual or automatic dialing.

(a) With manual dialing (option M) a key telephone set is used. If this option is specified on the service order, nine plug-in straps should be placed in the M1 through M9 positions (Fig. 58).

(b) With automatic dialing (option A), the following items are used: a station dial and a customer- or modem-provided contact; a station dial and the O/R (originate/release) switch on the faceplate of the 48ER1 data unit; or an automatic calling

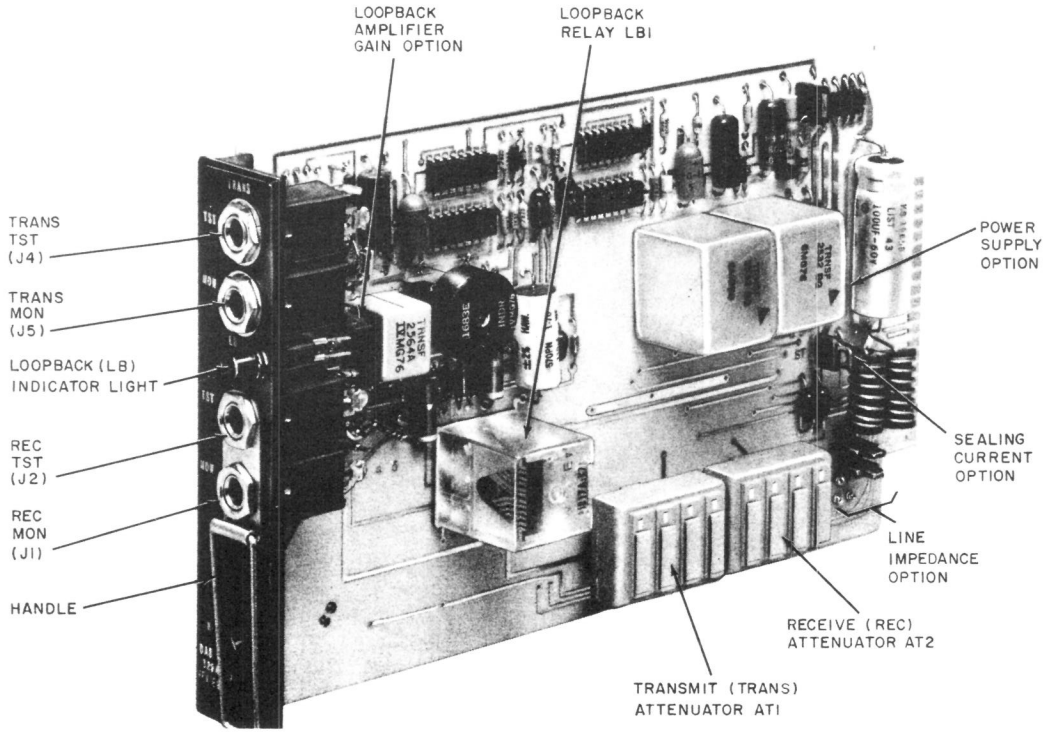


Fig. 51—DAS 829A-L1A CIU

unit (ACU) and a customer- or modem-provided contact. If this option is specified on the service order, nine plug-in straps should be placed in the A1 through A9 positions (Fig. 58).

4.36 ***Unit Control:*** Operating control of the 48ER1 data unit is provided by a key telephone set, a customer- or modem-provided contact, or the O/R (originate/release) switch on the faceplate of the 48ER1 data unit.

(a) With a key telephone set (option T), the 48ER1 data unit will establish a 4-wire dial backup channel and connect the modem to the dial backup channel when directed by control signals from the telephone set. To release the dial backup channel and return the modem to the 4-wire private line, the required control signals are again provided by the key telephone set. If this option is specified on the service order, a plug-in strap should be placed in the T position (Fig. 58).

(b) With a customer- or modem-provided contact (option D), the 48ER1 data unit and an associated station dial or ACU will attempt to establish a 4-wire dial backup channel when the customer or modem provides and maintains a contact closure. When the dial backup channel is established, the 48ER1 data unit will connect the modem to the dial backup channel. If the dial backup channel is not established within 3 minutes, the customer or modem must generate a retry request by interrupting the contact closure for a minimum of 25 ms. To release the dial backup channel and return the modem to the 4-wire private line, the customer or modem removes the contact closure. If this

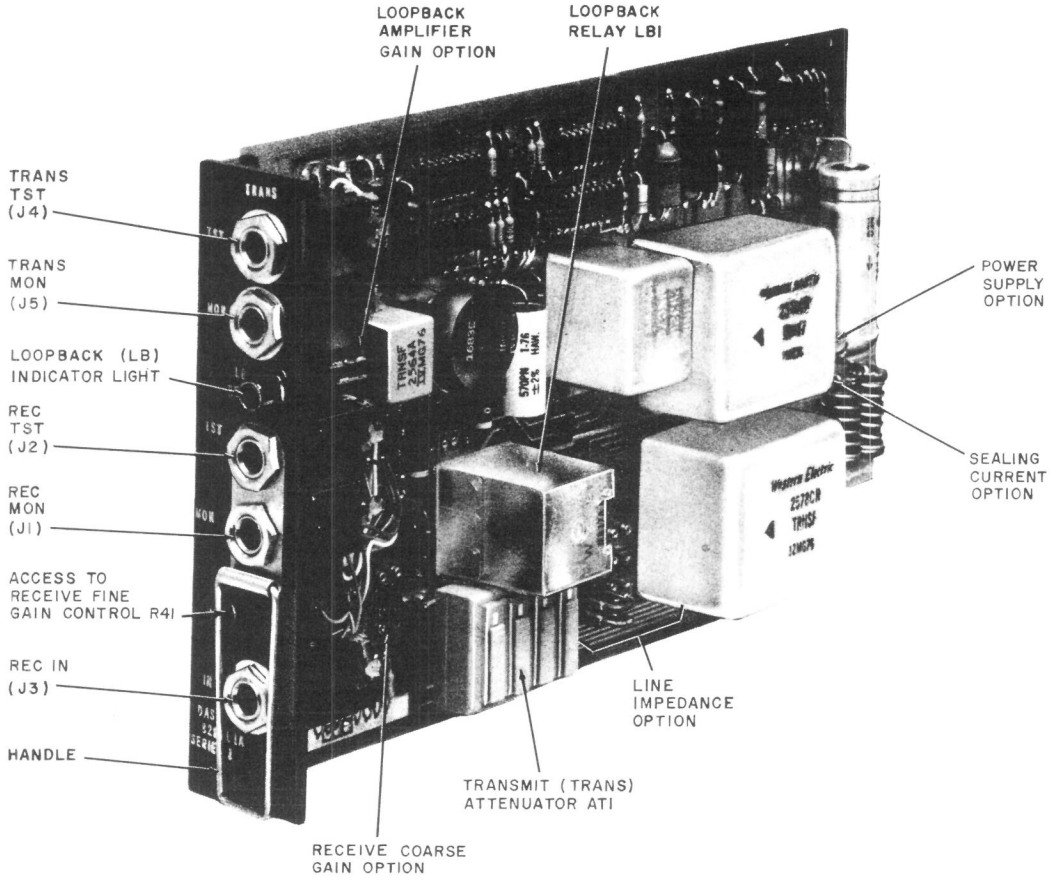


Fig. 52—DAS 829B-L1A CIU

option is specified on the service order, a plug-in strap should be placed in the D position (Fig. 58).

(c) With the O/R switch (option S), the 48ER1 data unit and an associated station dial will attempt to establish a 4-wire dial backup channel when the O/R switch is operated. When the dial backup channel is established, the 48ER1 data unit will connect the modem to the dial backup channel. If the dial backup channel is not established within 3 minutes, a retry request must be generated by releasing and then operating the O/R switch. To release the dial backup channel and return the modem to the 4-wire private line, the O/R switch is released. If this option is specified on the service order, a plug-in strap should be placed in the S position (Fig. 58).

4.37 ***Power Supply:*** Operating power for the 48ER1 data unit can be provided by either a 24 Vac (option N) or a -48 Vdc (option -48) supply. A plug-in strap should be placed in the option position specified on the service order (N position for 24 Vac and -48 position for -48 Vdc (Fig. 58).

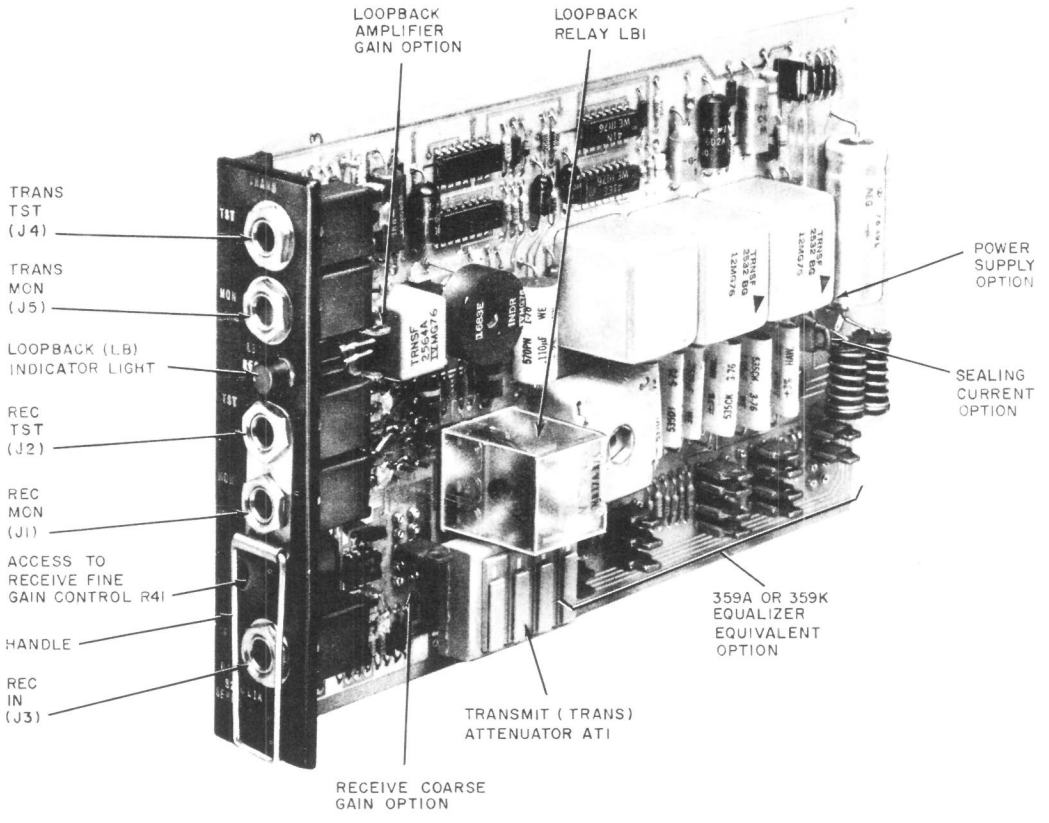


Fig. 53—DAS 829C-L1A CIU

Note: Use of a -48 Vdc supply is not permitted.

4.38 ***Adjustments:*** The transmit (XMT) switch (Fig. 58) and the receive (REC) switch (Fig. 58) on the 48ER1 data unit control the signal gain of the transmit and receive circuits. Adjustment of these switches is described in Section 598-082-500.

K. 48FR1 Data Unit

4.39 The 48FR1 data unit (Fig. 59) has options that must be installed prior to placing the data unit in operation. The options to be installed should be specified on the service order. Refer to Table D for a summary of the options.

4.40 ***Call Control:*** Two methods of automatic answering are provided.

(a) With two calls answered (option T), the 48FR1 data unit automatically answers a call on line 1 and then automatically answers a call on line 2, if the second call is received within 2 minutes of the time line 1 went on hold. If this option is specified on the service order, six plug-in straps should be placed in the T position (Fig. 60).

(b) With automatic call back (option A), the 48FR1 data unit automatically answers a call on line 1 and then automatically initiates a call on line 2. If this option is specified on the

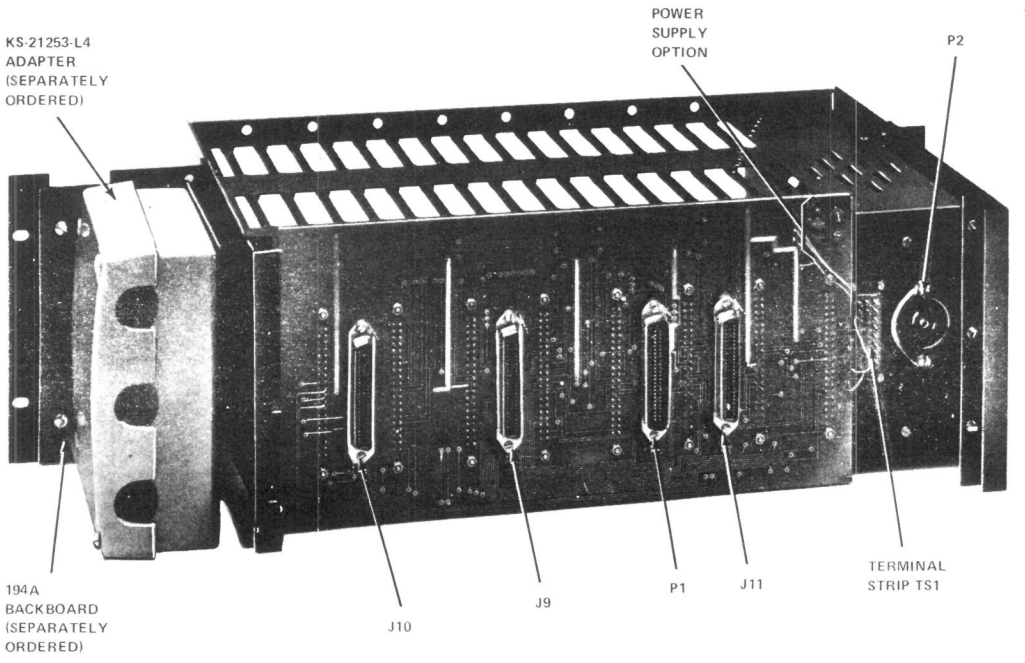


Fig. 54—46A2 Data Mounting—Rear View

service order, six plug-in straps should be placed in the A position (Fig. 60).

4.41 ***Unit Control:*** Two methods of enabling automatic answering are provided.

(a) With unit internal logic (option E), automatic answering is enabled by the internal logic in the 48FR1 data unit. The data unit can automatically answer a call on line 1 and then automatically answer or initiate a call on line 2. If this option is specified on the service order, a plug-in strap should be placed in the E position (Fig. 60).

(b) With a customer- or modem-provided contact (option D), automatic answering is enabled only when the customer or modem provides and maintains a contact closure. The data unit can automatically answer a call on line 1 and then automatically answer or initiate a call on line 2. If this option is specified on the service order, a plug-in strap should be placed in the D position (Fig. 60).

4.42 ***Power Supply:*** Operating power for the 48FR1 data unit can be provided by either a 24 Vac (option N) or a -48 Vdc (option -48) supply. A plug-in strap should be placed in the option position specified on the service order (N position for 24 Vac and -48 position for -48 Vdc (Fig. 60).

> ***Note:*** Use of a -48 Vdc supply is not permitted.

4.43 ***Adjustments:*** The transmit (XMT) switch (Fig. 60) and the receive (REC) switch (Fig. 60) on the 48FR1 data unit control the signal gain of the transmit and receive circuits. Adjustment of these switches is described in Section 598-082-500.

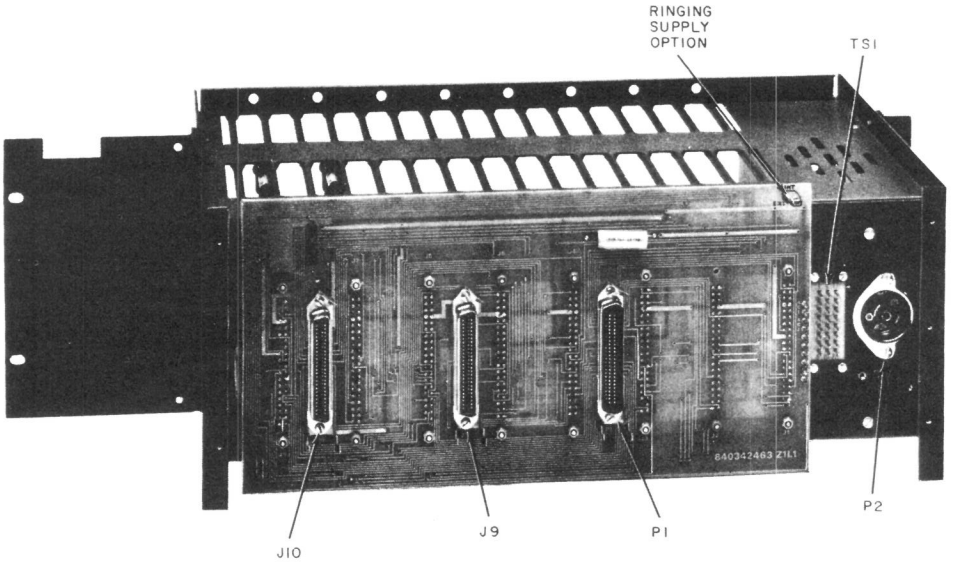


Fig. 55—46B1 Data Mounting—Rear View

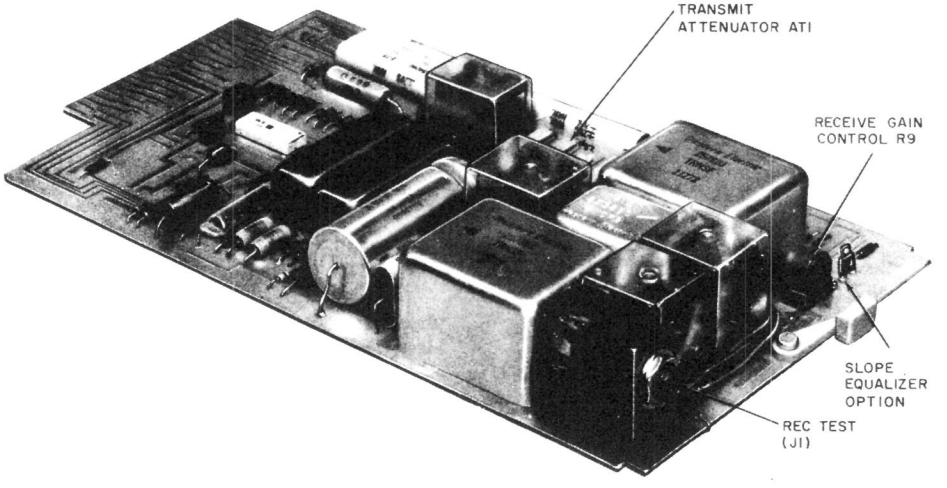


Fig. 56—48B1 Data Unit

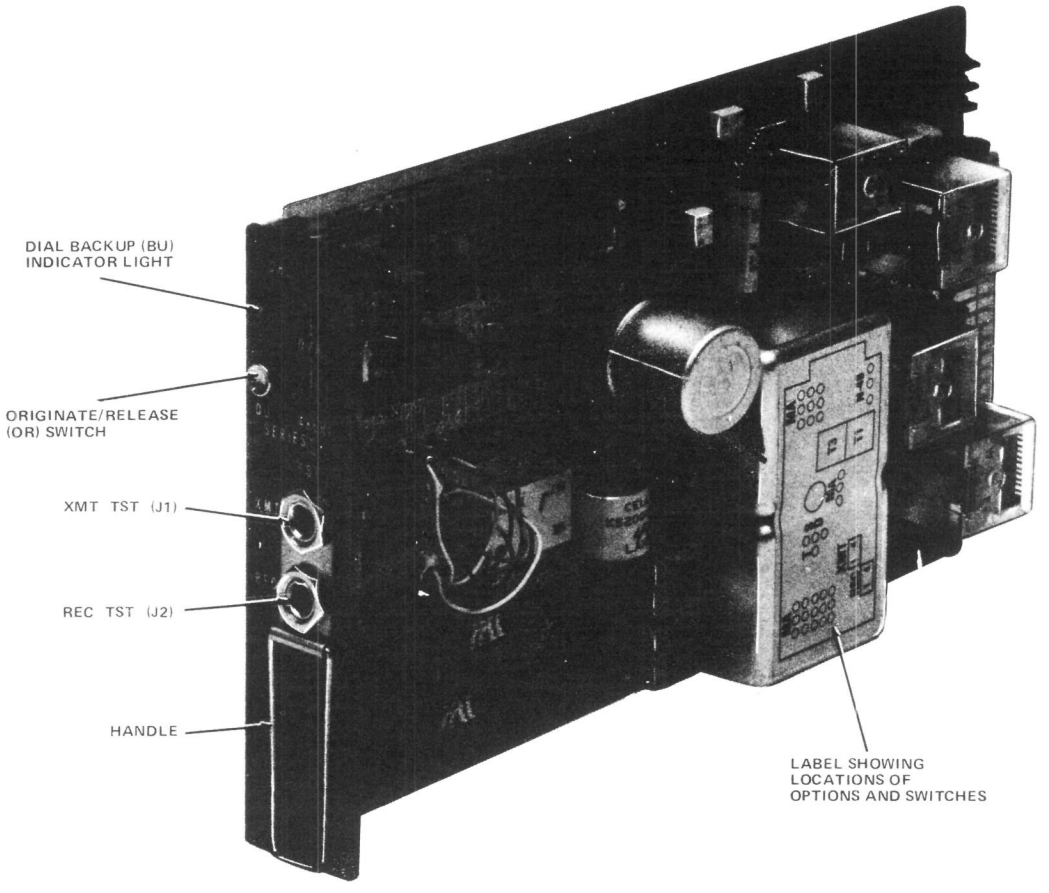


Fig. 57—48ER1 Data Unit

L. 48G1 Data Unit

4.44 A power supply option (Fig 61) on the 48G1 data unit permits operation from a 24 Vac, -24 Vdc, or -48 Vdc power source. A plug-in strap should be placed in the option position specified on the service order (N position for 24 Vac or -24 Vdc and -48 position for -48 Vdc).

5. TESTING

5.01 After the installation procedures are completed, the DAS 829-type CIUs and the supplementary data units and data mountings must be tested as described in Section 598-082-500.

5.02 A tone-activated or manual loopback test should be made by the test center to provide benchmark transmission tests. The test results should be recorded for future maintenance purposes.

5.03 Ensure that the front and rear dust covers are installed on the 44A-type, 45A1, 59A1, or 62A1 data mounting after all installation and testing is completed.

TABLE C

48ER1 DATA UNIT OPTIONS

FEATURE	OPTION	PLUG-IN STRAP(S)		PROVIDE
		QUANTITY	POSITION	
Call Control	Manual Dialing (M)	9	M1-M9	One Per Unit
	Automatic Dialing (A)	9	A1-A9	
Unit Control	Key Telephone Set (T)	1	T	One Per Unit
	Customer- or Modem-Provided Contact (D)	1	D	
	O/R (Originate/Release) Switch (S)	1	S	
Power Supply	24 Vac (N)	1	N	One Per Unit
	-48 Vdc (-48)*	1	-48	

* Use not permitted.

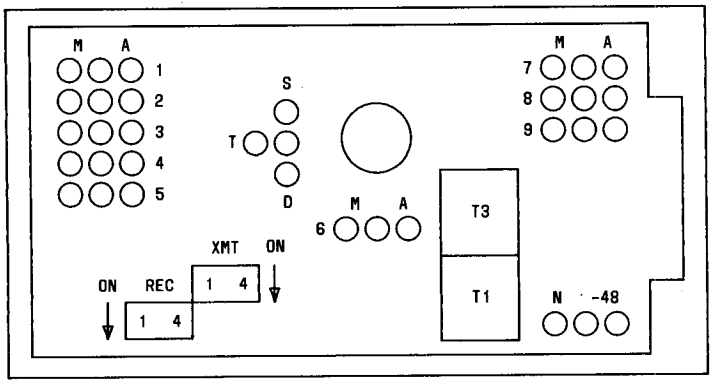


Fig. 58—48ER1 Data Unit—Locations of Options

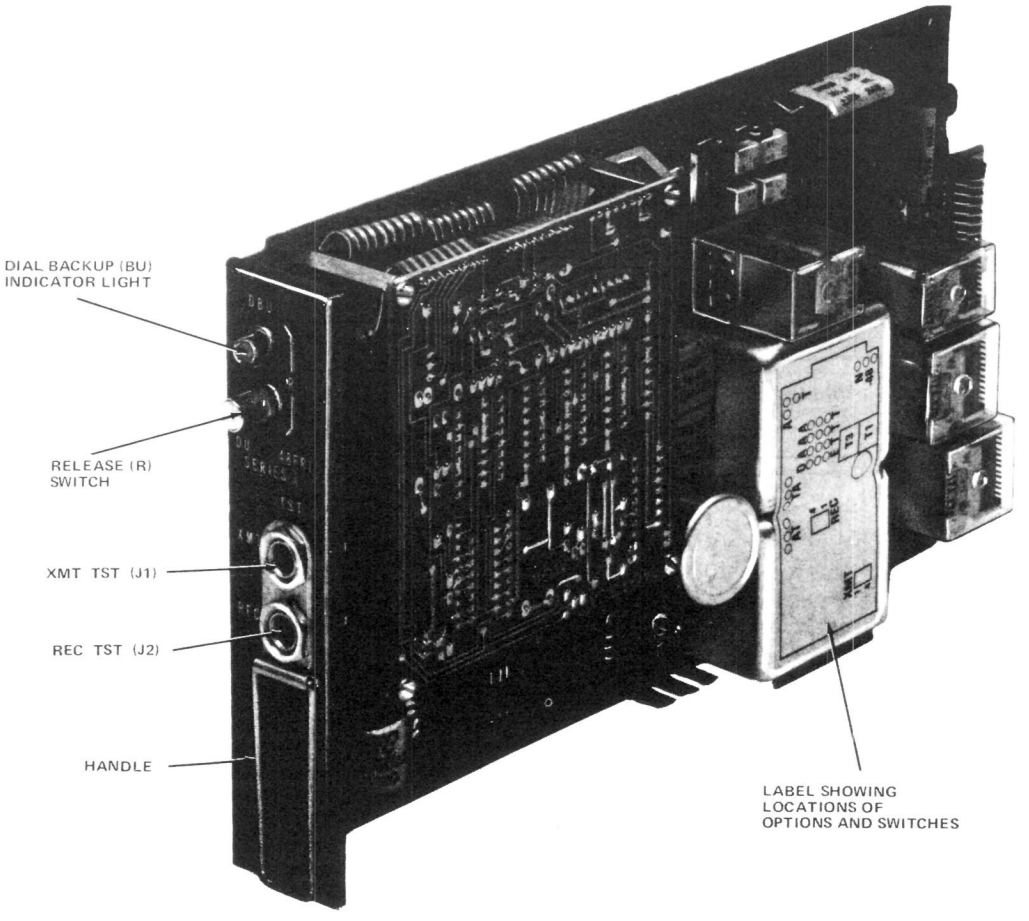


Fig. 59—48FR1 Data Unit

TABLE D

48FR1 DATA UNIT OPTIONS

FEATURE	OPTION	PLUG-IN STRAP(S)		PROVIDE
		QUANTITY	POSITION	
Call Control	Two Calls Answered (T)	6	T	One Per Unit
	Automatic Call Back (A)	6	A	
Unit Control	Unit Internal Logic (E)	1	E	One Per Unit
	Customer- or Modem-Provided Contact (D)	1	D	
Power Supply	24 Vac (N)	1	N	One Per Unit
	-48 Vdc (-48)*	1	-48	

* Use not permitted.

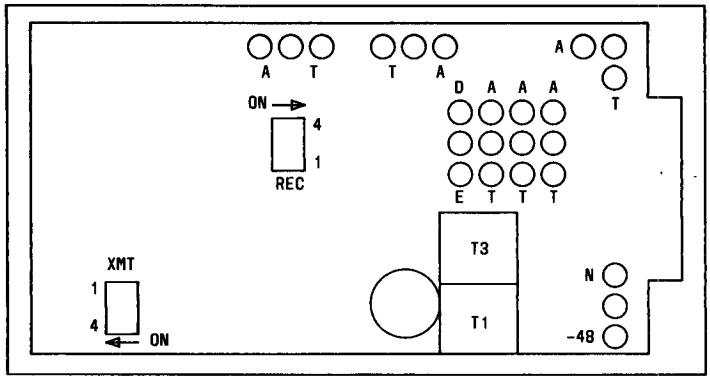


Fig. 60—48FR1 Data Unit—Locations of Options

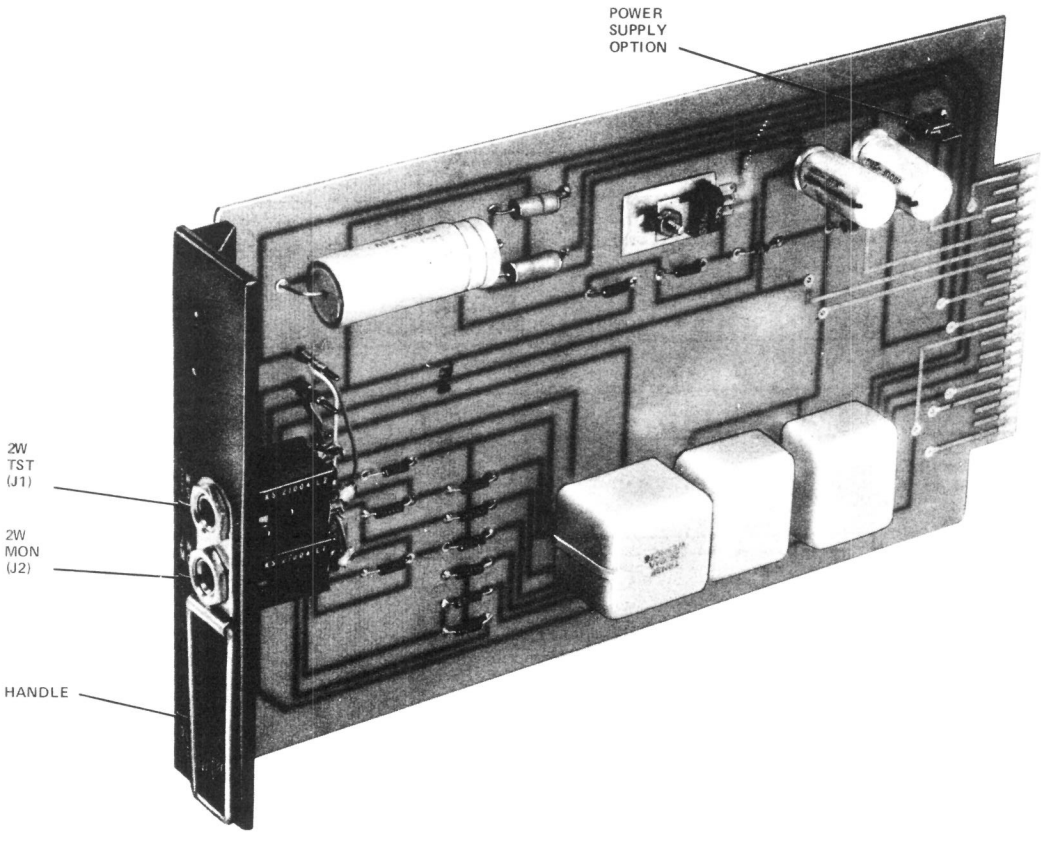


Fig. 61—48G1 Data Unit

6. REFERENCES

6.01 Additional information concerning the DAS 829-type CIU and the supplemental data units and data mountings is contained in the following publications:

SECTION	TITLE
332-104-500	V4-Type Repeaters—Initial Line-Up
332-116-201	Strapping Charts for 359A and 359D Equalizers or 4182C Network
461-200-102	Adapters—148, 149, 153, and 3-Way Bridging Types—Identification
461-604-100	Connecting Blocks 66-Type—Tools, Terminating, Adapters, and Maintenance
463-140-100	Equipment Cabinets and Apparatus Mountings—Installation
590-010-200	Data Sets and Data Access Arrangements—General Installation and Connection Information
590-010-201	Data Sets—Multiple Installation Information
598-082-100	Data Auxiliary Set 829-Type—Channel Interface Units—Voiceband Private Line Channels—Description
598-082-500	Data Auxiliary Set 829-Type—Channel Interface Units—Voiceband Private Line Channels—Maintenance and Test Procedures

6.02 Detailed information concerning the DAS 829-type CIU and the supplemental data units and data mountings is contained in CD- and SD-1D247-01.

DATA AUXILIARY SET 829-TYPE
CHANNEL INTERFACE UNITS
VOICEBAND PRIVATE LINE CHANNELS
TEST PROCEDURES

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1. GENERAL

1.01 This section contains installation and maintenance test procedures for data auxiliary set (DAS) 829-type and the supplementary data units and data mountings. This section does not contain the tests for modems used in conjunction with the DAS and the supplementary apparatus.

1.02 This section is reissued to add information on the 48ER1, 48FR1, and 48G1 data units and the 44A2, 46A2, 46C2, 59A1, and 62A1 data mountings. Since this reissue is a general revision, arrows normally used to indicate changes have been omitted.

1.03 DAS 829-type functions as a channel interface unit (CIU) to provide a prewired and tested standard termination for 4-wire private line voiceband data channels. Basic station arrangements use the DAS 829-type CIU to provide 4-wire data only service. Other station arrangements use the DAS 829-type CIU and the supplementary apparatus to provide 4-wire data with alternate voice, dial backup, and switched dial backup service. Two-wire data only and data with alternate voice service are also provided.

NOTICE
Not for use or disclosure outside the
Bell System except under written agreement

1.04 A choice of six codes for the DAS 829-type CIU provides proper termination of channels having various loop facilities.

- DAS 829A-L1 or -L1A for short loops
- DAS 829B-L1 or -L1A for longer nonloaded loops
- DAS 829C-L1 or -L1A for longer loaded loops.

1.05 A choice of seven data units combined with a DAS 829-type CIU provides the following features:

- 48A1 data unit for 4-wire or 2-wire alternate voice service.
- 48B1 data unit for 4-wire dial backup service with manual dialing.
- 48C1 data unit (switching matrix) for switching any one of four 4-wire modems to either one of two 4-wire dial backup channels.
- 48D1 data unit (interface adapter) for use with a 46C-type and/or 46B1 data mounting to concentrate control leads in an 18- or 30-button CALL DIRECTOR® key telephone set.
- 48ER1 data unit for 4-wire dial backup service with manual or automatic dialing. This data unit complies with all requirements of the FCC Registration Program. The registration number for the 48ER1 data unit is AS593M-67751-PC-E. The ringer equivalence number for each line is 0.5A.
- 48FR1 data unit for 4-wire dial backup service with automatic answering. This data unit complies with all requirements of the FCC Registration Program. The registration number for the 48FR1 data unit is AS593M-67757-PC-E. The ringer equivalence number for each line is 0.5A.
- 48G1 data unit for 2-wire to 4-wire conversion.

1.06 A choice of seven data mountings house single or multiple arrangements of DAS 829-type CIUs and/or 48-type data units without any change in wiring.

- 44A1 or 44A2 data mounting houses one DAS 829-type CIU.
- 45A1 data mounting houses one DAS 829-type CIU or one DAS 829-type CIU with the following data units: one 48A1 or 48B1, or one 48A1 and one 48B1.
- 46A1 or 46A2 data mounting houses up to eight DAS 829-type CIUs.
- 46B1 data mounting houses up to eight 48A1 or 48G1 data units.
- 46C1 data mounting houses one or two 48B1 data units and up to six 48C1 data units.
- 46C2 data mounting houses one or two 48B1 or 48ER1 data units and up to six 48C1 data units.
- 59A1 data mounting houses one DAS 829-type CIU or one DAS 829-type CIU with the following data units: one 48A1, 48B1, 48ER1, 48FR1, or 48G1; or one 48A1 and one 48B1, 48ER1, or 48G1.
- 62A1 data mounting houses one DAS 829-type CIU or one DAS 829-type CIU and one 48G1 data unit.

1.07 The test procedures given in this section are performed prior to transmission tests. The DAS 829-type CIU and the supplemental data units are considered to be part of the private line channel; transmission tests, such as slope, envelope delay, noise, etc, should be made through them. These test procedures do not replace the station-to-station or station-to-serving test center lineup procedures. These test procedures serve to assure the installer that the station is operational.

2. TEST EQUIPMENT

2.01 The following test equipment is required at the station and is used in testing the DAS 829-type CIU and the supplemental data units:

1—Voiceband transmission test set, TTS-4B or equivalent, with bridging measurement capability

2—2P4B patch cords (310 plug on both ends)

1—KS-21253-L5 adapter

1—1013B handset

1—Portable volt-ohm-milliammeter (VOM), KS-14510-L1 or equivalent (for maintenance tests)

2—2W6A patch cords (310 plug on one end and clip leads on other end) (for maintenance tests)

1—171C adapter (for maintenance tests)

1—66E-type connecting block (for maintenance tests).

3. INSTALLATION TESTS

3.01 These tests are to be performed at the time of installation to verify that the equipment is operating properly. In addition to transmission test sets required for installing the private line channel, a Northeast Electronics transmission test set TTS-4B or equivalent, is required. The sequence in which installation tests are to be performed is specified in Fig. 1.

PRIVATE LINE

3.02 The operating performance of the installed DAS 829-type CIU can be checked by performing the tests specified in Section 314-410-500 through the TRANS TST and REC TST jacks of the DAS 829-type CIU. These tests can be performed end-to-end or to the serving test center (STC). Proceed as follows:

STEP	PROCEDURE
1	Install options in DAS 829-type CIU as directed in Section 598-082-200 and as specified on service order and/or circuit layout record card. ***Note:*** If CIU is a DAS 829B- or C-type, adjust receive amplifier as described in Steps 2 through 7. If CIU is a DAS 829A-type, proceed to Step 8.
2	Place TTS-4B test set close to CIU and apply power to equipment. Allow test set to warm up and stabilize, then calibrate test set, using instructions printed on test set case.
3	Set controls on test set as follows: • SEND FREQ to 1000 • SEND LEVEL to estimated receive level at input to CIU amplifier • SEND IMP to 600Ω • FUNCTION to SEND + TALK + REC • REC IMP to 600Ω
4	Connect a 2P4B cord between SEND 310 jack on test set and REC IN jack on CIU.
5	Connect another 2P4B cord between REC 310 jack on test set and REC TST jack on CIU.
6	Adjust receive fine gain control on CIU to obtain a level reading on test set meter equal to value specified on service order (usually -16 dBm).

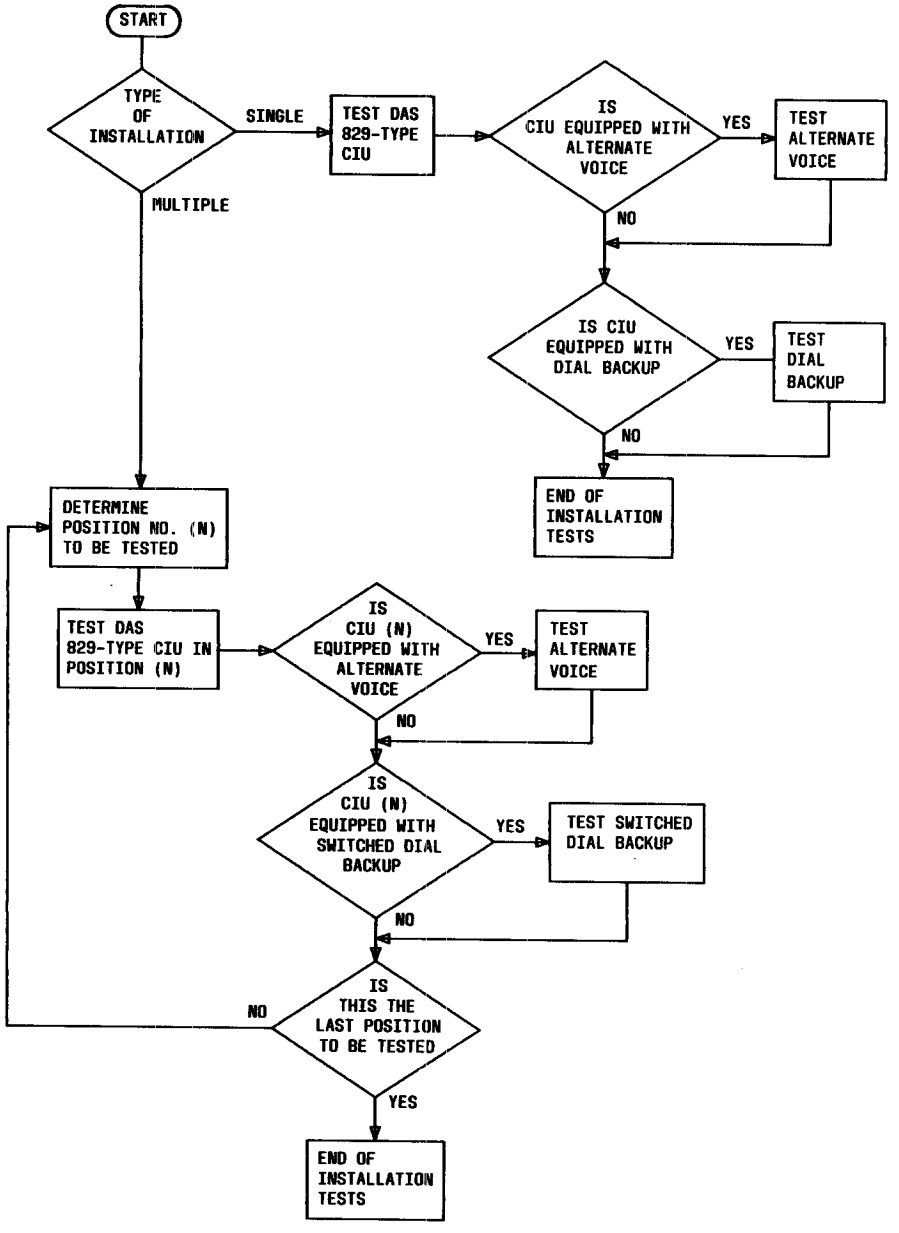


Fig. 1—Installation Test Sequence

STEP	PROCEDURE
7	Disconnect test set from CIU.
8	Perform tests for type of private line channel being installed as specified in Section 314-410-500. For 4-wire private line channels, tests to STC or distant end must be made through TRANS TST and REC TST jacks on CIU. For 2-wire private line channels, tests to STC or distant end must be made through 2W TST jack on 48G1 data unit, except tests that require a 4-wire interface.
9	Have STC perform loopback tests for benchmark purposes.
10	Refer to Fig. 1 for any remaining tests. If any remaining tests require use of TTS-4B test set, do not turn off power switch. This avoids having to recalibrate test set for each test.

ALTERNATE VOICE

3.03 This test checks the ability to switch from the data to the voice mode, checks the signaling, checks the associated telephone set for proper visual and audible indications, and checks the voice path. Two methods of testing are provided:

- Distant end available
- Distant end not available.

A. Distant End Available

3.04 If both ends are installed, perform the test of the alternate voice equipment as follows:

STEP	PROCEDURE
1	Take local handset off-hook.
2	Depress PL TALK button. ***Requirement:*** PL TALK lamp lights.
3	Depress RING button until ringback is heard (about 10 seconds). Distant end should receive ringing and answer call. ***Note:*** If distant end is in loopback mode, ringing will not be detected.
4	When distant end has answered call, request distant end to signal local end by depressing RING button until ringback is heard. Inform distant end that call will not be answered until ringing times out.
5	Place local handset on-hook.

STEP	PROCEDURE
6	When ringing is heard, do not take local handset off-hook. Allow ringing to time out. An audible indication is heard. ***Requirement:*** PL TALK lamp flashes in response to audible indication. After about 40 seconds, ringing ceases.
7	When ringing has timed out, take local handset off-hook and answer call. Verify that alternate voice path operates properly.
8	Refer to Fig. 1 for any remaining tests.

B. Distant End Not Available

3.05 If the distant end has not been installed, the alternate voice equipment can be tested using a TTS-4B test set. The test set must be capable of transmitting a 2600-Hz tone. Perform the test as follows:

STEP	PROCEDURE
1	Verify handset is on-hook and CIU is not in loopback mode.
2	Set controls on TTS-4B test set as follows: SEND FREQ to 2600 SEND LEVEL to -20 SEND IMP to 600Ω FUNCTION to SEND + TALK + REC REC IMP to BRDG
3	Connect a 2P4B cord between SEND 310 jack on test set and REC MON jack on CIU. ***Requirement:*** PL TALK lamp lights when an audible indication is heard.
4	Remove 2P4B cord from REC MON jack. ***Requirement:*** PL TALK lamp remains lighted and audible indication continues for about 40 seconds.
5	After ringing times out, plug 2P4B cord back into REC MON jack. When audible indication begins and PL TALK lamp lights, take handset off-hook.
6	Depress PL TALK button.

STEP	PROCEDURE
	Requirement: Audible indication stops. PL TALK lamp lights steady.
7	Listen in handset for 2600-Hz tone.
	Requirement: Tone is heard in handset.
8	Remove 2P4B cord from test set and CIU.
9	Connect 2P4B cord between REC 310 jack on test set and TRANS MON jack on CIU.
10	Whistle or blow into telephone handset.
	Requirement: Test set meter reads same level as sound. A loud sound should produce a peak meter reading in range of -10 to +10 dBm.
11	Depress RING button.
	Requirement: Test set meter reads signal level of about 0 dBm.
12	Refer to Fig. 1 for any remaining tests.

4-WIRE DIAL BACKUP

3.06 This test checks the ability of the 48B1 or 48ER1 data unit to switch from a 4-wire private line to a 4-wire dial backup channel, and checks the associated telephone set or station dial for proper operation. A procedure is provided for adjusting the transmit and receive levels.

Note: If a DAS 801CR-L1/2 automatic calling unit (ACU) is installed with the 48ER1 data unit, test the ACU using the test procedures in Section 598-088-500.

A. Single Installation (Manual Dialing With 48B1 Data Unit)

3.07 This installation consists of a DAS 829-type CIU and a 48B1 data unit housed in a 45A1 or 59A1 data mounting. The data mounting may also house a 48A1 data unit. The presence of a 48A1 data unit does not affect this test. A key telephone set is used to originate and answer calls. Perform the test as follows:

STEP	PROCEDURE
1	Install options in 48B1 data unit as directed in Section 598-082-200 and as specified on service order and/or circuit layout record card.
	Note: Steps 2 and 3 are for adjusting transmit attenuator AT1 on 48B1 data unit.
2	Measure loop loss of line 1 (T2, R2) using a 900-ohm loop termination and the milliwatt supply in serving central office.

STEP	PROCEDURE
3	Set transmit attenuator AT1 on 48B1 data unit as follows: Attenuator setting = 11.5 dBm - line loss. For example, if line loss is 4 dB, attenuator setting = 11.5 dBm -4 dB = 7.5 dB. Since attenuator is adjustable in 1-dB steps, in this example it would be set to provide 8 dB of loss (slide switches on attenuator would be set so that only number 8.0 is exposed). ***Note 1:*** The 11.5 dBm is arrived at by subtracting a 0.5 dB loss through transformer on 48B1 data unit from the -12 dBm required level at serving central office. ***Note 2:*** Steps 4 through 11 are for adjusting receive gain control R9 on 48B1 data unit.
4	Set controls on TTS-4B test set as follows: FUNCTION to REC + TALK REC IMP to 600Ω REC LEVEL to +7
5	Take handset off-hook and depress DDD2 button. ***Requirement:*** Dial tone is heard in handset.
6	Dial milliwatt supply in serving central office.
7	When connection to milliwatt supply is completed, depress and release HOLD button. ***Requirement:*** DDD2 lamp lights and DDD2 button releases on up-stroke of HOLD button.
8	Place handset on-hook.
9	Connect a 2P48 cord between REC 310 jack on test set and REC TST jack on 48B1 data unit.
10	Measure receive level of milliwatt supply and adjust receive gain control R9 on 48B1 data unit for a reading of +3.7 dBm on test set meter.
11	Take handset off-hook, depress and release REL button, and place handset on-hook. ***Requirement:*** DDD2 lamp goes off, indicating call is ended.
12	Disconnect test set from 48B1 data unit. ***Note:*** Steps 13 through 24 check telephone set, switching functions, and ring detection functions of 48B1 data unit.
13	Take handset off-hook and depress DDD1 button.

STEP	PROCEDURE
	Requirement: DDD1 lamp does not light. Dial tone is heard in handset.
14	Dial directory number of DDD2 line.
	Requirement: Audible indication is heard. DDD2 lamp flashes in response to audible indication.
15	When audible indication is heard, depress and release HOLD button.
	Requirement: DDD1 lamp lights and DDD1 button releases on up-stroke of HOLD button. Audible indication continues.
16	Depress DDD2 button.
	Requirement: Audible indication stops and DDD2 lamp stops flashing.
17	Depress and release HOLD button.
	Requirement: DDD2 lamp lights and DDD2 button releases on up-stroke of HOLD button. Station is now in dial backup mode.
18	Depress and release REL button.
	Requirement: Both DDD1 and DDD2 lamps go off. Station is now released from dial backup mode.
19	Take handset off-hook and depress DDD2 button.
	Requirement: DDD2 lamp does not light. Dial tone is heard in handset.
20	Dial directory number of DDD1 line.
	Requirement: Audible indication is heard. DDD1 lamp flashes in response to audible indication.
21	When audible indication is heard, depress and release HOLD button.
	Requirement: DDD2 lamp lights and DDD2 button releases on up-stroke of HOLD button. Audible indication continues.
22	Depress DDD1 button.
	Requirement: Audible indication stops and DDD1 lamp stops flashing.
23	Depress and release HOLD button.
	Requirement: DDD1 lamp lights and DDD1 button releases on up-stroke of HOLD button. Station is now in dial backup mode.

STEP	PROCEDURE
24	Depress and release REL button. ***Requirement:*** Both DDD1 and DDD2 lamps go off. Station is now released from dial backup mode.
25	Refer to Fig. 1 for any remaining tests.

B. Single Installation (Manual Dialing With 48ER1 Data Unit)

3.08 This installation consists of a DAS 829-type CIU and a 48ER1 data unit housed in a 59A1 data mounting. The data mounting may also house a 48A1 data unit. The presence of a 48A1 data unit does not affect this test. A key telephone set is used to originate and answer calls. Perform the test as follows:

STEP	PROCEDURE
1	Install options in 48ER1 data unit as directed in Section 598-082-200 and as specified on service order and/or circuit layout record card.
2	For nonregistered arrangements, perform Steps 3 through 6. For registered arrangements, verify that transmit (XMT) and receive (REC) switches on 48ER1 data unit are set to 8 dB fixed loss loop as specified in Table A, then proceed to Step 7. ***Note:*** Steps 3 and 4 are for adjusting transmit (XMT) switch on 48ER1 data unit.
3	Measure loop loss of line 1 (T2, R2) using a 600-ohm loop termination and the milliwatt supply in serving central office.
4	Set 4-pole transmit (XMT) switch on 48ER1 data unit for measured line loss as specified in Table A. For example, if measured line loss is 4.5 dB, switch would be set with poles 1 and 4 released and poles 2 and 3 operated. ***Note:*** Steps 5 and 6 are for adjusting receive (REC) switch on 48ER1 data unit.
5	Measure loop loss of line 2 (T3, R3) using a 600-ohm loop termination and the milliwatt supply in serving central office.
6	Set 4-pole receive (REC) switch on 48ER1 data unit for measured line loss as specified in Table A. For example, if measured line loss is 4.5 dB, switch would be set with poles 1 and 4 released and poles 2 and 3 operated. ***Note:*** Steps 7 through 23 check telephone set, switching functions, and ring detection functions of 48ER1 data unit.

STEP | PROCEDURE

TABLE A

SWITCH SETTINGS FOR TRANSMIT AND RECEIVE LEVEL ADJUSTMENT

1000-Hz LOOP LOSS IN dB FOR LINE DDD1 (OR DDD2)		SWITCH DESIGNATED TRANS (OR REC)			
LOSS GREATER THAN OR EQUAL TO	LOSS LESS THAN	POLE			
		1	2	3	4
		POSITION*			
0	1	1	0	0	1
1	2	0	1	0	1
2	3	1	1	0	1
3	4	1	0	1	0
4	5	0	1	1	0
5	6	1	1	1	0
6	7	1	0	0	0
7	8	0	1	0	0
8	—	1	1	0	0
8 dB fixed loss loop		1	1	0	0

*1 = on (contact closed)
0 = off (contact open)

7 Set controls on TTS-4B test set as follows:

SEND FREQ to 1000

SEND LEVEL to 0 (CAL)

SEND IMP to 600Ω

FUNCTION to SEND + TALK + REC

REC IMP to 600Ω

8 Connect a 2P4B cord between REC 310 jack on test set and REC TST jack on 48ER1 data unit.

9 Take handset off-hook and depress DDD1 button.

STEP	PROCEDURE
	Requirement: DDD1 lamp does not light. Dial tone is heard in handset.
10	Dial directory number of DDD2 line.
	Requirement: Audible indication is heard. DDD2 lamp flashes in response to audible indication.
11	When audible indication is heard, depress and release HOLD button.
	Requirement: DDD1 lamp lights and DDD1 button releases on up-stroke of HOLD button. Audible indication continues.
12	Depress DDD2 button.
	Requirement: Audible indication stops and DDD2 lamp stops flashing.
13	Depress and release HOLD button.
	Requirement: DDD2 lamp lights and DDD2 button releases on up-stroke of HOLD button. For next 10 seconds, test set meter reads signal level of about -12 dBm. At end of signal, BU lamp on 48ER1 data unit lights. Station is now in dial backup mode.
14	Depress and release REL button.
	Requirement: BU lamp on 48ER1 data unit goes off. For next 3 seconds, test set meter reads signal level of about -12 dBm. At end of signal, both DDD1 and DDD2 lamps go off. Station is now released from dial backup mode.
15	Take handset off-hook and depress DDD2 button.
	Requirement: DDD2 lamp does not light. Dial tone is heard in handset.
16	Dial directory number of DDD1 line.
	Requirement: Audible indication is heard. DDD1 lamp flashes in response to audible indication.
17	When audible indication is heard, depress and release HOLD button.
	Requirement: DDD2 lamp lights and DDD2 button releases on up-stroke of HOLD button. Audible indication continues.
18	Depress DDD1 button.
	Requirement: Audible indication stops and DDD1 lamp stops flashing.
19	Depress and release HOLD button.

STEP	PROCEDURE
	Requirement: DDD1 lamp lights and DDD1 button releases on up-stroke of HOLD button. For next 10 seconds, test set meter reads signal level of about -12 dBm. At end of signal, BU lamp on 48ER1 data unit lights. Station is now in dial backup mode.
20	Connect a 2P4B cord between SEND 310 jack on test set and XMT TST jack on 48ER1 data unit.
	Requirement: Test set meter reads signal level of -12 ±4 dBm.
21	On test set, set SEND LEVEL to +10.
	Requirement: After 1 second, test set meter reads signal level not more than 2 dB greater than level in Step 20.
22	Remove 2P4B cord from SEND 310 jack on test set and XMT TST jack on 48ER1 data unit.
23	Depress and release REL button.
	Requirement: BU lamp on 48ER1 data unit goes off. For next 3 seconds, test set meter reads signal level of about -12 dBm. At end of signal, both DDD1 and DDD2 lamps go off. Station is now released from dial backup mode.
24	Disconnect test set from 48ER1 data unit.
25	Refer to Fig. 1 for any remaining tests.

C. Single Installation (Automatic Dialing With Station Dial)

3.09 This installation consists of a DAS 829-type CIU and a 48ER1 data unit housed in a 59A1 data mounting. A station dial is used to originate a call on DDD2 line. The 48ER1 data unit automatically answers a call on DDD1 line. When option D is installed, the 48ER1 data unit is controlled by a customer- or modem-provided contact. When option S is installed, the 48ER1 data unit is controlled by the O/R switch on the data unit. Perform the test as follows:

STEP	PROCEDURE
1	Install options in 48ER1 data unit as directed in Section 598-082-200 and as specified on service order and/or circuit layout record card.
2	If option D is installed in 48ER1 data unit, temporarily remove option D and install option S.
3	For nonregistered arrangements, perform Steps 4 through 7. For registered arrangements, verify that transmit (XMT) and receive (REC) switches on 48ER1 data unit are set to 8 dB fixed loss loop as specified in Table A, then proceed to Step 8.

STEP	PROCEDURE

Note: Steps 4 and 5 are for adjusting transmit (XMT) switch on 48ER1 data unit.

4 Measure loop loss of line 1 (T2, R2) using a 600-ohm loop termination and the milliwatt supply in serving central office.

5 Set 4-pole transmit (XMT) switch on 48ER1 data unit for measured line loss as specified in Table A. For example, if measured line loss is 4.5 dB, switch would be set with poles 1 and 4 released and poles 2 and 3 operated.

Note: Steps 6 and 7 are for adjusting receive (REC) switch on 48ER1 data unit.

6 Measure loop loss of line 2 (T3, R3) using a 600-ohm loop termination and the milliwatt supply in serving central office.

7 Set 4-pole receive (REC) switch on 48ER1 data unit for measured line loss as specified in Table A. For example, if measured line loss is 4.5 dB, switch would be set with poles 1 and 4 released and poles 2 and 3 operated.

Note: Steps 8 through 15 check station dial, switching functions, and ring detection functions of 48ER1 data unit.

8 Set controls on TTS-4B test set as follows:

SEND FREQ to 1000

SEND LEVEL to 0 (CAL)

SEND IMP to 600Ω

FUNCTION to SEND + TALK + REC

REC IMP to 600Ω

9 Connect a 2P4B cord between REC 310 jack on test set and REC TST jack on 48ER1 data unit.

10 Program station dial to dial directory number of DDD1 line of 48ER1 data unit.

11 Depress O/R switch on 48ER1 data unit.

Requirement: Station dial dials directory number of DDD1 line of 48ER1 data unit. The 48ER1 data unit automatically answers call on DDD1 line. About 5 seconds after call is answered, test set meter reads signal level of about -12 dBm for about 5 seconds. At end of signal, BU lamp on 48ER1 data unit lights. Station is now in dial backup mode.

12 Connect a 2P4B cord between SEND 310 jack on test set and XMT TST jack on 48ER1 data unit.

Requirement: Test set meter reads signal level of -12 ±4 dBm.

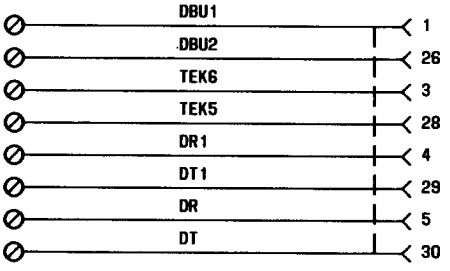
STEP	PROCEDURE
13	On test set, set SEND LEVEL to +10. ***Requirement:*** After 1 second, test set meter reads signal level not more than 2 dB greater than level in Step 12.
14	Remove 2P4B cord from SEND 310 jack on test set and XMT TST jack on 48ER1 data unit.
15	Release O/R switch on 48ER1 data unit. ***Requirement:*** BU lamp on 48ER1 data unit goes off. For next 3 seconds, test set meter reads signal level of about -12 dBm. At end of signal, station is released from dial backup mode.
16	Disconnect test set from 48ER1 data unit.
17	Program station dial to dial directory number of DDD1 line of customer's remote 48FR1 data unit. ***Note:*** If possible, use 48ER1 data unit to establish and release a dial backup channel with customer's remote 48FR1 data unit as described in Steps 18 and 19.
18	Depress O/R switch on 48ER1 data unit. ***Requirement:*** Station dial dials directory number of DDD1 line of remote 48FR1 data unit. Within next 2 minutes, remote 48FR1 data unit initiates a return call to DDD1 line of 48ER1 data unit. The 48ER1 data unit automatically answers call on DDD1 line. About 10 seconds after call is answered, BU lamp on 48ER1 data unit lights. The dial backup channel is now established.
19	Release O/R switch on 48ER1 data unit. ***Requirement:*** BU lamp on 48ER1 data unit goes off. After about 3 seconds, the 48ER1 data unit places DDD1 and DDD2 lines on-hook. The dial backup channel is now released.
20	If option S was temporarily installed in 48ER1 data unit in Step 2, remove option S and install option D.
21	Refer to Fig. 1 for any remaining tests.

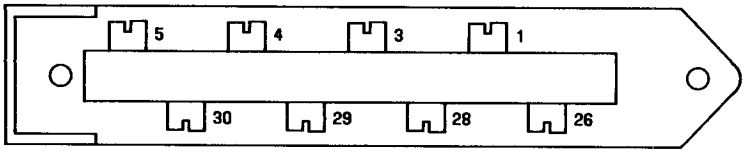
D. Single Installation (Automatic Dialing With Automatic Calling Unit)

3.10 This installation consists of a DAS 829-type CIU and a 48ER1 data unit housed in a 59A1 data mounting. A DAS 801CR-L1/2 automatic calling unit (ACU) is used to originate a call on DDD2 line. The 48ER1 data unit automatically answers a call on DDD1 line. The 48ER1 data unit (option D installed) is controlled by a customer- or modem-provided contact.

STEP	PROCEDURE
1	Install options in 48ER1 data unit as directed in Section 598-082-200 and as specified on service order and/or circuit layout record card.
2	If option D is installed in 48ER1 data unit, temporarily remove option D and install option S.
3	For nonregistered arrangements, perform Steps 4 through 7. For registered arrangements, verify that transmit (XMT) and receive (REC) switches on 48ER1 data unit are set to 8 dB fixed loss loop as specified in Table A, then proceed to Step 8.
	Note: Steps 4 and 5 are for adjusting transmit (XMT) switch on 48ER1 data unit.
4	Measure loop loss of line 1 (T2, R2) using a 600-ohm loop termination and the milliwatt supply in serving central office.
5	Set 4-pole transmit (XMT) switch on 48ER1 data unit for measured line loss as specified in Table A. For example, if measured line loss is 4.5 dB, switch would be set with poles 1 and 4 released and poles 2 and 3 operated.
	Note: Steps 6 and 7 are for adjusting receive (REC) switch on 48ER1 data unit.
6	Measure loop loss of line 2 (T3, R3) using a 600-ohm loop termination and the milliwatt supply in serving central office.
7	Set 4-pole receive (REC) switch on 48ER1 data unit for measured line loss as specified in Table A. For example, if measured line loss is 4.5 dB, switch would be set with poles 1 and 4 released and poles 2 and 3 operated.
	Note: Steps 8 through 19 check switching functions and ring detection functions of 48ER1 data unit.
8	Set controls on TTS-4B test set as follows: SEND FREQ to 1000 SEND LEVEL to 0 (CAL) SEND IMP to 600Ω FUNCTION to SEND + TALK + REC REC IMP to 600Ω
9	Connect a 2P4B cord between REC 310 jack on test set and REC TST jack on 48ER1 data unit.
10	Connect a jumper wire between screw terminals 28 and 30 on KS-21253-L5 adapter (Fig. 2).

STEP	PROCEDURE





CONNECTOR COVER OFF

Fig. 2—KS-21253-L5 Adapter

11 Disconnect ACU cord from connector J4 on rear of 59A1 data mounting and install KS-21253-L5 adapter in connector J4.

12 Connect 1013B handset to screw terminals 4 and 29 on KS-21253-L5 adapter (Fig. 2).

13 Depress O/R switch on 48ER1 data unit.

14 Take 1013B handset off-hook and dial directory number of DDD1 line of 48ER1 data unit.

Requirement: The 48ER1 data unit automatically answers call on DDD1 line and disconnects 1013B handset from switched network. About 5 seconds after call is answered, test set meter reads signal level of about -12 dBm for about 5 seconds. At end of signal, BU lamp on 48ER1 data unit lights. Station is now in dial backup mode.

15 Place 1013B handset on-hook.

16 Connect a 2P4B cord between SEND 310 jack on test set and XMT TST jack on 48ER1 data unit.

Requirement: Test set meter reads signal level of -12 ±4 dBm.

STEP	PROCEDURE
17	On test set, set SEND LEVEL to +10. ***Requirement:*** After 1 second, test set meter reads signal level not more than 2 dB greater than level in Step 16.
18	Remove 2P4B cord from SEND 310 jack on test set and XMT TST jack on 48ER1 data unit.
19	Release O/R switch on 48ER1 data unit. ***Requirement:*** BU lamp on 48ER1 data unit goes off. For next 3 seconds, test set meter reads signal level of about -12 dBm. At end of signal, station is released from dial backup mode.
20	Disconnect test set from 48ER1 data unit. ***Note:*** If possible, use 48ER1 data unit to establish and release a dial backup channel with customer's remote 48FR1 data unit as described in Steps 21 through 23.
21	Depress O/R switch on 48ER1 data unit.
22	Take 1013B handset off-hook and dial directory number of DDD1 line of remote 48FR1 data unit. ***Requirement:*** Within next 2 minutes, remote 48FR1 data unit initiates a return call to DDD1 line of 48ER1 data unit. The 48ER1 data unit automatically answers call on DDD1 line and disconnects 1013B handset from switched network. About 10 seconds after call is answered, BU lamp on 48ER1 data unit lights. The dial backup channel is now established.
23	Release O/R switch on 48ER1 data unit. ***Requirement:*** BU lamp on 48ER1 data unit goes off. After about 3 seconds, the 48ER1 data unit places DDD1 and DDD2 lines on-hook. The dial backup channel is now released.
24	Disconnect 1013B handset from KS-21253-L5 adapter.
25	Remove KS-21253-L5 adapter from connector J4 on rear of 59A1 data mounting and connect ACU cord to connector J4.
26	Remove jumper wire from KS-21253-L5 adapter.
27	If option S was temporarily installed in 48ER1 data unit in Step 2, remove option S and install option D.
28	Refer to Fig. 1 for any remaining tests.

E. Single Installation (Automatic Answering With Two Calls Answered)

3.11 This installation consists of a DAS 829-type CIU and a 48FR1 data unit housed in a 59A1 data mounting. The 48FR1 data unit automatically answers calls on DDD2 and DDD1 lines when option E is installed in the data unit or when option D is installed in the data unit and a customer- or modem-provided contact is closed.

STEP	PROCEDURE
1	Install options in 48FR1 data unit as directed in Section 598-082-200 and as specified on service order and/or circuit layout record card.
2	If option D is installed in 48FR1 data unit, temporarily remove option D and install option E.
3	For nonregistered arrangements, perform Steps 4 through 7. For registered arrangements, verify that transmit (XMT) and receive (REC) switches on 48FR1 data unit are set to 8 dB fixed loss loop as specified in Table A, then proceed to Step 8. ***Note:*** Steps 4 and 5 are for adjusting transmit (XMT) switch on 48FR1 data unit.
4	Measure loop loss for line 1 (T2, R2) using a 600-ohm loop termination and the milliwatt supply in serving central office.
5	Set 4-pole transmit (XMT) switch on 48FR1 data unit for measured line loss as specified in Table A. For example, if measured line loss is 4.5 dB, switch would be set with poles 1 and 4 released and poles 2 and 3 operated. ***Note:*** Steps 6 and 7 are for adjusting receive (REC) switch on 48FR1 data unit.
6	Measure loop loss for line 2 (T3, R3) using a 600-ohm loop termination and the milliwatt supply in serving central office.
7	Set 4-pole receive (REC) switch on 48FR1 data unit for measured line loss as specified in Table A. For example, if measured line loss is 4.5 dB, switch would be set with poles 1 and 4 released and poles 2 and 3 operated. ***Note:*** Steps 8 through 19 check switching and ring detection functions of 48FR1 data unit. This procedure requires the assistance of a serving test center (STC) equipped with a 48ER1 data unit with options M and T installed.
8	Set controls on TTS-4B test set as follows: SEND FREQ to 1000 SEND LEVEL to 0 (CAL) SEND IMP to 600Ω FUNCTION to SEND + TALK + REC REC IMP to 600Ω

STEP	PROCEDURE
9	Connect a 2P4B cord between REC 310 jack on test set and REC TST jack on 48FR1 data unit.
10	Contact STC and agree on test procedure to be performed.
11	STC uses DDD2 line of 48ER1 data unit to call directory number of DDD1 line of 48FR1 data unit. ***STC Requirement:*** STC hears 48FR1 data unit automatically answer call (trip ringing).
12	STC depresses and releases HOLD button. ***STC Requirement:*** DDD2 lamp lights.
13	STC uses DDD1 line of 48ER1 data unit to call directory number of DDD2 line of 48FR1 data unit. ***STC Requirement:*** STC hears 48FR1 data unit automatically answer call (trip ringing).
14	STC depresses and releases HOLD button. ***STC Requirement:*** DDD1 lamp lights. After about 10 seconds, BU lamp on 48ER1 data unit lights. ***Station Requirement:*** Test set meter reads signal level of -16 ±7 dBm for about 10 seconds. At end of signal, BU lamp on 48FR1 data unit lights. Station is now in dial backup mode.
15	Connect a 2P4B cord between SEND 310 jack on test set and XMT TST jack on 48FR1 data unit. ***STC Requirement:*** STC measures and records signal level of -16 ±7 dBm at REC TST jack on 48ER1 data unit (600 ohms terminating impedance).
16	STC connects a 1000-Hz 0 dBm signal source (600 ohms terminating impedance)(to XMT TST jack on 48ER1 data unit. ***Station Requirement:*** Test set meter reads signal level of -16 ±7 dBm.
17	On test set, set SEND LEVEL to +10. ***STC Requirement:*** Signal level at REC TST jack on 48ER1 data unit is not more than 2 dB greater than level recorded in Step 15.
18	After 10 dB signal has been sent to STC for about 10 seconds, set SEND LEVEL on test set to -10.
19	When STC observes a 10 dB drop in signal level for a minimum of 3 seconds, STC takes handset off-hook and depresses and releases REL button.

STEP	PROCEDURE
	Station Requirement: BU lamp on 48FR1 data unit goes off. Station is now released from dial backup mode.
20	Disconnect test set from 48FR1 data unit.
21	If option E was temporarily installed in 48FR1 data unit in Step 2, remove option E and install option D.
22	Refer to Fig. 1 for any remaining tests.

F. Single Installation (Automatic Answering With Automatic Call Back)

3.12 This installation consists of a DAS 829-type CIU and a 48FR1 data unit housed in a 59A1 data mounting. A station dial is used to originate a call on DDD2 line. The 48FR1 data unit automatically answers a call on DDD1 line when option E is installed in the data unit or when option D is installed in the data unit and a customer- or modem-provided contact is closed.

STEP	PROCEDURE
1	Install options in 48FR1 data unit as directed in Section 598-082-200 and as specified on service order and/or circuit layout record card.
2	If option D is installed in 48FR1 data unit, temporarily remove option D and install option E.
3	For nonregistered arrangements, perform Steps 4 through 7. For registered arrangements, verify that transmit (XMT) and receive (REC) switches on 48FR1 data unit are set to 8 dB fixed loss loop as specified in Table A, then proceed to Step 8.
	Note: Steps 4 and 5 are for adjusting transmit (XMT) switch on 48FR1 data unit.
4	Measure loop loss for line 1 (T2, R2) using a 600-ohm loop termination and the milliwatt supply in serving central office.
5	Set 4-pole transmit (XMT) switch on 48FR1 data unit for measured line loss as specified in Table A. For example, if measured line loss is 4.5 dB, switch would be set with poles 1 and 4 released and poles 2 and 3 operated.
	Note: Steps 6 and 7 are for adjusting receive (REC) switch on 48FR1 data unit.
6	Measure loop loss for line 2 (T3, R3) using a 600-ohm loop termination and the milliwatt supply in serving central office.

STEP	PROCEDURE
7	Set 4-pole receive (REC) switch on 48FR1 data unit for measured line loss as specified in Table A. For example, if measured line loss is 4.5 dB, switch would be set with poles 1 and 4 released and poles 2 and 3 operated.
	Note: Steps 8 through 20 check station dial, switching functions, and ring detection functions of 48FR1 data unit. This procedure requires the assistance of a serving test center (STC) equipped with a 48ER1 data unit with options M and T installed.
8	Set controls on TTS-4B test set as follows: SEND FREQ TO 1000 SEND LEVEL to 0 (CAL) SEND IMP to 600Ω FUNCTION to SEND + TALK + REC REC IMP to 600Ω
9	Connect a 2P4B cord between REC 310 jack on test set and REC TST jack on 48FR1 data unit.
10	Contact STC and agree on test procedure to be performed.
11	Program station dial to dial directory number of DDD1 line of 48ER1 data unit at STC.
12	STC uses DDD2 line of 48ER1 data unit to call directory number of DDD1 line of 48FR1 data unit.
	STC Requirement: STC hears 48FR1 data unit automatically answer call (trip ringing).
13	STC depresses and releases HOLD button.
	STC Requirement: DDD2 lamp lights.
14	STC waits up to 1 minute for call on DDD1 line of 48ER1 data unit. When ringing is heard on DDD1 line, STC answers call.
15	STC depresses and releases HOLD button.
	STC Requirement: DDD1 lamp lights. After about 10 seconds, BU lamp on 48ER1 data unit lights.
	Station Requirement: Test set meter reads signal level of -16 ±7 dBm for about 10 seconds. At end of signal, BU lamp on 48FR1 data unit lights. Station is now in dial backup mode.

STEP	PROCEDURE
16	Connect a 2P4B cord between SEND 310 jack on test set and XMT TST jack on 48FR1 data unit. ***STC Requirement:*** STC measures and records signal level of -16 ±7 dBm at REC TST jack on 48ER1 data unit (600 ohms terminating impedance).
17	STC connects a 1000-Hz 0 dBm signal source (600 ohms terminating impedance) to XMT TST jack on 48ER1 data unit. ***Station Requirement:*** Test set meter reads signal level of -16 ±7 dBm.
18	On test set, set SEND LEVEL to +10. ***STC Requirement:*** Signal level at REC TST jack on 48ER1 data unit is not more than 2 dB greater than level recorded in Step 16.
19	After 10 dB signal has been sent to STC for about 10 seconds, set SEND LEVEL on test set to -10.
20	When STC observes a 10 dB drop in signal level for a minimum of 3 seconds, STC takes handset off-hook and depresses and releases REL button. ***Station Requirement:*** BU lamp on 48FR1 data unit goes off. Station is now released from dial backup mode.
21	Disconnect test set from 48FR1 data unit.
22	If option E was temporarily installed in 48FR1 data unit in Step 2, remove option E and install option D.
23	Program station dial to dial number specified by customer. ***Note:*** Do not leave station dial programmed to dial STC number.
24	Refer to Fig. 1 for any remaining tests.

G. Multiple Installation (Manual Dialing With 48B1 or 48ER1 Data Unit)

3.13 This installation uses switched 4-wire dial backup and consists of a maximum of twenty-three DAS 829-type CIUs housed in 46A-type data mountings, one or two 48B1 or 48ER1 data units, a maximum of six 48C1 data units, and one 48D1 data unit. The 48B1 or 48ER1 data units and the 48C1 data units are housed in a 46C-type data mounting. A maximum of twenty-three 48A1 data units housed in 46B1 data mountings may also be provided. The presence of 48A1 data units does not affect this test.

Note: Use of the 48B1 data unit or the 46C1 data mounting is not permitted in registered arrangements.

3.14 With switched 4-wire dial backup, the 4-wire dial backup channel must first be established; then, using an 18- or 30-button CALL DIRECTOR key telephone set, a modem is selected and switched to the dial backup channel. Two 4-wire dial backup

channels, designated A and B, can be provided. The two 2-wire lines required for channel A are controlled by the pickup keys designated DDD1A and DDD2A. For channel B the keys are designated DDD1B and DDD2B. Each channel provided is terminated by a 48B1 or 48ER1 data unit. Perform the test as follows:

Note: Only the indicated channels can be used for dial backup. For example, a dial backup channel cannot be established using pickup keys DDD1A and DDD2B.

STEP	PROCEDURE
1	For channel A and/or channel B, perform installation test for a single installation (manual dialing with 48B1 data unit) as described in paragraph 3.07 or for a single installation (manual dialing with 48ER1 data unit) as described in paragraph 3.08. ***Note:*** Steps 2 through 8 check switching matrix and telephone set for each position equipped with switched 4-wire dial backup.
2	Take handset off-hook. Depress DDD1A (channel A) or DDD1B (channel B) button, then depress HOLD button. ***Requirement:*** DDD1A (channel A) or DDD1B (channel B) lamp lights.
3	Depress DDD2A (channel A) or DDD2B (channel B) button, then depress HOLD button. ***Requirement:*** DDD2A (channel A) or DDD2B (channel B) lamp lights. When station uses a 48ER1 data unit, BU lamp on 48ER1 data unit lights after about 10 seconds.
4	Depress DBU(N) button, that is, DBU button for Nth position. Start with lowest number position equipped with switched 4-wire dial backup. ***Requirement:*** DBU(N) lamp lights. ***Note:*** If alternate voice is also provided for Nth position, button will be labeled TALK-DBU.
5	Depress HOLD button to release DBU(N) button. ***Requirement:*** DBU(N) lamp remains lighted.
6	Depress DBU(N) button, then depress and release REL button. ***Requirement:*** DDD1A or DDD1B, DDD2A or DDD2B, and DBU(N) lamps go off immediately when station uses a 48B1 data unit or after about 3 seconds when station uses a 48ER1 data unit. If DBU(N) button is labeled TALK-DBU, it remains lighted.
7	Depress and release HOLD button. ***Requirement:*** All lamps go off.

STEP	PROCEDURE
8	Repeat Steps 2 through 7 for each position equipped with switched 4-wire dial backup.
9	Refer to Fig. 1 for any remaining tests.

4. TROUBLE ISOLATION TESTS

4.01 There are four methods of isolating trouble encountered on CIUs and their associated equipment:

- Loopback from STC
- Access channel through test jacks
- Access CIU and channel through 171C test adapter
- Access interface leads through KS-21253-L5 adapter or through 66E-type connecting block.

4.02 Whenever trouble is encountered on the private line channel, the first test to be performed is the loopback test by the STC. The STC personnel may compare actual measurements against benchmark tests recorded at time of installation. Local policy should dictate the conditions under which personnel will be dispatched to the CIU location.

4.03 Test jacks on the DAS 829-type CIU provide access to the transmit and receive circuits of a 4-wire private line channel, or provide access to the transmit and receive circuits of the 4-wire portion of a 2-wire private line channel. Four-wire private line channel transmission tests, either end-to-end or end-to-STC, must be made through these test jacks. Two-wire private line transmission tests, either end-to-end or end-to-STC, must be made through the 2W TST jack on the 48G1 data unit, except tests that require a 4-wire interface.

4.04 The 171C adapter is a card extender that can be used to access the CIU for voltage measurements and to access T, R, T1, and R1 leads of the 4-wire metallic facilities without going through the CIU.

4.05 The KS-21253-L5 adapter is a 50-pin Amphenol-type connector for accessing the DT, DR, DT1, DR1, TEK5, TEK6, DBU1, and DBU2 leads (for a single 4-wire private line modem interface), or for accessing the DT1, DR1, TEK5, and TEK6 leads (for a single 2-wire private line modem interface), at the point where 25-pair cables normally interconnect the various pieces of equipment. This adapter can be used for making continuity checks through the data mountings.

4.06 To clear a trouble report involving a CIU and its associated equipment, the type of trouble must be determined:

(a) Trouble with transmitting or receiving data on private line

(b) Trouble with alternate voice equipment

(c) Trouble with switching from 4-wire private line to 4-wire dial backup channel

(d) Trouble with transmitting or receiving data on 4-wire dial backup channel.

A. Private Line

4.07 If the loopback test from the STC determines that trouble exists in the private line, the trouble must be cleared by following procedures specified in Section 314-410-300. If the station equipment is suspected of being defective, a dispatch to the station location is required.

4.08 To determine if a CIU (4-wire private line channel) or a CIU and a 48G1 data unit (2-wire private line channel) operate properly, perform tests specified for the type of channel as called for in Section 314-410-500. For 4-wire private line channels, tests to the STC or distant end must be made through the TRANS TST and REC TST jacks on the CIU. For 2-wire private line channels, tests to the STC or distant end

must be made through the 2W TST jack on the 48G1 data unit, except tests that require a 4-wire interface.

4.09 The trouble may be due to failure of the low voltage power supply. Verify that the CIU has the required voltage by using a KS-14510-L1 VOM (or equivalent). Measure for a voltage of approximately 24 Vac on terminals AC1 and AC2 of the 44A-type, 45A1, 59A1, or 62A1 data mounting. If a 46A-type data mounting is used, measure for a voltage of approximately 24 Vac between terminals AC1(1) and AC2(1) located on the backplane.

4.10 Replace any defective CIU or 48G1 data unit. If the private line channel then tests good at the test jacks and the trouble is not cleared, the trouble may be in the station wiring or in the data mounting wiring. This may be determined by checking the continuity of the telco-provided station wiring. It is necessary to access the DT, DR, DT1, DR1, TEK5, and TEK6 leads at a 4-wire modem interface, or to access the DT1, DR1, TEK5, and TEK6 leads at a 2-wire modem interface.

4.11 If the modem is telco-provided, there are two ways of connecting the modem to the CIU.

- Some arrangements provide access to the interface of a single modem, such as single installations using a 44A-type, 45A1, 59A1, or 62A1 data mounting or multiple installations using a KS-21253-L1 or -L4 adapter.
- Some arrangements do not provide access to the interface of a single modem. An example of this is data sets 202T installed in a 40B1 data mounting. To access the interface of a single modem, it is necessary to interrupt service to the other seven modems associated with the same connector.

4.12 If the modem is customer-provided, access to the modem interface can be made at the demarcation point, such as the 42A, 44A, or 66E-type connecting block.

4.13 The general procedure is to disconnect the modem at the private line demarcation point and then test for continuity between the demarcation point and the CIU and/or 48G1 data unit. When the demarcation point is for a single telco-provided modem, convenient access to pairs DT and DR, DT1 and DR1, TEK5 and TEK6, and DBU1 and DBU2 is provided through use of the KS-21235-L5 adapter (Fig. 2). When the demarcation point is for a multiple arrangement of modems, use a 66E-type connecting block to access individual leads per Table B, or use the connector terminals to access individual leads per Table C.

4.14 For 2-wire private line modems, tests for continuity on pair DT1 and DR1 can be made from the demarcation point to the 2W MON jack on the 48G1 data unit as per local company practice. Likewise, tests for continuity on pair TEK5 and TEK6 can be made from the demarcation point to the CIU.

TABLE B

CONNECTIONS AT 66E-TYPE CONNECTING BLOCK USED IN PLACE OF MODEM

DAS 829-TYPE CIU INSERTED IN POSITION DESIGNATED (N)	TERMINAL CONNECTIONS ON 66E-TYPE CONNECTING BLOCK					
	DT(N)	DR(N)	DT1(N)	DR1(N)	TEK5(N)	TEK6(N)
1 or 9 or 17	1	2	3	4	5	6
2 or 10 or 18	7	8	9	10	11	12
3 or 11 or 19	13	14	15	16	17	18
4 or 12 or 20	19	20	21	22	23	24
5 or 13 or 21	25	26	27	28	29	30
6 or 14 or 22	31	32	33	34	35	36
7 or 15 or 23	37	38	39	40	41	42
8 or 16	43	44	45	46	47	48

TABLE C

MULTIPLE CONNECTIONS FOR STANDARD 6-LEAD INTERFACE

DAS 829-TYPE CIU INSERTED IN POSITION DESIGNATED (N)	PIN NUMBERS ON STANDARD 50-PIN CONNECTORS					
	DT(N)	DR(N)	DT1(N)	DR1(N)	TEK5(N)	TEK6(N)
1 or 9 or 17	26	1	27	2	28	3
2 or 10 or 18	29	4	30	5	31	6
3 or 11 or 19	32	7	33	8	34	9
4 or 12 or 20	35	10	36	11	37	12
5 or 13 or 21	38	13	39	14	40	15
6 or 14 or 22	41	16	42	17	43	18
7 or 15 or 23	44	19	45	20	46	21
8 or 16	47	22	48	23	49	24

4.15 For 4-wire private line modems, tests for continuity on pair DT and DR can be made from the demarcation point to the REC MON jack on the CIU as per local company practice. Likewise, tests for continuity on pair DT1 and DR1 can be made from the demarcation point to the TRANS MON jack on the CIU. Finally, tests for continuity on pair TEK5 and TEK6 can be made from the demarcation point to the CIU.

B. Alternate Voice

4.16 If the trouble report indicates problems associated with the alternate voice service, the trouble may be due to failure of the low voltage power supply. Verify that the 48A1 data unit has the required voltage by using a KS-14510-L1 VOM (or equivalent). Measure for a voltage of approximately 24 Vac on terminals AC1 and AC2 of the 45A1 or 59A1 data mountings. If a 46B1 data mounting is used, measure for a voltage of approximately 24 Vac between terminals AC1(1) and AC2(1) located on the backplane.

4.17 If the power supplied to the 48A1 data unit is proper, then proceed as follows:

STEP	PROCEDURE
1	Check data-to-talk transfer by performing installation tests for an installation equipped with alternate voice.
2	If installation tests pass, proceed to Step 4.
3	If installation tests fail, replace 48A1 data unit and retest. If retest fails, replace telephone set and retest.
	Note: Steps 4 through 7 check that TEK5, TEK6 connection is broken when station is in talk mode.
4	If 48A1 data unit is installed in a 45A1 or 59A1 data mounting, connect KS-21253-L5 adapter in place of modem. If 48A1 data unit is installed in a 46B1 data mounting, disconnect

STEP	PROCEDURE
	modem and use a 66E-type connecting block to access TEK5 and TEK6 per Table B, or use the connector terminals to access TEK5 and TEK6 per Table C.
5	With CIU in data mode, test for continuity on pair TEK5 and TEK6 as per local company policy. ***Requirement:*** Test indicates continuity (short circuit).
6	Transfer to talk mode by taking handset off-hook and depressing TALK button. ***Requirement:*** TALK lamp lights.
7	Test for continuity on pair TEK5 and TEK6 as per local company policy. ***Requirement:*** Test indicates open circuit.
8	If step 6 or 7 fails, replace 48A1 data unit.
9	Restore station to pretest condition.

C. 4-Wire Dial Backup

4.18 If the trouble report indicates problems associated with the 4-wire dial backup equipment:

(a) For single installations, perform the installation tests. If these tests fail, replace the 48B1, 48ER1, or 48FR1 data unit and retest. If the tests still fail, replace the telephone set.

(b) For multiple installations equipped with switched 4-wire dial backup, perform the tests specified in paragraph 4.19. If when performing these tests, a telephone set lamp fails to light, check the bulb for failure before replacing any equipment. If the telephone set is replaced, ensure wiring is modified as specified in Section 598-082-200.

4.19 Proceed as follows:

STEP	PROCEDURE
1	Perform Steps 2 through 20 for each 4-wire dial backup channel provided. ***Note:*** Steps 2 through 8 check the operation of the 48B1 or 48ER1 data unit providing 4-wire dial backup channel A or channel B.
2	Take handset off-hook and depress DDD1A (channel A) or DDD1B (channel B) button. ***Requirement:*** DDD1A (channel A) or DDD1B (channel B) lamp does not light. Dial tone is heard in handset.
3	Dial directory number of DDD2A (channel A) or DDD2B (channel B) line.

STEP	PROCEDURE

Requirement: Audible indication is heard. DDD2A (channel A) or DDD2B (channel B) lamp flashes in response to audible indication.

4 When audible indication is heard, depress and release HOLD button.

Requirement: DDD1A (channel A) or DDD1B (channel B) lamp lights and DDD1A or DDD1B button releases on up-stroke of HOLD button. Audible indication continues.

5 Depress DDD2A (channel A) or DDD2B (channel B) button.

Requirement: Audible indication ceases. DDD2A (channel A) or DDD2B (channel B) lamp stops flashing.

6 Depress and release HOLD button.

Requirement: DDD2A (channel A) or DDD2B (channel B) lamp lights and DDD2A or DDD2B button releases on up-stroke of HOLD button. When station uses a 48ER1 data unit, BU lamp on 48ER1 data unit lights after about 10 seconds. Station is now in dial backup mode using dial backup channel A or channel B.

7 Depress and release REL button.

Requirement: Both DDD1A and DDD2A (channel A) or DDD1B and DDD2B (channel B) lamps go off immediately when station uses a 48B1 data unit or after about 3 seconds when station uses a 48ER1 data unit. Station is now released from dial backup mode.

8 Repeat Steps 2 through 7 using DDD2A line to call DDD1A line (channel A) or DDD2B line to call DDD1B line (channel B).

9 If any of Steps 2 through 8 fails, replace 48B1 or 48ER1 data unit associated with that channel and retest. If test still fails, replace telephone set.

Note 1: Ensure telephone set wiring is modified as specified in Section 598-082-200.

Note 2: Steps 10 through 15 check switching matrix and telephone set for each position equipped with switched 4-wire dial backup.

10 Take handset off-hook. Depress DDD1A (channel A) or DDD1B (channel B) button, then depress HOLD button.

Requirement: DDD1A (channel A) or DDD1B (channel B) lamp lights.

11 Depress DDD2A (channel A) or DDD2B (channel B) button, then depress HOLD button.

Requirement: DDD2A (channel A) or DDD2B (channel B) lamp lights. When station uses a 48ER1 data unit, BU lamp on 48ER1 data unit lights after about 10 seconds.

12 Depress DBU(N) button, that is, DBU button for Nth position. Start with lowest number position equipped with switched 4-wire dial backup.

STEP	PROCEDURE
	Requirement: DBU(N) lamp lights.
	Note: If alternate voice is also provided for Nth position, button will be labeled TALK-DBU.
13	Depress HOLD button to release DBU(N) button.
	Requirement: DBU(N) lamp remains lighted.
14	Depress DBU(N) button, then depress and release REL button.
	Requirement: DDD1A or DDD1B, DDD2A or DDD2B, and DBU(N) lamps go off immediately when station uses a 48B1 data unit or after about 3 seconds when station uses a 48ER1 data unit. If DBU(N) button is labeled TALK-DBU, it remains lighted.
15	Depress and release HOLD button.
	Requirement: All lamps go off.
16	Repeat Steps 10 through 15 for each position equipped with switched 4-wire dial backup.
17	If Step 13 fails, replace 48C1 data unit associated with Nth position and retest. If test still fails, replace telephone set.
	Note: Ensure telephone set wiring is modified as specified in Section 598-082-200.
18	If Steps 10 through 15 pass ***except*** that none of DBU(N) or TALK-DBU(N) lamps light, check fuses in 48D1 data unit and replace fuses or 48D1 data unit as required.
19	If step 12 or 13 fails for all positions, check wiring modification in telephone set.
20	If Step 12 passes, but Step 13 fails, replace 48B1 or 48ER1 data unit associated with that channel.
21	Restore station to pretest condition.

4.20 After completing tests specified in paragraph 4.18, perform the following test to determine if the 4-wire dial backup channel meets requirements.

STEP	PROCEDURE
1	Plug KS-21253-L5 adapter in place of modem (N). If it is not possible to access a single modem interface, use a 66E-type connecting block to access individual leads. Refer to Table B for appropriate terminals.

STEP	PROCEDURE

2 Set controls on TTS-4B test set as follows:

- SEND FREQ to 1000
- SEND LEVEL to 0
- SEND IMP to 600Ω
- FUNCTION to SEND + TALK + REC
- REC IMP to 600Ω

3 Insert plug of a 2W6A cord into SEND 310 jack on test set. Connect the alligator clips to DR1 and DT1.

4 Insert plug of another 2W6A cord into REC 310 jack on test set. Connect the alligator clips to DR and DT.

5 Use DDD1 line to call DDD2 line. When audible indication is heard, depress and release HOLD button.

Requirement: DDD1 lamp lights.

6 Depress DDD2 button, then depress and release HOLD button. If station is a single installation, it is immediately in dial backup mode when station uses a 48B1 data unit or after about 10 seconds when station uses a 48ER1 data unit.

Requirement: DDD2 lamp lights. After about 10 seconds, BU lamp on 48ER1 data unit lights.

7 If station is a multiple installation, depress DBU(N) button, then depress and release HOLD button. Station is immediately in dial backup mode when station uses a 48B1 data unit or after about 10 seconds when station uses a 48ER1 data unit.

Requirement: DBU(N) lamp lights. After about 10 seconds, BU lamp on 48ER1 data unit lights.

8 Check test set meter for level of received signal.

Requirement: -8 to -16 dBm.

Note: The test set is transmitting a 0-dBm signal. The transmit side is arranged so that the signal to the serving central office is no greater than -12 dBm. There is a 3- to 4-dB loss through the central office and a +3.7 dB gain in the receive side to the modem. Therefore the received signal should be a nominal -12 dBm.

9 If there is no received signal, or if there is difficulty in placing call, clear trouble in same way as a telephone trouble.

STEP	PROCEDURE
10	If telephone portion of a single station installation functions properly, but trouble is encountered in switching from 4-wire private line to 4-wire dial backup channel, replace 48B1 or 48ER1 data unit.
11	If telephone portion of a multiple station installation functions properly, but trouble is encountered in switching from 4-wire private line to 4-wire dial backup channel, replace 48C1 data unit associated with channel (N) and retest. If retest fails, replace 48B1 or 48ER1 data unit and retest.
12	Restore station to pretest condition.

5. REFERENCES

5.01 Additional information concerning testing of the DAS 829-type CIU and the supplemental data units and data mountings is contained in the following publications:

SECTION	TITLE
314-410-300	Voice Bandwidth Private Line Data Circuits—Maintenance
314-410-500	Voice Bandwidth Private Line Data Circuits—Tests and Requirements
598-082-100	Data Auxiliary Set 829-Type—Channel Interface Units—Voiceband Private Line Channels—Description
598-082-200	Data Auxiliary Set 829-Type—Channel Interface Units—Voiceband Private Line Channels—Installation and Connections
598-088-500	Data Auxiliary Set 801CR-L1/2—Test Procedures

5.02 Detailed information concerning the DAS 829-type CIU and the supplemental data units and data mountings is contained in CD- and SD-1D247-01.

PART IV

DIGITAL TRANSMISSION

DIGITAL DATA SYSTEM
LOCAL LOOP
MAINTENANCE PROCEDURES

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1. GENERAL

1.01 This section describes maintenance considerations and procedures used to locate trouble on a digital data system (DDS) local loop.

1.02 This section is reissued to incorporate information on maintenance procedures when Dataport facilities are used. In addition, maintenance procedures have been updated for the latest vintage equipment used in the field. Since these changes constitute a general revision, arrows normally used to denote changes have been omitted.

1.03 A DDS local loop consists of the following:

(1) A 500A-type data service unit (DSU) or a 550A-type channel service unit (CSU) located on customer premises.

(b) A connecting 4-wire circuit.

(c) An office channel unit (OCU) or OCU dataport (OCUDP) located in the serving central office (SCO) or for the OCU, in the hub office.

(d) Two repeaters where 56-kb/s service is provided.

(e) For 56-kb/s dataport service, an external OCU plus a DS-0 level dataport (DSODP).

Descriptive information on the DSU, CSU, and OCU is given in Sections 595-200-100, 595-100-100, and 314-910-100, respectively. The 56-kb/s repeater is described in Section 314-920-100.

1.04 The 4-wire circuit consists of cable to a serving office where DDS multiplexing equipment is located. In some cases the cable may

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route through one or local (baseboard) offices. Nonloaded cable pairs as used for any of the common services (such as message telephone, DATAPHONE®, and short-haul carrier systems) can be used. Loop engineering guidelines are given in Section 880-601-115.

1.05 A DDS local loop trouble is indicated by:

(a) A satisfactory OCU loopback test and a failure of the channel loopback test.

(b) A satisfactory OCU and channel loopback test and a failure of the DSU loopback test.

(c) Intermittent error performance on channel and/or DSU loopback test.

1.06 Trouble analysis procedures and information in this section are based on the results of tests made under the following conditions:

(a) One-employee tests made at the OCU or local test desk (LTD).

Caution: A dc loop current in excess of 250 mA may damage the DSU/CSU at the station end. Do not use test equipment, for example, a breakdown test set, that applies a current greater than 250 mA to the cable pairs, unless the OCU or OCUDP has been unplugged and the DSU/CSU has been disconnected from the pairs.

(b) Two-employee tests made between the station and the OCU bay or OCUDP in the office, either for initial installation tests of the 4-wire channel or for more detailed tests during trouble analysis.

1.07 These various tests are outlined in Part 3 of this section. The step-by-step procedure for performing these tests is given in Section 314-410-510.

Trouble Reporting and Isolation

1.08 No routine maintenance is required for DDS local loops. Procedures for clearing trouble normally start at receipt of a trouble report.

1.09 Transmission faults on the local loop are not alarmed and will normally be detected and reported to the serving test center (STC) by the customer. The customer may be notified by lamp or interface lead indications on the DSU in the event of circuit trouble.

1.10 No routine maintenance is required for the digital 56-kb/s repeater. All circuit packs are plug in basis. In the event of a repeater failure, the defective circuit pack can be easily replaced.

1.11 Two green light emitting diodes (LEDs) on the central office (CO) mounted repeater monitor for the presence of data or idle code transmitted through the repeater in each direction. The TRMT DA LED, when illuminated, indicates the presence of data toward the station DSU or CSU. The RCV DA LED, when illuminated, indicates the presence of data towards the DDS network. The absence of data, due to facility trouble or component failure, will cause one or both of the LEDs to be off. A fuse failure will cause an office alarm.

1.12 Four jacks located on the CO mounted repeater shelf provide access for dc and ac testing of the loop facilities from the repeater location. The repeater can also be bypassed by operating a switch located at the front of the repeater or removing simplex current in the newer (List 2) version of the repeater. In the bypassed condition, testing of the entire loop (except the repeater) can be performed from the central office containing the OCU.

Note: The outside plant (OP) repeater can be remotely bypassed to allow dc tests to be performed by removing the dc simplex current from the loop. Normal OP repeater operation is restored by reapplying dc simplex current to the loop.

1.13 When a trouble report is received from the STC, the craft employee at the SCO must perform the one-employee tests on the local loop, and notify the STC of the results, within 15 minutes in order to meet the overall maintenance objectives for DDS service. If dispatch to the customer station is required, the STC will coordinate the dispatch.

2. ANALYSIS PROCEDURES

2.01 This part outlines the analysis procedures, shown in Fig. 1, that are used to isolate

and clear troubles on DDS local loops that do not contain 56-kb/s repeaters. The procedures may be made under the direction of the STC or, in some cases, directed by the local test desk (LTD). The procedure begins by the STC verifying (by loop-back tests) that the OCU loop-back is good and that the trouble is in the local loop.

Note: The following paragraphs (2.02 through 2.14) provide reference to the corresponding numbered blocks shown in Fig. 1.

2.02 The craft employee at the SCO performs tests A, B, and C at the OCU location. These tests are to be performed when directed during trouble periods and are listed in Table A. The procedures are given in Section 314-410-510. If results of test A, B, or C fail to meet test requirements, proceed to paragraph 2.10.

2.03 If results of tests A, B, and C meet requirements, check the simplex voltage by performing test D before replacing the OCU with a spare OCU. If simplex voltage is missing, check the fuse in the bay clock, power, and alarms (BCPA) unit or local timing supply (LTS) (non-Dataport applications). Then, replace the OCU or OCUDP with a new unit of the correct bit rate and proper options and repeat the channel loop-back test.

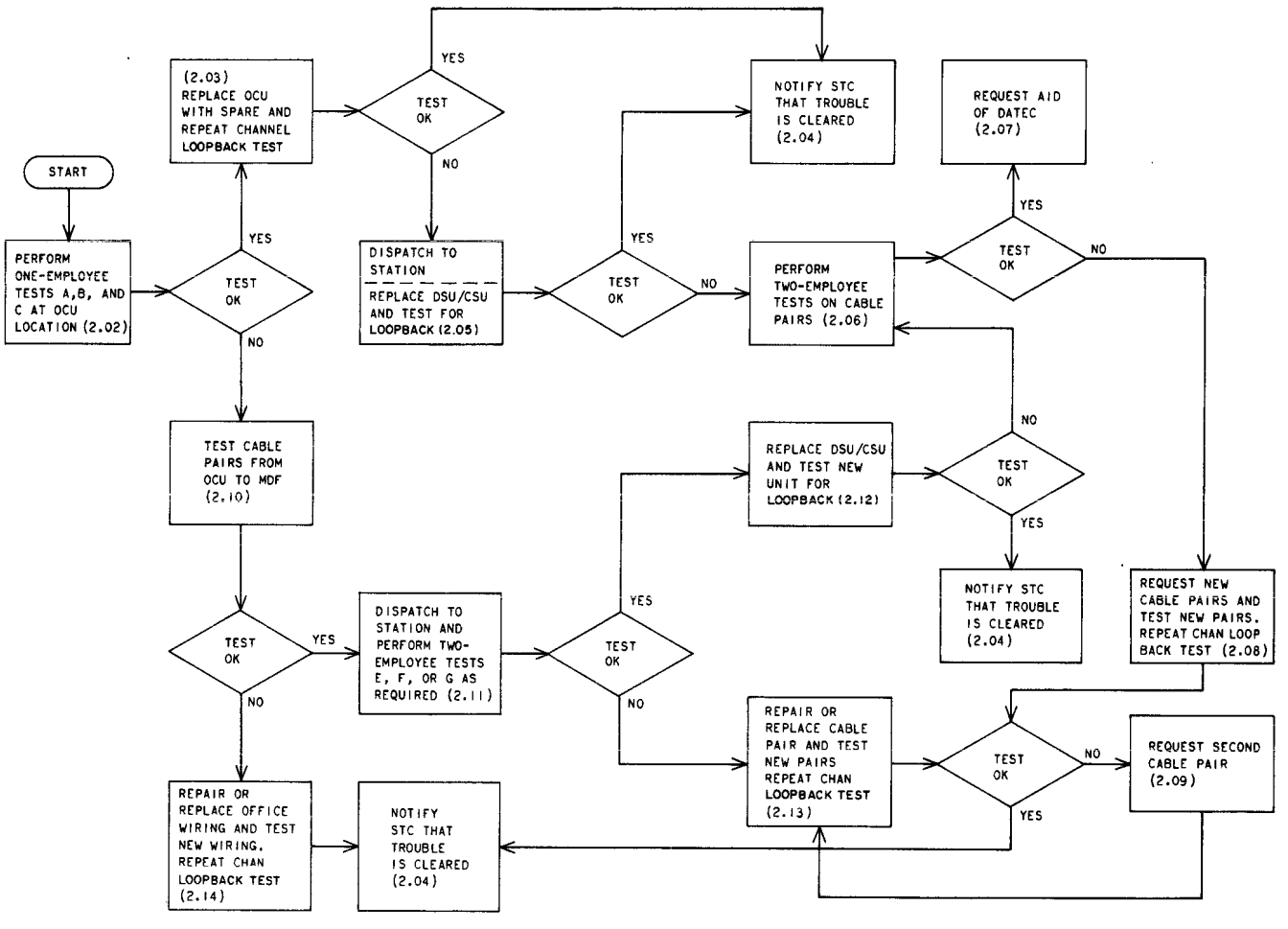

Fig. 1—Local Loop Trouble-Clearing Procedures

TABLE A

SERVING CENTRAL OFFICE (ONE-EMPLOYEE) TESTS

NAME OF TEST	TEST APPARATUS REQUIRED*	PROBABLE CAUSE OF TEST FAILURE
A. Foreign Voltage	(1) KS-14510-L1 Multimeter (2) 789A Tool For Dataport configuration use ED3C947 tool for D3 channel banks and ED3C948 tool for D4 channel banks instead of 789A tool.	Short circuit to another cable pair
B. Insulation Resistance		Short or ground in cable pairs
C. Loop Resistance		Open or short in cable pairs
D. OCU Simplex Voltage		Fuse in BCPA unit or battery wiring

* The 789A, ED3C947, and ED3C948 tools are not required if tests are performed at the LTD.

Note: Set the fixed line build-out (FLBO) on the OCU network option given on the circuit layout record card (CLRC) as shown below.

FLBO NETWORK OUT	FLBO NETWORK IN
S1 C	0
S2 C	0
S3 0	C
S4 0	C

C = Screw switch closed
0 = Screw switch open

2.04 If the channel loop-back test results are good, notify STC and report that local loop trouble is cleared.

2.05 If the channel loop-back test results are bad, a craft employee must be dispatched to the station with a DSU/CSU for the right speed. Replace the DSU/CSU and test according to Sections 595-200-500 and 595-100-500, respectively. Then, repeat the channel loop-back tests.

2.06 If the channel loop-back test results are still bad, perform the two-employee tests (E through J) between the OCU and customer station locations as required. The tests to be performed during trouble periods are listed in Table B. The procedures are given in Section 314-410-510.

2.07 If the two-employee test results on the cable pairs are good and loop trouble has not been located, request aid of data technical support group (DATEC) through normal lines of supervision.

2.08 If the two-employee test results on the cable pair are bad, notify cable assignment desk and request new nonloaded cable pairs. Test the new cable pairs by performing all the two-employee tests listed in Table B. The procedures are given in Section 314-410-510. If all cable test results are good, repeat the channel loop-back test, and if test is successful, notify STC that loop trouble has been cleared.

2.09 If results of two-employee tests on the new cable pairs are bad, request a second reassignment and repeat the two-employee tests. If the second cable pairs are also bad, request aid of DATEC through normal lines of supervision.

2.10 If the results of the one-employee tests A, B, or C are bad, test the cable pairs between the OCU and the main distributing frame (MDF).

2.11 If the results of the tests performed in paragraph 2.10 are good, dispatch a craft employee to the customer station end and perform

TABLE B

SERVING CENTRAL OFFICE-TO-STATION (TWO-EMPLOYEE) TESTS

NAME OF TEST	TEST APPARATUS REQUIRED*	PROBABLE CAUSE OF TEST FAILURE
E. Foreign Voltage	(1) KS-14510-L1 Multimeter (2) 789A Tool	Short circuit to another cable pair
F. Insulation Resistance	(1) KS-14510-L1 Multimeter (2) 789A Tool	Short or ground in cable pairs
G. Loop Resistance	(1) KS-14510-L1 Multimeter (2) 789A Tool	Open or short in cable pairs
H. Insertion Loss	(1) Two HP-3550B Test Sets (2) 789A Tool (3) P2ES Cord	Inaccurate cable records, load coils, bridged taps
I. Background Circuit Noise	(1) Two 6F NMSs (2) 789A Tool (3) P2ES Cord	Pair imbalance
J. Impulse Noise	(1) Two 6F NMSs (2) 789A Tool (3) P2ES Cord	Pair imbalance

* For Dataport configuration use ED3C947 tool for D3 channel banks and ED3C948 tool for D4 channel banks instead of 789A tool.

the two-employee tests E, F, or G as required and as listed in Table B. The procedures are given in Section 314-410-510.

2.12 If the two-employee test results are good, replace the DSU/CSU at station end and test according to Sections 595-200-500 and 595-100-500, respectively. Then request STC to repeat the channel loop-back tests. If the loop-back test is now good, notify STC that loop trouble is cleared. If loop-back test results are still bad, refer to paragraph 2.06 and perform remaining two-employee tests H, I and J.

2.13 If the two-employee test results on the cable pair are bad, notify the cable assignment desk and request new cable pairs. Test the new cable pairs by performing all the two-employee tests listed in Table B. The procedures are given in Section 314-410-510. If cable test results are now good, repeat the channel loop-back test, and if test is successful, notify STC that loop trouble is cleared. If test results are bad, refer to paragraph 2.09.

2.14 If test of wiring between OCU and MDF indicates trouble, repair the office wiring and repeat tests listed in paragraph 2.10. If these test results are now good, repeat the channel loop-back test, and if test is successful, notify STC that trouble has been cleared at the office. If tests results are still bad after repair or replacement of wiring, escalate problem by referring problem to higher levels of supervision.

3. ANALYSIS PROCEDURES FOR LOOPS CONTAINING 56-KB/S REPEATERS

3.01 This part outlines the analysis procedures that are used to isolate and clear troubles

on the DDS local loop containing a 56-kb/s repeater. Figure 2 shows the various loop arrangements that can be configured for 56-kb/s service and the various types of loop sections (A through H type) that may be involved. Trouble clearing procedures are shown in Fig. 3 through 11. The procedures begin under the direction of the STC, starting with its verifying (by channel loop-back tests) that the trouble is in the local loop.

Note: The following paragraphs (3.02 through 3.52) provide reference to the corresponding numbered blocks shown in Fig. 3 through 11.

3.02 For non-Dataport circuits, repeat all loop-back (LB) tests at the OCU location to verify that the OCU loop-back is good and the trouble fault is in the local loop. The loop-back tests, made using the KS-20908 and KS-20909 test sets, include the DSU/CSU loop-back, the channel loop-back at each repeater location, and the OCU loop-back.

3.03 If all loop-back tests fail, remove the OCU and insert a spare OCU with the same option installed as the defective OCU.

3.04 If all loop-back tests fail, remove OCU and insert 789A tool in its slot. Check for simplex voltage at the OCU by performing test D.

3.05 If simplex voltage is missing, check the fuse in the bay clock, power, and alarms (BCPA) unit or local timing supply (LTS).

3.06 If the channel loop-back test results are good, notify the STC and report that the local loop trouble has been cleared. If the channel loop-back test results are still bad, proceed to paragraph 3.07.

3.07 Insert the 789A tool in place of the OCU. Bypass all repeaters [both central office (CO) and outside plant (OP) type]. Bypassing the repeaters, if they are of the early or List 1 type, may require the assistance of other personnel in the same or other offices.

3.08 Loop sections consist of cable facilities which terminate in 56-kb/s repeaters, OCUs, DSUs, or CSUs. A faulty loop section can be recognized by a satisfactory loop-back test at the end of the loop section nearest the SCO and a loop-back test failure at the end farthest from the SCO. Comparison of the loop section being tested with Fig. 2 will identify the type of faulty loop section and the correct procedure to be selected in Fig. 3.

3.09 Perform the one-employee tests A, B, and C at the OCU location. A benchmark value should be recorded on the loop record card for this measurement.

3.10 Check the power unit simplex voltage and reversal of simplex voltage using the procedures given in Section 314-920-500.

3.11 If results of the simplex voltage test are bad, repair or replace the faulty circuit pack or shelf wiring; then repeat the channel loop-back tests. If the loop-back test results are now good, notify the STC and report that loop trouble has been cleared. If test results are still bad, proceed to paragraph 3.12.

3.12 Dispatch a craft employee to the OP repeater with operable circuit packs (CPs) for the repeater.

3.13 Replace each CP in the repeater in turn and notify the SCO test employee.

3.14 Perform all LB tests from the OCU until the defective CP is located. If changing a given CP does not clear the trouble, put it back in the repeater.

3.15 If the DSU/CSU, channel, and OCU loop-back test results are good, notify the STC and report that the local loop trouble has been cleared.

3.16 If results of the loop-back tests are still bad, perform the two-employee tests (E through J as listed in Table B) between the OCU and OP repeater as required. The procedures are given in Section 314-410-510. A benchmark value should be recorded on the loop record card for this measurement.

3.17 If the two-employee test results indicate a bad cable pair, notify cable assignment desk and request new nonloaded cable pairs. Test the new cable pairs by performing all the two-employee tests listed in Table B. The procedures are given in Section 314-410-510. If all cable test results are good, repeat the channel loop-back test. If the test is successful, notify the STC that loop trouble has been cleared.

3.18 If the two-employee test results on the cable pairs are good but loop-back tests fail and loop trouble has not been located, request the aid of DATEC through normal lines of supervision.

3.19 If results of the one-employee dc tests at the OCU are bad, perform the two-employee dc tests (E, F, and G). These tests are made between the OCU and the loop-side of the MDF in the OCU office. A benchmark value should be recorded on the loop record card for this measurement.

3.20 Repair or replace the wiring and repeat the two-employee tests (E, F, and G). If these test results are now good, repeat the channel loop-back tests. If test results are good, notify the STC that the trouble has been cleared at the office.

3.21 Perform the two-employee dc tests (E, F, and G). These tests are made between the MDF at the office and the OP repeater.

3.22 If the dc test results are good but loop-back tests still fail, replace the circuit packs in the OP repeater, one at a time.

3.23 If the channel loop-back test results are bad, dispatch a craft employee to the station end with a properly equipped and operable DSU/CSU.

3.24 Replace the DSU/CSU and test according to Sections 595-200-500 and 595-100-500, respectively. Then repeat the channel loop-back tests.

3.25 If the channel loop-back test results are still bad, perform the two-employee dc tests (E through G as listed in Table B) between the OCU and station as required. A benchmark value should be recorded on the loop record card for this measurement.

> ***Note:*** Both the CO and OP repeaters (if used in the loop section under test) must be bypassed in order to perform these tests. If trouble is found and cleared, remove the repeaters from the bypass mode and repeat the channel loop-back test.

3.26 Perform the two-employee ac tests (H, I, and J). These tests are made between the OP repeater and the station end. A benchmark value should be recorded on the loop record card for this measurement.

3.27 Replace the DSU/CSU and test according to Sections 595-200-500 and 595-100-500, respectively.

3.28 If results of the two-employee dc tests from the OCU to the station are bad, perform the same dc tests on just the station wiring.

3.29 After the tester reaches the OP repeater, perform the two-employee dc tests. These tests are made between the OP repeater and the station end.

3.30 Dispatch a craft employee to the CO repeater office if the office is unoccupied. The office should have spare repeater CPs and test equipment for performing dc and ac tests.

3.31 Perform the two-employee ac tests (H, I, and J). These are made between the CO repeater and the OCU.

3.32 After the tester reaches the CO repeater office, make the two-employee dc tests. These tests are performed between the MDF of the CO repeater and the OCU. A benchmark value should be recorded on the loop record card for this measurement.

3.33 If test results of repeater power and voltage reversals are good, perform the two-employee ac and dc tests (E through J). These tests are made between the CO repeater and the station end. The procedures are given in Section 314-410-510.

3.34 After the tester reaches the CO repeater office, make the two-employee dc tests. These tests are performed between the OCU and the station side of the last MDF. A benchmark value should be recorded on the loop record card for this measurement.

3.35 After the tester reaches the station, perform the two-employee dc tests. These tests are performed between the station and the MDF of the last office.

3.36 Dispatch a craft employee to the simplex power unit in the CO if office is unoccupied.

3.37 If test results of LB tests are bad, perform the two-employee dc and ac tests (E through J). These tests are made between the simplex power unit and the second OP repeater.

3.38 After the tester reaches the first OP repeater, make the two-employee dc and ac tests (E through J). These tests are made between the first OP repeater and the second OP repeater. The procedures are given in Section 640-251-107.

3.39 After the tester reaches the simplex power unit in the central office, perform the two-employee dc tests (E, F, and G). These tests are made between the OCU and the station side MDF at the simplex power unit. A benchmark value should be recorded on the loop record card for this measurement.

3.40 If dc test results between the OCU and the MDF are bad, perform the same dc tests from MDF to the MDF at the office.

3.41 After the tester reaches the first OP repeater, make the two-employee dc tests (E, F, and G). These tests are made from the simplex power unit in the office to the first OP repeater.

3.42 After the tester reaches the OP repeater, make two-employee dc tests (E, F, and G). These tests are made from the station side MDF at the CO repeater office to the OP repeater.

3.43 After the tester reaches the CO repeater office, check the simplex power at the CO repeater as received from the OP repeater.

3.44 If test results of loop-back tests are bad, perform the two-employee dc tests (E, F, and G). These tests are made from the OCU to the CO repeater. A benchmark value should be recorded on the loop record card for this measurement.

3.45 After the tester reaches the OP repeater, make the two employee ac tests (H, I, and J). These tests are made between the OP repeater and the CO repeater.

3.46 After the tester reaches the OP repeater, make the two-employee tests (E, F, and G). These tests are made from OP repeater to the MDF of the CO repeater.

3.47 If the one-employee dc test results are bad when testing a loop containing two CO repeaters, the probable fault is the loop between the repeaters. Sectionalize this type of trouble by performing the two-employee dc test (E, F, and G).

3.48 Check the simplex power and reversals through the CO repeater.

3.49 Repair the CO repeater to correct the simplex power or simplex reversal problem. Then repeat the channel loop-back tests.

3.50 Perform the two-employee dc and ac tests from the CO repeater to the OP repeater.

3.51 Perform the dc tests on office wiring from the MDF to the repeater.

3.52 Check the simplex power and reversals from the first CO repeater at the input to the second CO repeater.

3.53 Perform the two-employee dc and ac tests (E through J) from CO repeater to CO repeater.

4. TESTING

A. Serving Central Office (One-Employee) Tests

4.01 Serving central office tests are made at the SCO and consist of dc measurements performed by one employee at the OCU or the LTD. The tests to be performed are listed and briefly summarized in Table A. The DSU (or CSU) will normally be transmitting a data signal on the T1, R1 pair during these tests. Since the KS-14510 multimeter will not respond to the data signal, the ac data signal will not interfere with the dc measurements.

4.02 This part describes each test and indicates when it is performed. The procedure and test requirements for these tests are given in Section 314-410-510.

Apparatus Required

4.03 The following is a list of test apparatus required for performing these tests on the local loop:

- One portable volt-ohm-milliammeter (VOM), KS-14510-L1 or KS-16979-L1 or equivalent.
- One 789A tool (not required if test is performed at LTD). For the Dataport configuration, at 2.4, 4.8, or 9.6 kb/s, use the ED 3C947 tool for D3 channel banks or the ED 3C948 tool for D4 channel banks.

4.04 The following information is obtained from the CLRC before starting the tests:

- The cable pair loop resistance, measured during initial installation tests.
- The option selected for the FLBO network in the DSU (or CSU), 56-kb/s repeaters, and OCU or OCUDP, and the bit rate of the data service.

Test A. Foreign Voltage

4.05 This test is made to check that no foreign voltage is present on the line pairs. A foreign voltage indicates that a cable fault exists.

4.06 The test is made at the OCU bay using the 789A tool. For the Dataport configuration, use the ED 3C947 tool for D3 channel banks or the ED 3C948 tool for D4 channel banks. Connect the VOM between the following test points: T to R; T1 to R1; and T, R, T1, and R1 to ground. The voltage reading between any of these points should be less than 1 volt.

Test B. Insulation Resistance

4.07 The insulation resistance test measures the resistance from line terminals T, R, T1, and R1 to ground to insure adequate isolation between conductors and ground.

Test C. Loop Plus Terminal Resistance

4.08 Loop resistance measurement is the sum of the loop resistance of the cable pair, the line circuit resistance of the DSU (or CSU), and the resistance of any bypassed 56-kb/s repeaters in the loop. Both the transmit and receive cable pairs are measured. The value of the loop resistance of the cable pair was measured during the initial installation tests and should be recorded on the CLRC.

4.09 The DSU (or CSU) line circuit resistance depends on the bit rate if the FLBO network is installed. A CO repeater adds approximately 36 ohms to the line resistance when bypassed. An OP repeater adds 5758 ohms to the line resistance when bypassed.

Test D. OCU Simplex Voltage

4.10 The OCU simplex voltage measurement requires the use of the multimeter to measure the office battery voltage which is used as a simplex line voltage. The test is made at the OCU location, and the voltage is measured between the BAT and GRD test points on the 789A tool, the ED 3C947 tool, or the ED 3C948 tool. If no voltage is present, check the simplex current fuse associated with the OCU shelf in the BCPA unit or LTS.

4.11 If the simplex voltage measurement is made at the LTD or MDF, the simplex voltage is measured between T and T1 and also between R and R1, looking toward the OCU. The first measurement is made with the STC transmitting a 2047-bit word; the second measurement is made with the STC transmitting the channel loop-back code. The polarity of the simplex voltage must reverse in the second measurement. If no voltage is measured, check the following:

(a) Cable pair continuity between OCU and MDF or LTD.

(b) Simplex current fuse in BCPA or LTS.

(c) Replace OCU or OCUDP (install the FLBO network option listed on the CLRC). Refer to Section 314-410-510 for procedures. Then retest for reversal.

B. Serving Central Office-to-Station (Two-Employee) Tests

4.12 Serving central office-to-station tests consist of dc and ac measurements performed by two employees between the station and the OCU bay or, for Dataport, the channel bank bay in the central office. These measurements will require

that the pairs be opened, shorted, or terminated. The DSU (or CSU) is removed from the local loop before these tests are performed. The tests are performed between the 789A tool, the ED 3C947 tool, or the ED 3C948 tool and the station terminal block. The tests to be performed are listed and briefly summarized in Table B.

4.13 This part describes each test. The step procedure and requirements for these tests are given in Section 314-410-510.

Apparatus Required

4.14 The following is a list of apparatus required for these tests on the local loop:

- Two 6F noise measuring sets (NMSs) with 50-kHz network (479F), or equivalent NMSs with 50-kilobit noise weighting filters.
- Two Hewlett Packard 3550B test sets, or equivalent.
- One KS-14510-L1 multimeter.
- Three 135-ohm resistors.
- One 386B plug (310 plug with a 135-ohm termination).
- One P2ES cord (specify 8- or 12-foot cord length for use with 7- or 11-foot bays).

4.15 The following information is required before starting the tests:

- The cable pair loop resistance, measured during initial installation tests and recorded on the CLRC. [If the measurement result is not available, measure the loop resistance (Test G) and record on the CLRC.]
- The expected measured loss (EML) for the cable pair.

Test E. Foreign Voltage

4.16 Remove DSU (or CSU) at the station end. The test is described in paragraphs 4.05 and 4.06. For loops containing 56-kb/s repeaters, the repeaters must be bypassed.

Test F. Insulation Resistance

4.17 Measure the insulation resistance between the test points on the 789A tool, the ED3C947 tool, or the ED3C948 tool as follows:

T and R; R and R1

T and T1; R and T1

T1 and R1; T and R1

and

T and GRD; R and GRD

T1 and GRD; R1 and GRD.

Test G. Loop Resistance

4.18 Loop resistance measurement checks the dc resistance of the transmit and receive cable pairs while they are shorted together at the station end. The measurement reading is taken at the OCU location in the office using the 789A tool or, for Dataport, ED-type tool and KS-14510 multimeter. If this is an initial installation test, record the value on the CLRC. For loops containing 56-kb/s repeaters, the repeaters must be bypassed.

4.19 If the dc measurements do not meet requirements, the cable fault-locating procedures given in Section 634-310-501 can be used to locate the trouble. This procedure is normally done by the cable repair crew.

Test H. Insertion Loss

4.20 Insertion loss measurement is made using test signal at various frequencies. The test check that the receive signal level will be within the normal operating range. It also verifies that the loops do not have load coils or long bridged taps.

4.21 The HP-3550B test set at the office is connected to the line using the 789A tool or for Dataport, ED-type tool and the P2ES cord and transmits the test signals to the station.

4.22 The HP-3550B test set at the station uses the voltmeter portion of the set to measure (in dBm) the level of the received signal.

4.23 If the insertion loss measurement on the cable pairs fails to meet the test requirements, as based on the EML, the problem may be inaccurate cable records or excessive bridged taps. If the measurement at the top test frequency is 20 or more dB above the EML, the trouble is probably one or more loading coils.

Test I. Background Circuit Noise

4.24 The noise measurement is made on the receive side of both cable pairs. At the OCU location, the 789A tool, the ED3C947 or ED3C948 tool, and the P2ES cord are used to access the line.

Note: Tests I and J must be made separately for each segment of a loop equipped with 56-kb/s repeaters. For example, each loop section from OCU to first repeater, first repeater to second repeater, and second repeater to DSU/CSU.

4.25 The noise measurement is made using two 135-ohm resistors at the office to terminate both pairs and two 135-ohm resistors at the station to terminate both pairs. The 6F NMS at the station is connected to the T, R pair and the 6F NMS at the office is connected to the T1, R1 pair. The FUNCTION switches on both 6F NMSs are set to the 600 OHM BRIDGING position.

4.26 Instructions for operating the 6F NMS are given in Section 103-626-100. Noise measurements can be made at any time; however, it is preferable that they be made during a peak traffic load or busy-hour period.

Test J. Impulse Noise

4.27 The impulse noise measurement is normally made after the background circuit noise test is completed and uses the noise counter of the 6F NMS. The NMS is set to operate for a period of 15 minutes at a threshold value that depends on bit rate.

5. REFERENCES

5.01 The following sections can be referenced for additional information on maintaining local loops:

SECTION	TITLE
103-626-100	6F and 6FR Voiceband Noise Measuring Sets—(J94006F and J94006FR)—Description, Operation, and Maintenance
107-600-100	Digital Data System—KS-20909 Data Test Set (Transmitter)
107-601-100	Digital Data System—KS-20908 Data Test Set (Receiver)
314-410-510	Digital Data System—Local Loop—Tests and Requirements
314-910-100	Digital Data System—Office Channel Unit—Description
314-910-300	Digital Data System—Office Channel Unit—Maintenance
314-910-500	Digital Data System—Office Channel Unit—Test Procedures
314-920-100	Digital Data System—56-kb/s Repeater—Description
314-920-500	Digital Data System—56-kb/s Repeater—Test Procedures
365-150-107	Digital Transmission Systems—D3B Channel Bank—Dataport Operation—Description, Installation, Maintenance and Tests
595-100-100	Digital Data System—550A-Type Channel Service Unit—Description
595-100-300	Digital Data System—550A-Type Channel Service Unit—Maintenance
595-100-500	Digital Data System—550A-Type Channel Service Unit—Test Procedures

SECTION	TITLE
595-200-100	Digital Data System—500A-Type Data Service Unit—Description and Operation
595-200-300	Digital Data System—500A-Type Data Service Unit—Maintenance
595-200-500	Digital Data System—Data Service Unit 500A-Type—Test Procedures
634-310-501	Locating Cable Faults With the 96A Test Set
640-251-106	468F Apparatus Case—Description and Installation
640-251-107	468F Apparatus Case—Maintenance and Acceptance Testing
666-600-100	Digital Data System—950A Testboard (J70176A and B)—Description and Operation
880-601-115	Digital Data System—Local Loops — Engineering Guidelines.

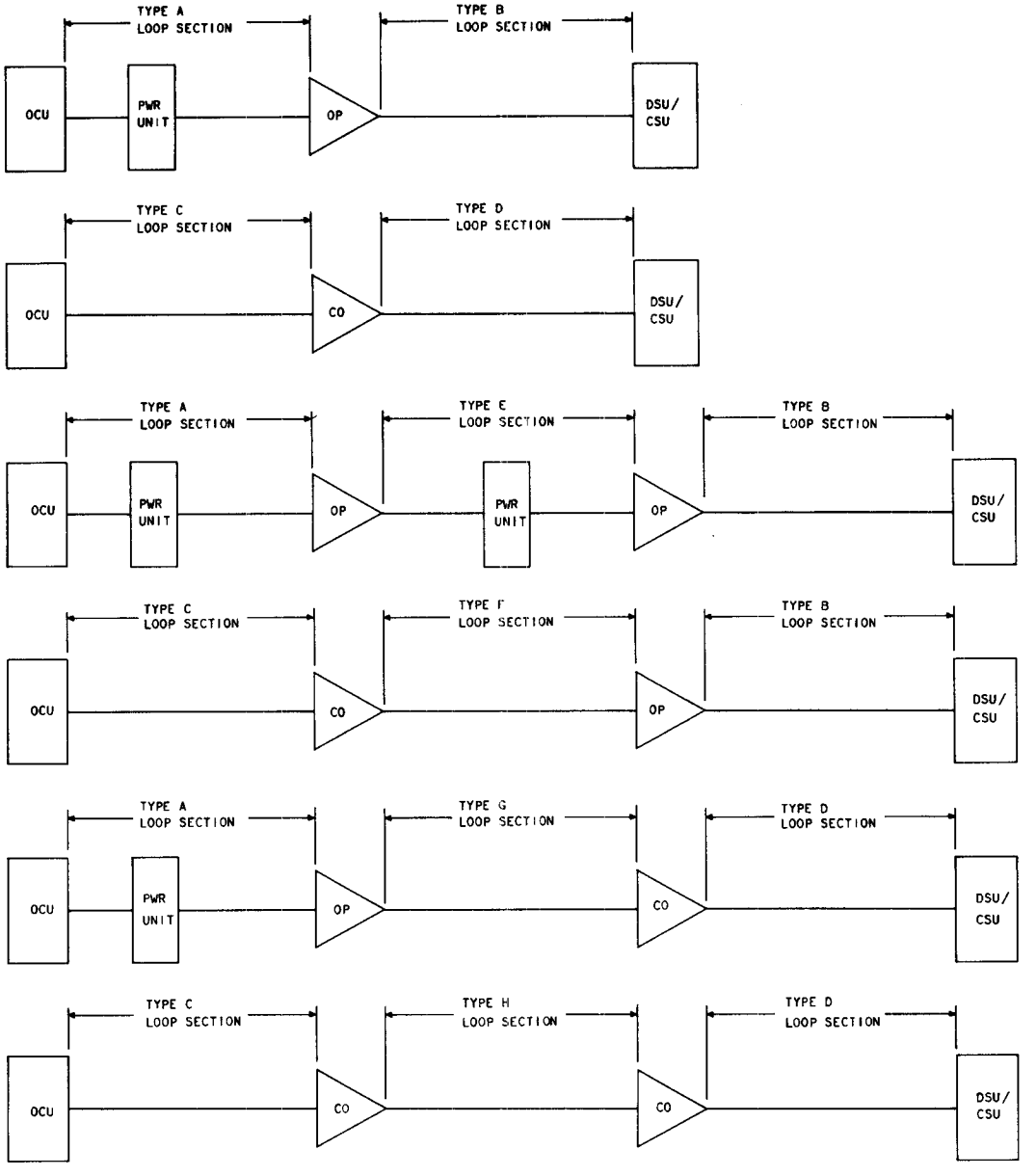

Fig. 2—Local Loop Containing 56-kb/s Repeater—Trouble Clearing Procedures

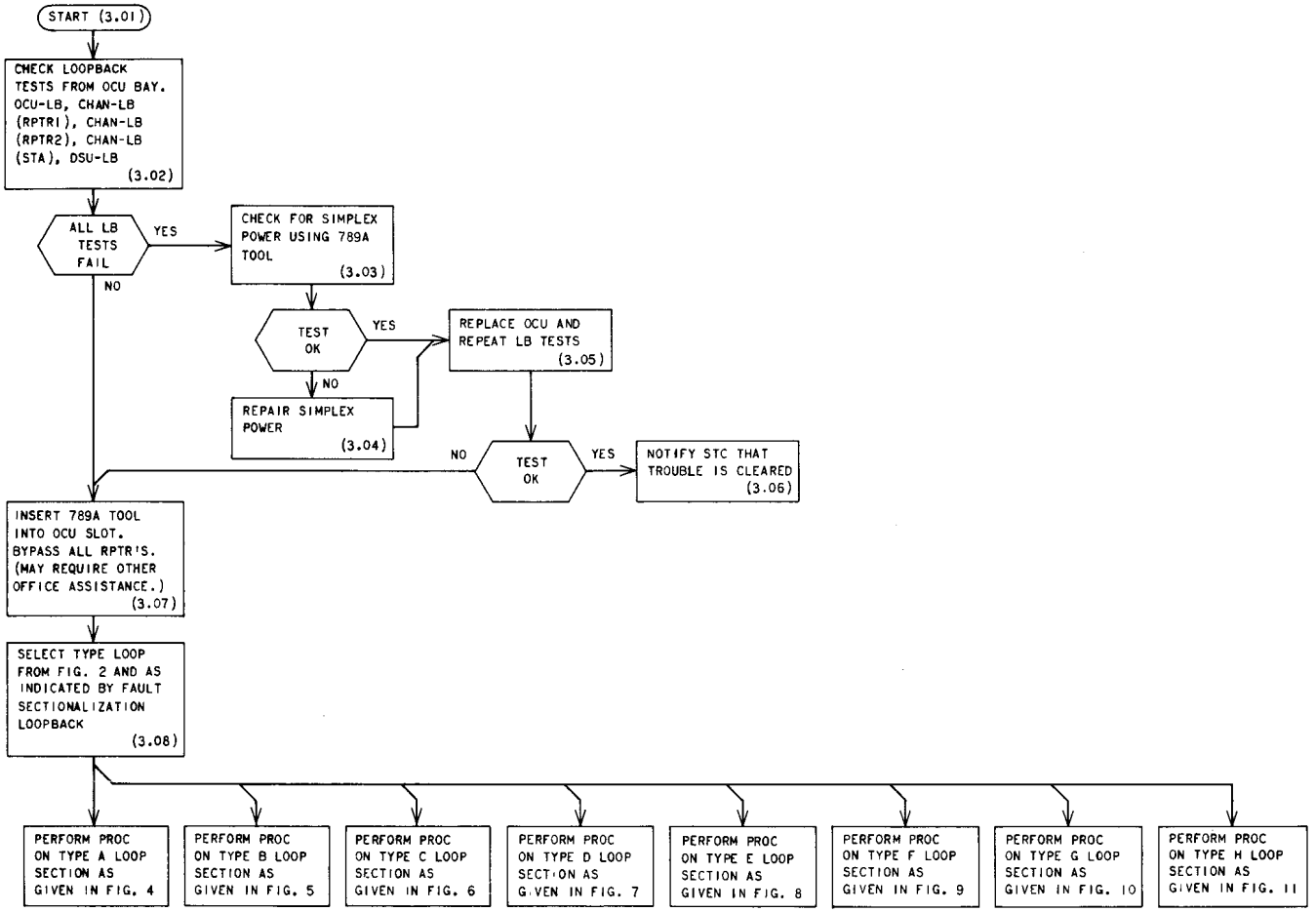

Fig. 3—Local Loop Containing 56-kb/s Repeaters—Initial Trouble Clearing Procedures

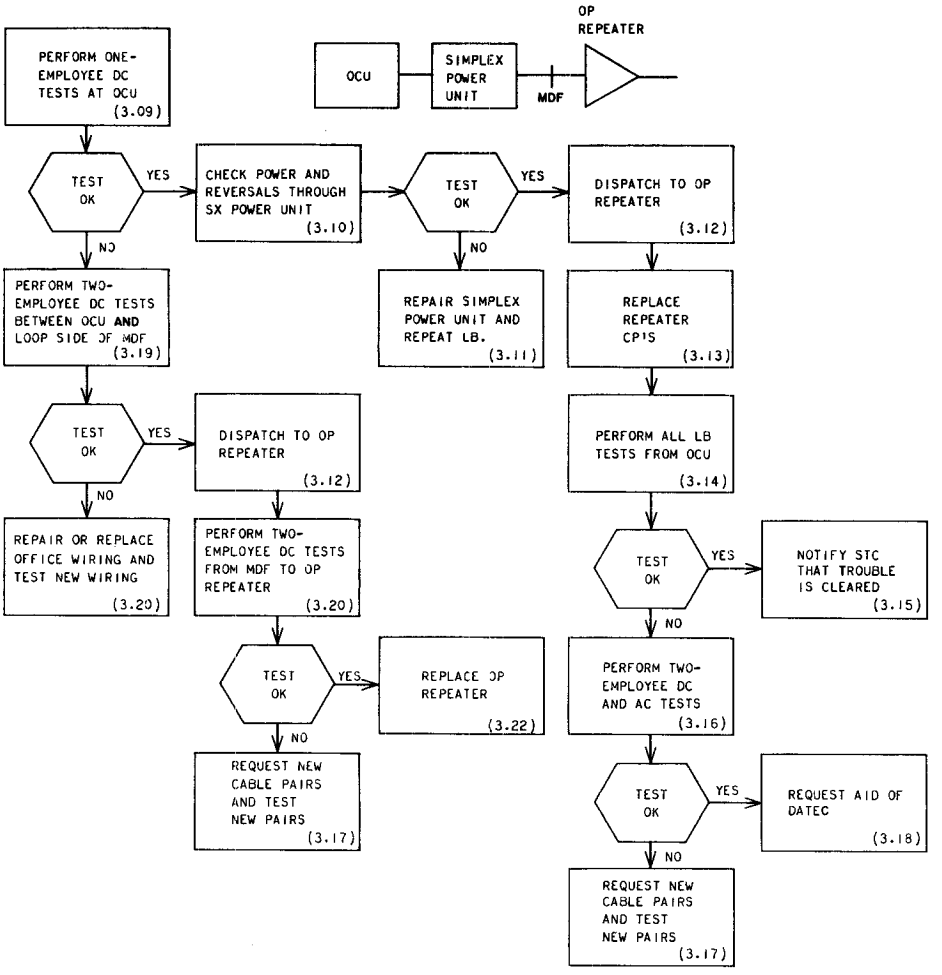

Fig. 4—Trouble Clearing Procedures on Type A Loop Section

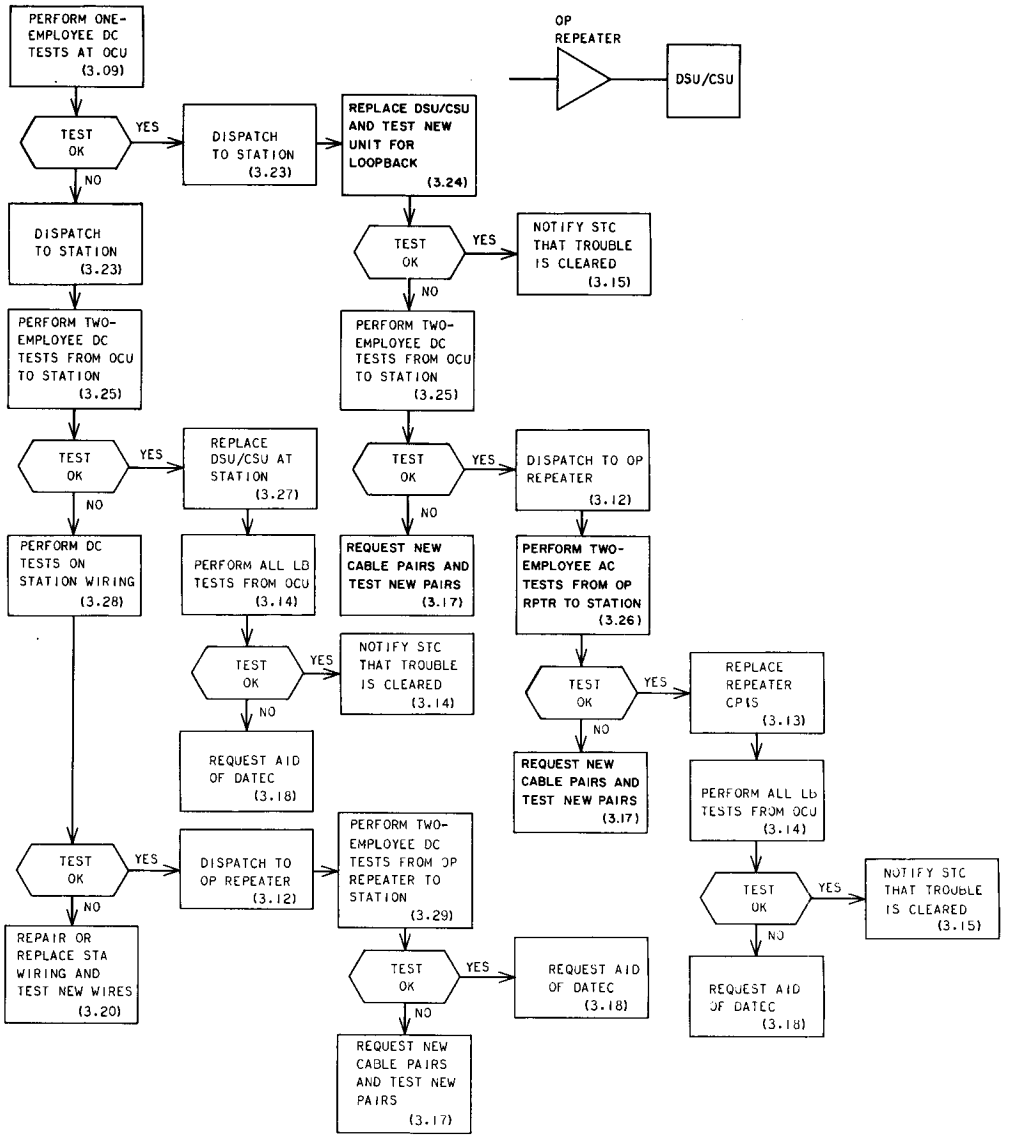

Fig. 5—Trouble Clearing Procedures on Type B Loop Section

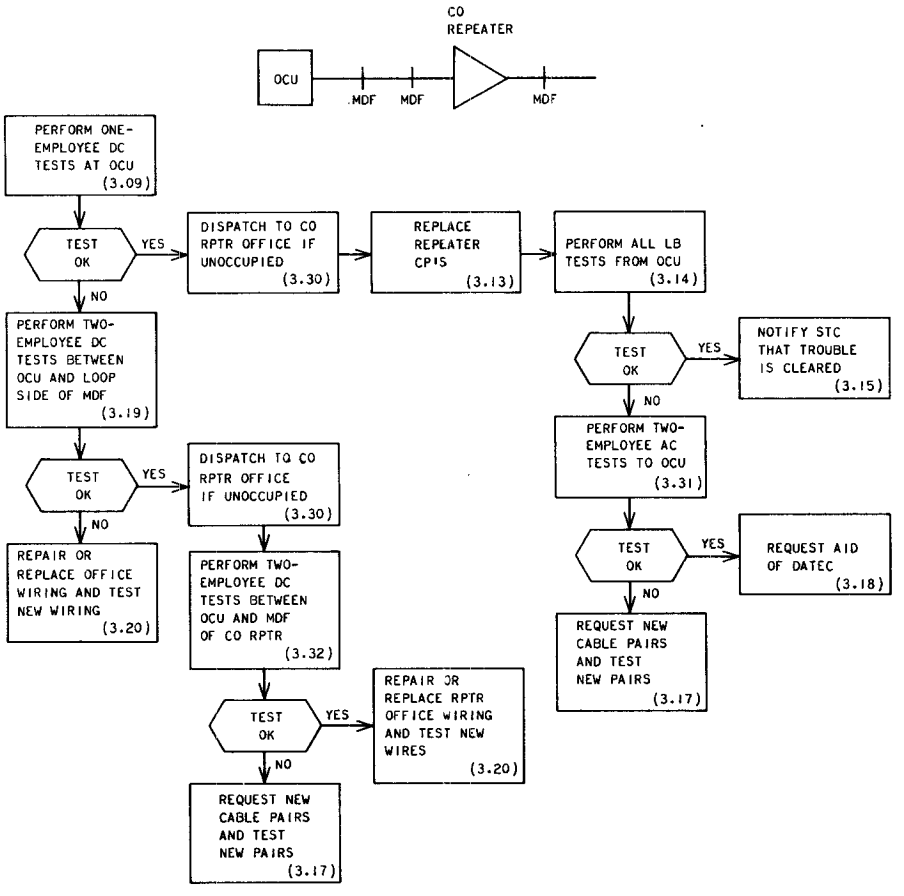

Fig. 6—Trouble Clearing Procedures on Type C Loop Section

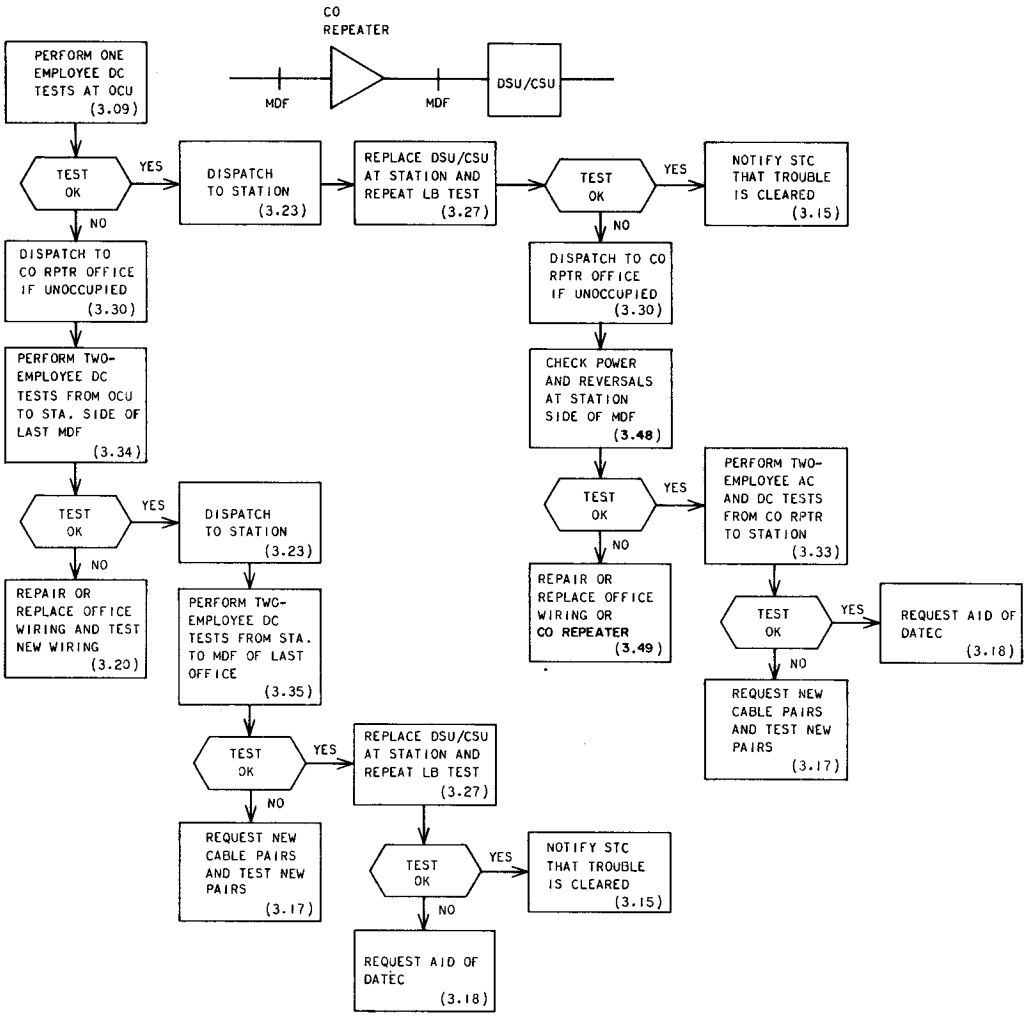

Fig. 7—Trouble Clearing Procedures on Type D Loop Section

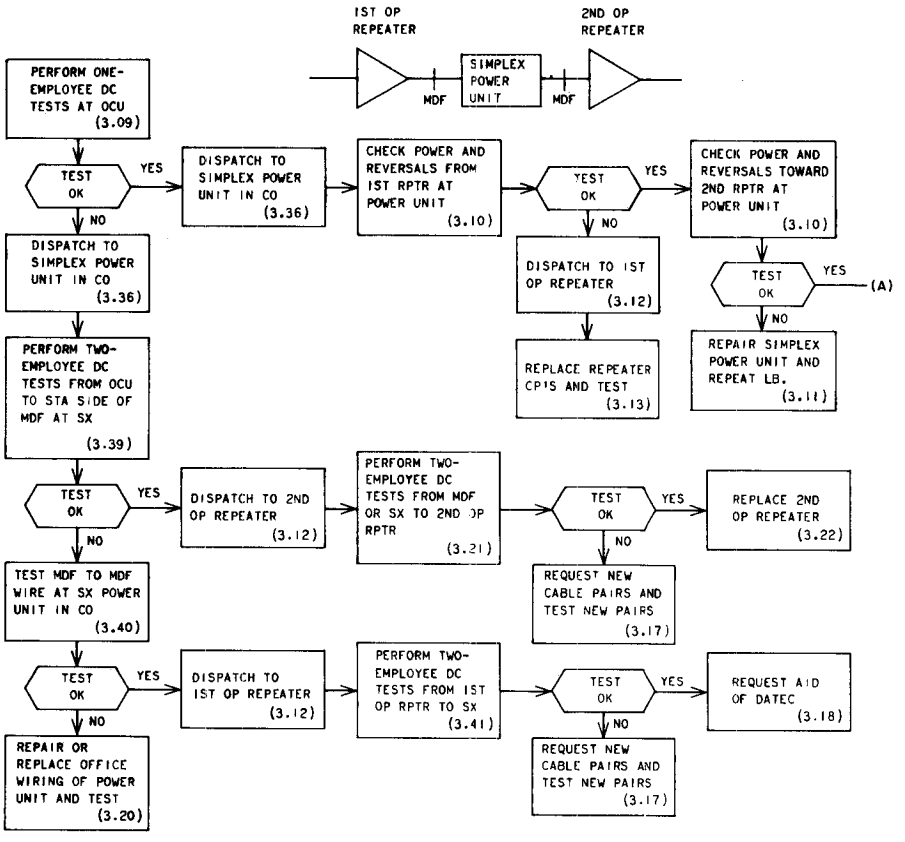

Fig. 8—Trouble Clearing Procedures on Type E Loop Section (Sheet 1 of 2)

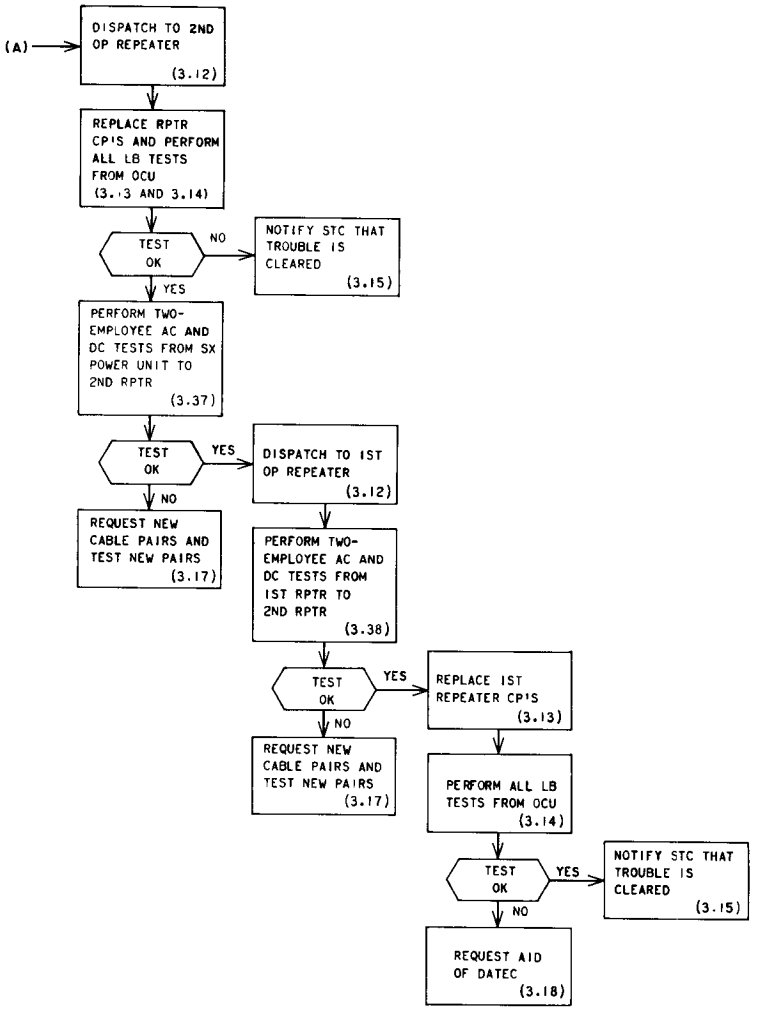

Fig. 8—Trouble Clearing Procedures on Type E Loop Section (Sheet 2 of 2)

NOTES

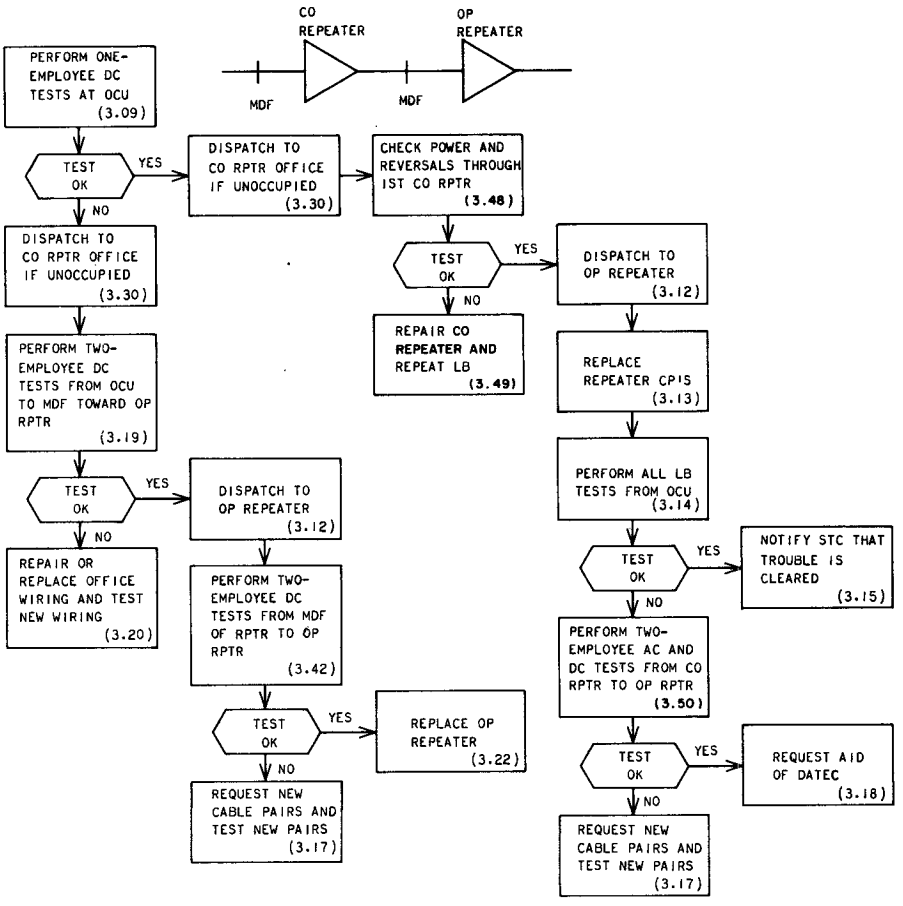

Fig. 9—Trouble Clearing Procedures on Type F Loop Section

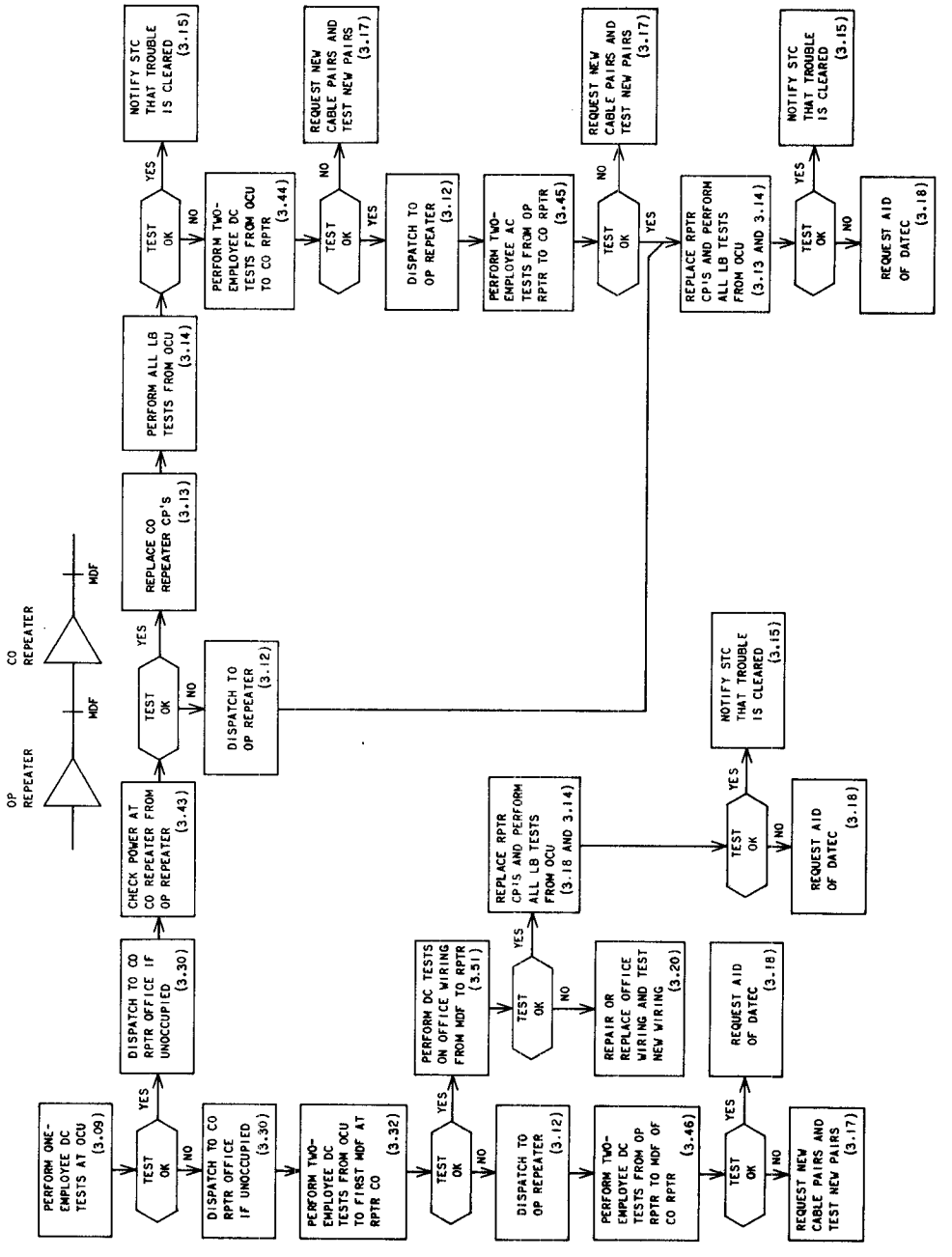

Fig. 10—Trouble Clearing Procedures on Type G Loop Section

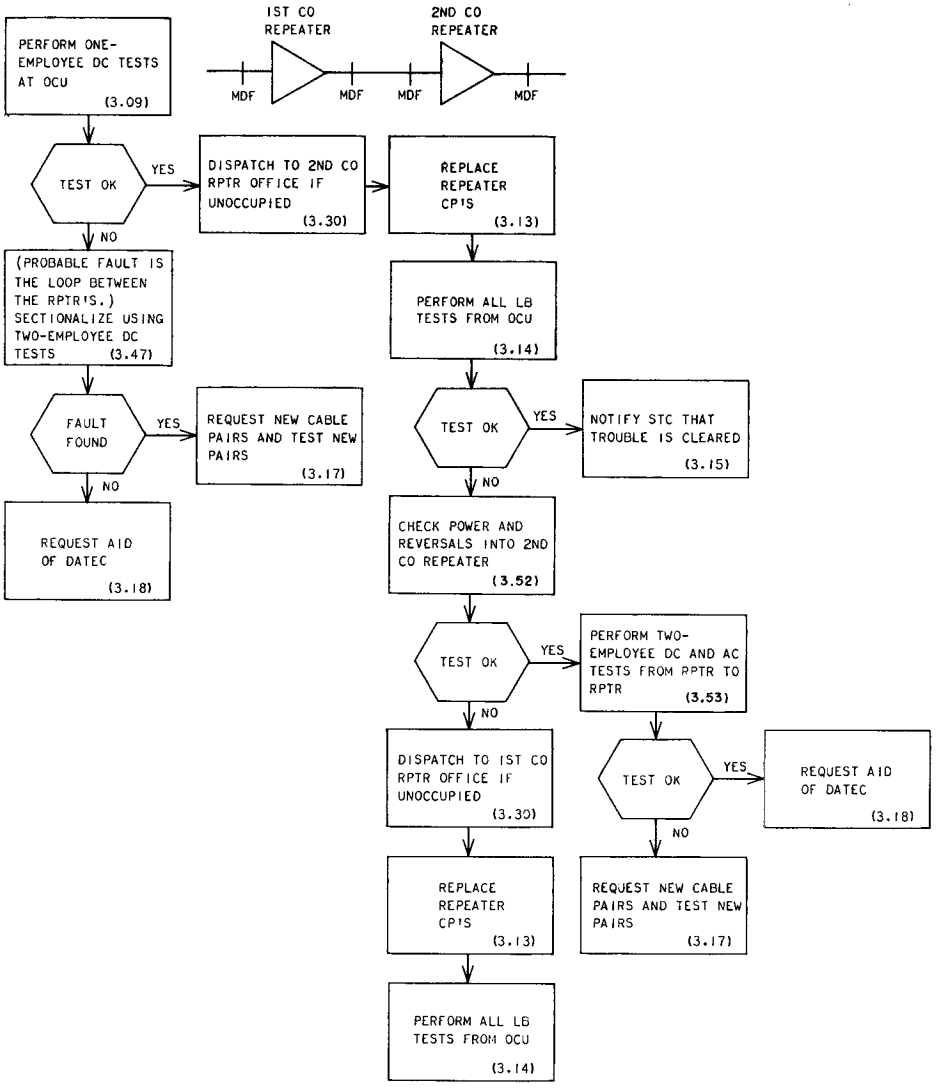

Fig. 11—Trouble Clearing Procedures on Type H Loop Section

NOTES

LOCAL LOOP
TESTS AND REQUIREMENTS
DIGITAL DATA SYSTEM

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1. GENERAL

1.01 This section provides test procedures for local loop cable pairs during installation and maintenance to ensure that the pairs are suitable for digital data system (DDS) service. These tests also apply to loops used with 56-Kb/s off-network extensions of DDS circuits.

1.02 This section is reissued for the following reasons:

(a) To delete all references to the ED 3C948 tool which was never manufactured

(b) To add references to the J98726-MF Channel Unit Extender (ED 3C 296-01 tool)

(c) To add references to the J1C141MF-1,L1 Channel Unit Extender.

Since these changes constitute a general revision, arrows normally used to denote changes have been omitted.

1.03 For loops equipped with 56-kb/s repeaters, the central office (CO) and outside plant (OP) repeaters must be bypassed (using either the automatic or manual bypass) in Tests A through G. The tests covered are:

Test A. Foreign Voltage: This procedure checks for foreign voltage on the cable pairs at the serving central office (SCO).

Test B. Insulation Resistance: This test checks the resistance between the cable pairs and ground at the office channel unit (OCU) location in the SCO.

Test C. Loop Plus Terminal Resistance: The loop resistance test measurement is the sum of the resistance of the cable pair (R_L), the input resistance (R_I) of the data service unit (DSU) or channel service unit (CSU), and the resistance of any bypassed 56-kb/s repeaters in the loop. The resistance of the cable pair was measured during the installation tests and should be recorded on the circuit layout record card (CLRC) or loop record card. The DSU (or CSU) input resistance depends on bit rate if the fixed line build out (FLBO) network is installed.

Note: A CO repeater inserts approximately 36 ohms in the bypassed mode. An OP repeater inserts about 5700 ohms in the bypassed mode. The polarity of the test meter leads must be applied as follows: negative to tip and positive to ring.

Test D. OCU Simplex Voltage: This test verifies that voltage is present to provide simplex current to the loop. The test is made at the OCU location using the 789A tool. For the Dataport configuration, the test is made using tool ED 3C947 for D3 channel banks, the J98726-MF Channel Unit Extender (CHAN UN EXT) for D4 channel banks, and the J1C141MF-1, L1 CHAN UN EXT for the 96 channel Subscriber Loop Carrier (SLC-96) terminals.

Test E. Foreign Voltage: This procedure checks for foreign voltage on the cable pairs at the SCO. This test requires that the DSU/CSU be removed at the station end and the line pairs be opened. The voltage reading between any test point should be less than 1 volt.

Test F. Insulation Resistance: This test checks the resistance between the cable pairs and ground at the OCU location in the SCO. This test requires that the DSU/CSU be removed at the station end and the line pairs be opened.

Test G. Loop Resistance: The loop resistance procedure verifies, at the OCU or OCUDP location in the SCO, that the loop resistance of each cable pair meets the maximum resistance requirement for initial installation. For subsequent tests, this resistance value should meet the benchmark resistance value recorded on the CLRC or the loop record card.

Note: A CO repeater inserts approximately 36 ohms in the bypassed mode. An OP repeater inserts about 5700 ohms in the bypassed mode. The polarity of the test meter leads must be applied as follows: negative to tip and positive to ring.

Test H. Insertion Loss: This measurement is made on a nonrepeatered line at two test frequencies for 2.4- and 4.8-kilobits per second (kb/s) service: one test frequency for 9.6-kb/s service and three test frequencies for 56-kb/s service. The subrate insertion loss measurements are made at a frequency equal to one-half of the bit rate to check that the receive signal level will be within the normal operating range of the line receiver. In addition, it is made at 4.8 kHz to check that all load coils have been removed from the cable pairs. For 56-kb/s service, the insertion loss measurement is made for each repeater section at 28, 48, and 82 kHz.

Test I. Background Circuit Noise: This test is made using the 6F voiceband noise measuring set (NMS) equipped with a 50-kHz weighting network. This set is used to measure both background circuit noise and impulse noise counts. For best results, the measurement should be made during a busy-hour period in the central office. The measurement is made on the T, R pair at the station and the T1, R1 pair at the SCO. For repeatered lines, the measurement is made on the T, R pair on the network side of the repeater and the T1, R1 pair on the station side of the repeater.

Test J. Impulse Noise: The impulse noise test follows the background circuit noise test. The same setup is used for making both tests.

Note: Tests I and J must be made separately for each repeater section of a loop equipped with 56-kb/s repeaters; ie, from OCU to first repeater, first repeater to second repeater, and second repeater to DSU or CSU.

1.04 The maintenance procedures consist of one-employee dc tests (A through D) for trouble isolation. The tests are made in the SCO at the OCU mounting or at the local test desk (LTD). The two-employee tests may also be required to locate trouble in case the one-employee dc tests do not locate the trouble.

1.05 The cable pair installation tests are two-employee dc and ac tests (E through J) made between the OCU location and the station. For repeatered lines, the tests are also made at the repeaters. These tests are made prior to the installation of DDS station equipment (DSU/CSU). When making these tests, any 56-kb/s repeaters in the loop must be in the bypassed mode. Results of these tests should be recorded on the loop record cards for use during maintenance periods. The installation tests should be performed as soon as the cable pairs are assigned in order to correct any transmission difficulties prior to the plant test date.

1.06 The 4-wire circuits used for DDS service interconnect either a 500A-type DSU or a 550A-type CSU located at the customer station with 56-kb/s repeaters or an OCU or OCUDP in the SCO. The DDS provides full-duplex synchronous operation for data service at bit rates of 2.4-, 4.8-, 9.6-, or 56-kb/s.

TEST ACCESS AT OFFICE AND STATION

1.07 A typical arrangement showing test access for DDS 4-wire cable pair tests on the local loop is shown in Fig. 1. The OCU associated with the faulty loop is removed and the 789A tool or the Dataport equivalent is inserted in its place. The Dataport equivalent is the ED 3C947 tool used for D3 channel banks, the J98726-MF CHAN UN EXT used for D4 channel banks, or the J1C141MF-1, L1 CHAN UN EXT used for SLC-96 terminals. The ED 3C947 tool and the channel unit extenders are shown in Fig. 2. These tools contain two jacks and six test points. The jacks accept 310-type plugs and provide access to the T, R (OCU transmit), and T1, R1 (OCU receive) cable pairs. The six pin-type connector test points accept meter test probes and connect to the T, R, T1, and R1 cable pairs and to ground (GRD) and office battery (BAT).

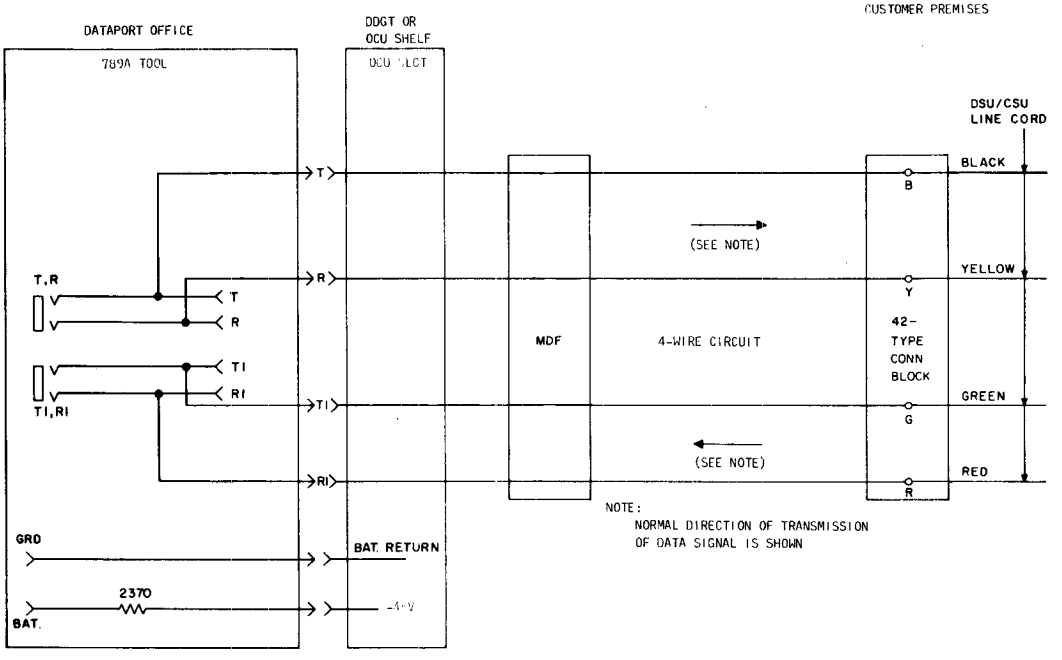


Fig. 1—Test Access for DDS Cable Pair Tests

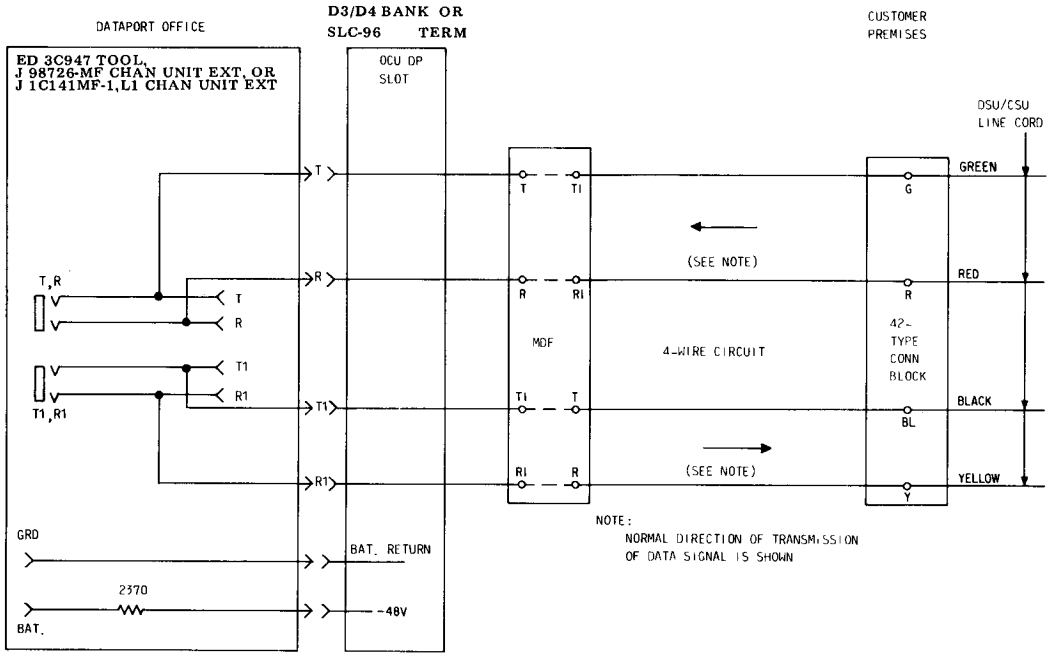


Fig. 2—Test Access for DDS Cable Pair Tests—Dataport Facilities

1.08 Tests A, B, C, E, F, and G may be made at the LTD. Access is obtained at the main distributing frame (MDF) using MDF test cords. At the LTD, measurements are made either toward the DSU/CSU or the OCU. When long test trunks are used, the resistance of the test trunks must be measured and subtracted from the overall loop resistance.

Caution: A dc loop current in excess of 250 mA may damage the DSU/CSU at the station end. Do not use test equipment that applies a current greater than 250 mA, such as a breakdown test set, to the cable pairs unless the OCU or OCUDP has been removed and the DSU/CSU has been disconnected from the pairs. In addition, a dc voltage in excess of 50 volts applied to repeatered loops can cause damage to the repeater. Do not use test equipment that applies a voltage greater than 50 volts to the cable pair on repeatered loops.

TEST ACCESS AT 56-KB/S REPEATERS

1.09 Test access at the CO repeater to the local loop providing 56-kb/s service is provided by four jacks mounted on the front of the repeater housing. Additional information on test access and tests on the CO repeater are given in Section 314-920-500.

1.10 Test access at the OP repeater to the local loop providing 56-kb/s service is provided by terminals on the 31A connector block.

Note: Circuit pack LA5 must be removed from the 468F apparatus case before performing dc or ac tests on the local loop pairs. Additional information on test access and repeater tests are given in Section 640-251-107.

1.11 The SCO (one-employee) dc tests on loops providing 56-kb/s service require that the repeaters in the loop section be bypassed. This must be done in order to provide continuity to

the station and back to the CO. The CO or OP repeater is bypassed either by manually operating the bypass switch on the front of the CO repeater housing, or by removing simplex current to the loop at the OCU bay. Simplex current is removed at the OCU bay by unplugging the OCU and inserting the 789A tool or the Dataport equivalent in its place. This removes the simplex current to the CO repeater or powering unit which automatically bypasses all repeaters (CO or OP) in the loop. The ac tests are made on a per-repeater-section basis and do not require operation of the repeater bypass.

2. TEST EQUIPMENT

2.01 This part provides a listing and brief description of the test equipment required for testing DDS local loops. In many instances, equivalent test equipment may be used instead. Other noise-measuring sets having 50-kHz weighting filters and 135-ohm impedance may be used in place of the 6F NMS specified. Other transmission measuring sets capable of operation up to 85 kHz with 135-ohm impedance may be used in place of the HP 3550B.

APPARATUS REQUIRED FOR SERVING CENTRAL OFFICE (One-Employee) TESTS

2.02 The test apparatus required at the SCO for the one-employee tests is described as follows.

- One portable volt-ohm-milliammeter (VOM), KS-14510-L1 or KS-16979-L1 or equivalent.
- One 789A tool for OCU configuration or for Dataport configuration the ED 3C947 tool for D3 banks, the J98726-MF CHAN UNIT EXT for D4 banks, or the J1C141MF-1,L1 CHAN UN EXT for SLC-96 terminals.

When the service rides Dataport on SLC-96, the SCO could be a remote terminal not necessarily located in a CO.

APPARATUS REQUIRED FOR SERVING CENTRAL OFFICE-TO-STATION (Two-Employee) TESTS

2.03 The serving central office-to-station tests require the efforts of two employees, one at each end of the local channel. For this reason, the following list of equipment is separated into two parts: (1) equipment required at the office and (2) equipment required at the station. When the service rides Dataport on SLC-96, the SCO could be remote terminal not necessarily located in a CO.

Serving Central Office Equipment

2.04 The required test equipment is as follows.

- One portable VOM, such as the KS-14510-L1 or KS-16979-L1 or equivalent volt-ohm-meter, having a meter of at least 20,000 ohms per volt.
- One 789A tool for standard configuration or the Dataport equivalent. The Dataport equivalent is the ED 3C947 tool used with D3 banks, the J98726-MF CHAN UN EXT used with D4 banks, or the J1C141MF-1,L1 CHAN UNIT EXT used with SLC-96 terminals.
- One P2ES or equivalent cord (specify 8- or 12-foot cord length for use with 7- or 11-foot bays).
- One HP-3550B test set or equivalent.
- One 6F voiceband NMS with 50-kHz network (497F).
- One 135-ohm resistor.
- One 386B plug (310 plug with 135-ohm termination).

Station Equipment

2.05 The required test equipment and apparatus are as follows:

- One 6F voiceband NMS with 50-kHz network (497F)
- One HP-3550B test set
- Two 135-ohm resistors.

APPARATUS REQUIRED AT 56-KB/S REPEATER

2.06 The test equipment and apparatus required at the 56-kb/s repeater location are as follows:

- One 6F voiceband NMS with 50-kHz network (497F)
- One HP-3550B test set (or a Hewlett-Packard model 403B voltmeter, a 146A repeat coil, and a 600-ohm resistor)
- Two 135-ohm resistors.

3. OVERALL LOOP TESTS

TEST RECORDS

3.01 Five local loop record cards, one for each bit/rate speed, plus a card for loops containing 56-kb/s repeaters, are available and should be used to record measurement results by the craft employee at the SCO. These cards are designated as E-6528-1, E-6528-2, E-6528-3, E-6528-4, and E-6528-4R and are shown in Fig. 3, 4, 5, 6, and 7, respectively.

3.02 Each card lists the various measurements to be made and provides blocks of spaces to be used for recording measurement results. Any additional information which may be helpful in maintaining the local loop should also be recorded on the card.

SERVING CENTRAL OFFICE (One-Employee) TESTS

3.03 The SCO tests should be performed on cable pairs from the SCO during maintenance periods. When the service rides Dataport on SLC-96, the SCO could be a remote terminal not necessarily located in a CO.

3.04 The procedures consist of dc measurements that can be performed by one employee and should be made in the following order:

(a) Foreign Voltage

(b) Insulation Resistance

(c) Loop Plus Terminal Resistance

(d) OCU Simplex Voltage.

If any of the test requirements are not met, proceed according to instructions given in Section 314-410-310.

> ***Note:*** Bypass the 56-kb/s repeaters if used in the loop section. Refer to paragraph 1.11. Restore repeaters to normal operation after completing these tests.

> ***Caution: Do not apply a dc voltage in excess of 50 volts to the loop when repeaters are in the bypass mode. Test voltage must be applied as follows: negative to tip, positive to ring.***

3.05 If the simplex voltage measurement is made at the LTD or MDF, the simplex voltage is measured between T and T1 and also between R and R1, looking toward the OCU or OCUDP. The first measurement is made with the STC transmitting a 2047-bit word; the second measurement is made with the STC transmitting the channel loop-back code. The polarity of the simplex voltage must reverse in the second measurement. If no voltage is measured, check the following.

(a) Be sure the OCU or OCUDP is plugged into the bay.

(b) Verify cable pair continuity between OCU or OCUDP and MDF or LTD.

(c) Check simplex current fuse in BCPA or LTS. (OCU only)

(d) Replace OCU or OCUDP (install the FLBO network option listed on the CLR).

SERVING CENTRAL OFFICE-TO-STATION (Two-Employee) TESTS

3.06 This part provides test procedures that consist of dc and ac tests on the cable pair which are performed between the customer data station and the SCO.

3.07 The tests are performed by two craft employees. This normally will be one employee at the customer station and the other employee in the SCO. On local loops providing 56-kb/s service, these tests must also be made at the repeater(s) and more than two employees will be involved in the tests. This may require coordination effort by the SCO. The DSU (or CSU) must be disconnected from the cable pairs before making these tests. In addition, the OCU is removed and replaced by the 789A tool or the Dataport equivalent during these tests.

FORM E-6528-1
DATE_____

LOCAL LOOP RECORD CARD

DDS 2.4 KB/S

CIRCUIT	SYSTEM	OCU

MAINTENANCE TESTS 314-410-510 1-EMPLOYEE TESTS (CO) CONNECT DSU/CSU FOR 1-EMPLOYEE TESTS

	TEST	TEST CONDITION	REQUIREMENTS	INITIALS
A	FOREIGN VOLTAGE	T − R, T1 − R1, T − G, R − G, T1 − G, R1 − G	LESS THAN ± 1 VDC	
B	INSULATION RESISTANCE	T − G, R − G, T1 − G, R1 − G	MORE THAN 120 K Ω	
C	LOOP + TERMINAL RES	T1 TO R1 = (RL2 + 35 Ω) ±30%	FOR RL2 SEE TEST G	
	DSU/CSU-WW OPTION IN	T TO R = (RL1 + 35 Ω) ±30%	FOR RL1 SEE TEST G	
	DSU/CSU-WV OPTION IN	T TO R = (RL1 + 1030 Ω) ±30%		
D	OCU SIMPLEX VOLTAGE	AT 789A TOOL GRD TO BAT.	− 47 ± 7 VDC OR − 24 ± 6 VDC	

CABLE AND PAIR	T − R / T1 − R1	PAIR	CABLE	PAIR	CABLE	PAIR	CABLE	PAIR	CABLE

REMARKS

DDS 2.4 KB/S

CIRCUIT	SYSTEM	OCU

NAME	ADDRESS	TEL. #	INST. DATE

INSTALLATION TESTS 314-410-510 2-EMPLOYEE TESTS (CO)
DISCONNECT DSU/CSU FOR 2-EMPLOYEE TESTS

STC TEL. #

	TEST	TEST CONDITION			REQUIREMENTS	INITIALS
E	FOREIGN VOLTAGE	T − R, T1 − R1, T − G, R − G, T1 − G, R1 − G			LESS THAN ± 1 VDC	
F	INSULATION RESISTANCE	T − R, T1 − R1, R − R1, T − R1, R − T1 T − T1, T − G, R − G, T1 − G, R1 − G			MORE THAN 300 K Ω	
G	LOOP RESISTANCE	T − R RL1 *	T1 − R1 RL2 *		LESS THAN 4200 Ω	
H	INSERTION LOSS HP − 3550 B	1.2 KHZ − 135 Ω	T, R *	T1, R1 *	LESS THAN OR EQUALS 34 dB AND EQUALS EML ± 5 or −2.5	
		4.8 KHZ − 135 Ω	*	*	LESS THAN OR EQUALS TWICE AML at 1.2 KHZ	
I	BACKGROUND NOISE 6F OR 6FR	50−KHZ FILTER 600 Ω BRDG 135 Ω TERM	*	*	MAX 12 dBrn	
J	IMPULSE NOISE 6F OR 6FR		*	*	58 dBrn − 15 MIN 7 OR LESS COUNTS	

* RECORD READING (OVER)

Fig. 3—Example of Local Loop Record Card of 2.4-Kb/s Service (ORANGE)

FORM E-6528-2
DATE_____

LOCAL LOOP RECORD CARD

DDS 4.8 KB/S

CIRCUIT	SYSTEM	OCU

MAINTENANCE TESTS 314-410-510 1-EMPLOYEE TESTS (CO) CONNECT DSU/CSU FOR 1-EMPLOYEE TESTS

	TEST	TEST CONDITION	REQUIREMENTS	INITIALS
A	FOREIGN VOLTAGE	T − R, T1 − R1, T − G, R − G, T1 − G, R1 − G	LESS THAN ± 1 VDC	
B	INSULATION RESISTANCE	T − G, R − G, T1 − G, R1 − G	MORE THAN 120 K Ω	
C	LOOP + TERMINAL RES	T1 TO R1 = (RL2 + 35 Ω) ±30%	FOR RL2 SEE TEST G	
	DSU/CSU-WW OPTION IN	T TO R = (RL1 + 35 Ω) ±30%	FOR RL1 SEE TEST G	
	DSU/CSU-WV OPTION IN	T TO R = (RL1 + 920 Ω) ±30%		
D	OCU SIMPLEX VOLTAGE	AT 789A TOOL GRD TO BAT.	− 47 ± 7 VDC OR − 24 ± 6 VDC	

CABLE AND PAIR	T − R / T1 − R1	PAIR	CABLE	PAIR	CABLE	PAIR	CABLE	PAIR	CABLE

REMARKS

DDS 4.8 KB/S

CIRCUIT	SYSTEM	OCU

NAME	ADDRESS	TEL. =	INST. DATE

INSTALLATION TESTS 314-410-510 2-EMPLOYEE TESTS (CO)
DISCONNECT DSU/CSU FOR 2-EMPLOYEE TESTS

STC TEL. =

	TEST	TEST CONDITION			REQUIREMENTS	INITIALS
E	FOREIGN VOLTAGE	T-R, T1-R1, T-G, R-G, T1-G, R1-G			LESS THAN ± 1 VDC	
F	INSULATION RESISTANCE	T-R, T1-R1, R-R1, T-R1, R-T1, T-T1, T-G, R-G, T1-G, R1-G			MORE THAN 300 K Ω	
G	LOOP RESISTANCE	T − R	RL1 *	T1 − R1	RL2 *	LESS THAN 4200 Ω	
H	INSERTION LOSS HP − 3550 B			T, R	T1, R1	LESS THAN OR EQUALS 34 dB AND EQUALS EML + 5 or −2.5	
		2.4 KHZ − 135 Ω		*	*		
		4.8 KHZ − 135 Ω		*	*	LESS THAN OR EQUALS AML AT 2.4 KHZ + 15	
I	BACKGROUND NOISE 6F OR 6FR	50−KHZ FILTER 600 Ω BRDG 135 Ω TERM		*	*	MAX 39 dBrn	
J	IMPULSE NOISE 6F OR 6FR			*	*	55 dBrn − 15 MIN 7 OR LESS COUNTS	

* RECORD READING (OVER)

Fig. 4—Example of Local Loop Record Card of 4.8-Kb/s Service (YELLOW)

FORM E-6528-3
DATE_____

LOCAL LOOP RECORD CARD

DDS 9.6 KB/S

CIRCUIT	SYSTEM	OCU

MAINTENANCE TESTS 314-410-510 1-EMPLOYEE TESTS (CO) CONNECT DSU/CSU FOR 1-EMPLOYEE TESTS

	TEST	TEST CONDITION	REQUIREMENTS	INITIALS
A	FOREIGN VOLTAGE	T − R, T1 − R1, T − G, R − G, T1 − G, R1 − G	LESS THAN ± 1 VDC	
B	INSULATION RESISTANCE	T − G, R − G, T1 − G, R1 − G	MORE THAN 120 K Ω	
C	LOOP + TERMINAL RES	T1 TO R1 = (RL2 + 35 Ω) ±30%	FOR RL2 SEE TEST G	
	DSU/CSU-WW OPTION IN	T TO R = (RL1 + 35 Ω) ·30%	FOR RL1 SEE TEST G	
	DSU/CSU-WV OPTION IN	T TO R = (RL1 + 475 Ω) ±30%		
D	OCU SIMPLEX VOLTAGE	AT 789A TOOL GRD TO BAT.	− 47 + 7 VDC OR − 24 + 6 VDC	

CABLE AND PAIR	T − R / T1 − R1									
		PAIR	CABLE	PAIR	CABLE	PAIR	CABLE	PAIR	CABLE	

REMARKS

DDS 9.6 KB/S

CIRCUIT	SYSTEM	OCU

NAME	ADDRESS	TEL. #	INST. DATE

INSTALLATION TESTS 314-410-510 2-EMPLOYEE TESTS (CO)
DISCONNECT DSU/CSU FOR 2-EMPLOYEE TESTS

STC TEL. #

	TEST	TEST CONDITION			REQUIREMENTS	INITIALS
E	FOREIGN VOLTAGE	T − R, T1 − R1, T − G, R − G, T1 − G, R1 − G			LESS THAN + 1 VDC	
F	INSULATION RESISTANCE	T − R, T1 − R1, R − R1, T − R1, R − T1, T − T1, T − G, R − G, T1 − G, R1 − G			MORE THAN 300 K Ω	
G	LOOP RESISTANCE	T − R	RL1 *	T1 − R1	RL2 *	LESS THAN 4200 Ω
H	INSERTION LOSS HP − 3550 B	4.8 KHZ 135 Ω	T, R *	T, R1 *		LESS THAN OR EQUALS 34 dB AND EQUALS EML + 5 or −2.5
I	BACKGROUND NOISE 6F OR 6FR	50−KHZ FILTER 600 Ω BRDG 135 Ω TERM	*	*		MAX 31 dBrn
J	IMPULSE NOISE 6F OR 6FR		*	*		47 dBrn − 15 MIN 7 OR LESS COUNTS

* RECORD READING (OVER)

Fig. 5—Example of Local Loop Record Card for 9.6-Kb/s Service (GREEN)

FORM E-6528-4
DATE_____

LOCAL LOOP RECORD CARD

DDS 56 KB/S

CIRCUIT	SYSTEM	OCU

MAINTENANCE TESTS 314-410-510 1-EMPLOYEE TESTS (CO) CONNECT DSU/CSU FOR 1-EMPLOYEE TESTS

	TEST	TEST CONDITION	REQUIREMENTS	INITIALS
A	FOREIGN VOLTAGE	T − R, T1 − R1, T − G, R − G, T1 − G, R1 − G	LESS THAN ± 1 VDC	
B	INSULATION RESISTANCE	T − G, R − G, T1 − G, R1 − G	MORE THAN 120 K Ω	
C	LOOP + TERMINAL RES	T1 TO R1 = (RL2 + 35 Ω) ±30%	FOR RL2 SEE TEST G	
	DSU/CSU-WW OPTION IN	T TO R = (RL1 + 35 Ω) ±30%	FOR RL1 SEE TEST G	
	DSU/CSU-WV OPTION IN	T TO R = (RL1 + 220 Ω) ±30%		
D	OCU SIMPLEX VOLTAGE	AT 789A TOOL GRD TO BAT.	− 47 ± 7 VDC OR − 24 ± 6 VDC	

CABLE AND PAIR										
	T − R									
	X	PAIR	CABLE	PAIR	CABLE	PAIR	CABLE	PAIR	CABLE	
	T1 − R1									

REMARKS

DDS 56 KB/S

CIRCUIT	SYSTEM	OCU

NAME	ADDRESS	TEL. #	INST. DATE

INSTALLATION TESTS 314-410-510 2-EMPLOYEE TESTS (CO)
DISCONNECT DSU/CSU FOR 2-EMPLOYEE TESTS

STC TEL. #

	TEST	TEST CONDITION			REQUIREMENTS	INITIALS
E	FOREIGN VOLTAGE	T-R, T1-R1, T-G, R-G, T1-G, R1-G			LESS THAN ± 1 VDC	
F	INSULATION RESISTANCE	T-R, T1-R1, R-R1, T-R1, R-T1, T-T1, T-G, R-G, T1-G, R1-G			MORE THAN 300 K Ω	
G	LOOP RESISTANCE	T − R RL1 *	T1 − R1	RL2 *	LESS THAN 4200 Ω	
H	INSERTION LOSS HP − 3550 B	28.0 KHZ − 135 Ω	T, R *	T1, R1 *	LESS THAN OR EQUALS 34 dB AND EQUALS EML ± 5 or −2.5	
		82.0 KHZ − 135 Ω	*	*	LESS THAN OR EQUALS AML at 28 KHZ + 20	
		48.0 KHZ − 135 Ω	*	*	(EQUALS SUM OF AML AT 28 KHZ + AML AT 82 KHZ DIVIDED BY 2) ± 2.5	
I	BACKGROUND NOISE 6F OR 6FR	50−KHZ FILTER 600 Ω BRDG 135 Ω TERM	*	*	MAX 28 dBrn	
J	IMPULSE NOISE 6F OR 6FR		*	*	44 dBrn − 15 MIN 7 OR LESS COUNTS	

* RECORD READING (OVER)

Fig. 6—Example of Local Loop Record Card for 56-Kb/s Service (BLUE)

FORM E-6528-4R
DATE _____

LOCAL LOOP RECORD CARD

DDS — 56 KB/S WITH REPEATER (S)

CIRCUIT	SYSTEM	OCU

MAINTENANCE TESTS 314-410-510 1-EMPLOYEE TESTS FROM OCU LOCATION WITH ALL REPEATERS BYPASSED AND THE DSU/CSU CONNECTED

	TEST	TEST CONDITION	REQUIREMENTS	INITIALS
A	FOREIGN VOLTAGE	T-R, T1-R1, T-G, R-G, T1-G, R1-G,	LESS THAN ± 1 VDC	
B	INSULATION RESISTANCE	T-G, R-G, T1-G, R1-G	MORE THAN 120K Ω	
C	LOOP + TERMINAL RES	T1 to R1 = [Sum of All #RL2s + ϕNx5740 + 80]	TEST RES CANNOT VARY	
	DSU/CSU-WW OPTION IN	T to R = [Sum of All #RL1s + ϕNx5740 + 80]	MORE THAN ± 30%	
	DSU/CSU-WV OPTION IN	T to R = [Sum of All #RL1s + ϕNx5740 + 265]		
D	OCU SIMPLEX VOLTAGE	AT 789A TOOL GRD TO BAT.	-47 ± 7 VDC OR -24 ± 6 VDC	

CABLE AND PAIR	T-R / T1-R1	PAIR	CABLE	PAIR	CABLE	PAIR	CABLE	PAIR	CABLE

REMARKS — # For RL1 & RL2 See test G — ϕ N = Number of Outside Plant Repeaters

DDS REPEATER SECTION — 56 KB/S WITH REPEATER (S)

(Check One) ☐ OCU TO REPEATER ☐ REPEATER TO REPEATER ☐ REPEATER TO STATION

CIRCUIT	SYSTEM	OCU
NAME	ADDRESS	TEL. INST. DATE

INSTALLATION TESTS 314-010-510 2-EMPLOYEE TESTS
REPEATERS AND DSU/CSU DISCONNECTED FOR 2-EMPLOYEE TEST — STC TEL.

	TEST	TEST CONDITION				REQUIREMENTS	INITIALS
E	FOREIGN VOLTAGE	T-R, T1-R1, T-G, T1-G, R1-G				LESS THAN ± 1 VDC	
F	INSULATION RESISTANCE	T-R, T1-R1, R-R1, T-R1, R-T1, T-T1, T-G, R-G, T1-G, R1-G				MORE THAN 300K Ω	
G	RPTR SECT. LOOP RES	T-R	RL1 *	T1-R1	RL2 *	LESS THAN 1140Ω	
H	INSERTION LOSS HP-3550 B	28.0 KHZ AT 135Ω TERMINATION		T,R *	T1, R1 *	LESS THAN OR EQUALS 31dB AND EQUALS EML +5 OR-2.5 dB	
		82.0 KHZ AT 135Ω TERMINATION		*	*	LESS THAN OR EQUALS AML AT 28 KHZ + 20	
		48.0 KHZ AT 135Ω TERMINATION		*	*	EQUALS SUM OF AML AT 28 KHZ + AML AT 82 KHZ DIVIDED BY 2) ± 2.5	
I	BACKGROUND NOISE 6F OR 6FR	50 - KHZ FILTER 600Ω BRDG		*	*	MAX 28 dBrn	
J	IMPULSE NOISE 6F OR 6FR	135Ω TERMINATION		*	*	44 dBrn FOR 15 MINUTES 7 OR LESS COUNTS	
K	SIMPLEX VOLTAGE at J70177AT SHELF	TIP OF TRMT PR TO TIP OF RCV PR			NET. SIDE *	-24±5V OR -50±10V	
		PIN JACK (J5) TO PIN JACK TO (J6)			STA SIDE *	+1.5V TO +140.0V	

* RECORD READING — (OVER)

Fig. 7—Example of Local Loop Record Card for 56 Kb/s Service with Repeater

Required Tests

3.08 The cable pair initial installation tests (E through J) should be made on each pair of the 4-wire loop before installation of the DSU or CSU or repeaters. The preliminary testing of the cable pairs should be completed far enough in advance to allow time to locate and correct problems that may exist. For maintenance, perform the tests as required.

DC Tests

3.09 The following tests are performed on the cable pairs to locate foreign voltage, opens, shorts, crosses, or grounds.

3.10 The dc tests are similar to the SCO (one employee) tests. They differ in that they require the coordinated effort of two craft employees; the DSU (or CSU) is not connected to the 4-wire circuit when the tests are made.

> ***Note:*** If 56-kb/s service is provided, these tests may also be made from the repeater location to the CO or station end. The test procedures should be modified accordingly.

These tests are as follows:

(a) Foreign Voltage

(b) Insulation Resistance

(c) Loop Resistance.

AC TESTS

3.11 The following tests are performed on the cable pairs to ensure that they meet the insertion loss and noise requirements for DDS.

> ***Note:*** If 56-kb/s service is provided, these tests may also be made from the repeater location to the CO and to the station end. The test procedures should be modified accordingly.

These tests are to be made prior to the start of DDS service:

(a) Insertion Loss

(b) Background Circuit Noise

(c) Impulse Noise.

If the noise requirements cannot be met, the problem may be caused by pair imbalance. Refer this type of problem to the cable repair group.

Insertion Loss

3.12 When performed during initial installation, this test will verify that the cable loss is correct, all load coils have been removed, and no long-bridged taps are on the pairs. The actual measured loss (AML) is compared with the expected measured loss (EML) on the CLR. The insertion loss requirements are given in Table A. The AML is recorded on the CLR as a benchmark value. Insertion loss measured during a maintenance test must be within ±3 dB of the value measured at installation; however, insertion loss at 1/2 the bit rate must always be less than or equal to 34 dB. Insertion loss at 1/2 the 56-kb/s rate (28 kHz) must be less than or equal to 31 dB on a loop section with a repeater, or 29 dB on a loop section with only a simplex power unit.

3.13 This test requires two HP-3550B test sets or equivalent (one at each end), a 789A tool, and a P2ES cord at the office location.

Background Circuit Noise

3.14 All noise measurements are made using four 135-ohm resistors to terminate both cable pairs at each end. At the OCU location in the SCO, the following equipment or apparatus will be required:

- One 6F or 6FR NMS with 50-kHz network (497F)
- One 135-ohm resistor
- One 386B plug (310 plug with 135-ohm resistor termination)
- One 789A tool or Dataport equivalent. The Dataport equivalent is the ED 3C947 tool used for D3 channel banks, the J98726-MF CHAN UN EXT used for D4 channel banks or the J1C141MF-1,L1 CHAN UN EXT used for SLC-96 terminals.
- One P2ES, or equivalent, cord.

TABLE A

INSERTION LOSS LIMITS FOR INITIAL INSTALLATION TESTS

BIT RATE KB/S	TEST FREQ (KHZ)	MEASURED LOSS LIMITS (DB)
2.4	1.2	AML is less than or equals 34 and AML equals the EML value +5 or —2.5*†
	4.8	AML is less than or equals twice the value of the AML measured at 1.2 kHz
4.8	2.4	AML is less than or equals 34 and AML equals the EML value +5 or —2.5*†
	4.8	AML is less than or equals AML value at 2.4 kHz +15
9.6	4.8	AML is less than or equals 34 and AML equals the EML value +5 or —2.5*†
56‡	28	AML is less than or equals 34 and AML equals the EML value +5 or —2.5*†
	82	AML is less than or equals the AML value at 28 kHz +20
	48	AML equals the sum of the AML at 28 kHz plus the AML at 82 kHz divided by 2. This quantity may vary + or —2.5.

* Maximum EML is 31 dB.
† Contact transmission engineer when AML exceeds 34 dB and/or AML exceeds EML +5 or —2.5 dB.
‡ For 56-kb/s repeatered loops, the limit applies to each repeater section.

3.15 At the station, the following equipment will be required:

- One 6F NMS with 50-kHz network (497F)
- Two 135-ohm resistors.

3.16 If all pair test requirements are met in this part, the 4-wire channel is suitable for initial DDS service.

4. REFERENCES

4.01 The following sections contain additional information on test equipment and maintenance procedures:

SECTION	TITLE
100-520-101	KS-14510 Meter (Portable Volt-Ohm-Milliammeter) — Description and Operation
103-626-100	6F and 6FR Voiceband Noise Measuring Sets—(J94006F and J94006FR)—Description, Operation, and Maintenance
314-410-310	Digital Data System—Local Loop—Maintenance Procedures
314-910-100	Digital Data System—Office Channel Unit (OCU) Assembly—Description
314-918-100	Digital Data System—Digital Data Group Terminal-Description
314-920-100	Digital Data System—Digital 56-kb/s Repeater—Description
314-920-500	Digital Data System—Digital 56-kb/s Repeater—Test Procedures
363-202-100	"SLC"®96 Subscriber Loop Carrier System—General Description
363-202-401	"SLC"®96 Subscriber Loop Carrier System—Remote Terminal
363-202-601	"SLC"®96 Subscriber Loop Carrier System—Remote Terminal Cabinet (AT-8908M)—Installation of Shelves
365-150-107	Dataport Operation—Description, Installation, and Tests—D3B Channel Bank
365-170-100	Description—D4 Channel Bank
365-170-120	Dataport Channel Units—Channel Unit Description—D4 Channel Bank
634-310-501	Locating Cable Faults With the 96A Test Set
640-251-106	468F Apparatus Case—Description and Installation
640-251-107	468F Apparatus Case—Splicing and Acceptance Testing
666-600-500	Digital Data System—950A Testboard (J70176A and B)—Inspection and Maintenance.

5. CHART PROCEDURES

5.01 This part includes procedures for the lineup of local loops on the DDS. These procedures are also used for maintenance and trouble testing as referenced by Section 314-410-310. An understanding of the text in Parts 1 through 3 and familiarity with the specified test equipment should be accomplished before attempting to use the chart procedures.

CHART 1

FOREIGN VOLTAGE

APPARATUS:

Portable volt-ohm-milliameter (VOM), KS-14510-L1 or KS-16979-L1 or equivalent

789A tool for OCU configuration or for Dataport configuration the ED 3C947 tool for D3 banks, the J98726-MF CHAN UN EXT for D4 banks, or the J1C141MF-1,L1 CHAN UN EXT for SLC-96 terminals

STEP	PROCEDURE
1	Set the KS-14510-L1 meter range switch to the 60 VOLT DC scale. Remove the OCU and insert the 789A tool into the slot. For the Dataport configuration, insert the Dataport equivalent.
2	At the 789A tool or Dataport equivalent, connect the meter test probes to the following test points. Measure the voltage between: T and R T1 and R1 T and GRD R and GRD T1 and GRD R1 and GRD. ***Requirement:*** Voltage reading less than 1 volt.

CHART 2

INSULATION RESISTANCE

APPARATUS:

Portable volt-ohm-milliameter (VOM), KS-14510-L1 or KS-16979-L1 or equivalent

789A tool for OCU configuration or for Dataport configuration the ED 3C947 tool for D3 banks, the J98726-MF CHAN UN EXT for D4 banks, or the J1C141MF-1,L1 CHAN UN EXT for SLC-96 terminals

STEP	PROCEDURE
1	Set the KS-14510-L1 meter range switch to the OHMS X10,000 scale and zero adjust the meter.
2	At the 789A tool or Dataport equivalent, connect the meter to the following test points and GRD: T1, R1, T, and R. ***Requirement:*** The insulation resistance reading between each test point and GRD must be greater than 120 kohms.

CHART 3

LOOP PLUS TERMINAL RESISTANCE

APPARATUS:

Portable volt-ohm-milliameter (VOM), KS-14510-L1 or KS-16979-L1 or equivalent

789A tool for OCU configuration or for Dataport configuration the ED 3C947 tool for D3 banks, the J98726-MF CHAN UN EXT for D4 banks, or the J1C141MF-1,L1 CHAN UN EXT for SLC-96 terminals

STEP	PROCEDURE
1	Set the KS-14510-L1 meter range switch to the OHMS X100 scale and zero adjust the meter.
2	At the 789A tool or Dataport equivalent, connect the meter first to test points T and R, and then to T1 and R1. Read the resistance of each connection. (See Note under Test C of paragraph 1.03.)

Requirement: The measured resistance must be as follows:
R (T1 to R1) = (RL2 + 35) ohms ±30%
R (T to R) = (RL1 + RI) ohms ±30%.

Note: On repeatered loops, the resistance of the bypassed repeaters in the loop must be included. Refer to Fig. 7 for the value of this resistance The values of RL1 and RL2 are from installation measurements recorded on the loop record cards and the values of input resistance (RI) are as follows.

- If the DSU or CSU uses FLBO option WW, RI is 35 ohms.
- If the DSU or CSU uses FLBO option WV, RI is as follows:

Bit Rate (KB/S)	Resistance Ohms (R1)
2.4	1030
4.8	920
9.6	475
56.0	220

CHART 4

OCU SIMPLEX VOLTAGE

APPARATUS:

Portable volt-ohm-milliameter (VOM), KS-14510-L1 or KS-16979-L1 or equivalent

789A tool for OCU configuration or for Dataport configuration the ED 3C947 tool for D3 banks, the J98726-MF CHAN UN EXT for D4 banks, or the J1C141MF-1,L1 CHAN UN EXT for SLC-96 terminals

STEP	PROCEDURE
	At the OCU Location
1	Set the voltmeter to the 60 VOLT DC scale.
2	Connect the + probe to the GRD test point and the - test probe to the BAT test point on the 789A tool or the Dataport equivalent.
3	Measure the voltage.
	Requirement:
	If office supply is -48 Vdc, measured voltage should be -49 Vdc minimum and -54 Vdc maximum.
	If office supply is -24 Vdc, measured voltage should be -18 Vdc minimum and -39 Vdc maximum.

SERVING CENTRAL OFFICE-TO-STATION TESTS

CHART 5

FOREIGN VOLTAGE

APPARATUS:

At the office

Portable VOM, such as the KS-14510-L1 or KS-16979-L1 or equivalent

789A tool for OCU configuration or for Dataport configuration the ED 3C947 tool for D3 banks, the J98726-MF CHAN UN EXT for D4 banks, or the J1C141MF-1,L1 CHAN UN EXT for SLC-96 terminals

At the station

None required

STEP	PROCEDURE
1	At the data station, disconnect the DSU (or CSU) from the 42A connecting block and leave the cable pairs open-circuited.
2	At the office location, set the KS-14510-L1 meter range switch to the 60 VOLT DC scale.
3	Remove the OCU and insert the 789A tool or the Dataport equivalent into the slot. At the 789A tool or the Dataport equivalent, connect the meter to the following test points and check for a voltage reading: T to R T1 to R1 T to GRD R to GRD T1 to GRD R1 to GRD. ***Requirement:*** Voltage reading less than 1 volt.
4	If voltage readings meet the above requirement, proceed to the insulation resistance test procedures.
5	If a voltage reading exceeded the requirement on any wire or pair, the faulty pair must be repaired or replaced.

CHART 6

INSULATION RESISTANCE

APPARATUS:

At the office

Portable VOM, such as the KS-14510-L1 or KS-16979-L1 or equivalent

789A tool for OCU configuration or for Dataport configuration the ED 3C947 tool for D3 banks, the J98726-MF CHAN UN EXT for D4 banks, or the J1C141MF-1,L1 CHAN UN EXT for SLC-96 terminals

At the station

None required

STEP	PROCEDURE
1	At the data station, verify that the two cable pairs are open-circuited and not shorted to each other or ground.
2	At the office location, set the KS-14510-L1 meter range switch to the OHMS X10,000 scale and zero adjust the meter.
3	At the 789A tool or the Dataport equivalent connect the meter to the following test points and measure the resistance: T and R, R and R1 T and R1, R and T1 T and T1, T1 and R1. ***Requirement:*** Each insulation resistance reading must be greater than 300 kohms.
4	Connect the meter between the following test points and measure the resistance: T and GRD R and GRD T1 and GRD R1 and GRD. ***Requirement:*** Each insulation resistance reading must be greater than 300 kohms.
5	If the requirements of Steps 3 and 4 are met, proceed to the loop resistance test procedures.
6	If the requirements of Steps 3 and 4 are ***not*** met, the faulty cable pair must be repaired or replaced.

CHART 7

LOOP RESISTANCE

APPARATUS:

At the office

Portable VOM, such as the KS-14510-L1 or KS-16979-L1 or equivalent

789A tool for OCU configuration or for Dataport configuration the ED 3C947 tool for D3 banks, the J98726-MF CHAN UN EXT for D4 banks, or the J1C141MF-1,L1 CHAN UN EXT for SLC-96 terminals

At the station

None required

STEP	PROCEDURE

1 At the data station, short the T, R pair on the connecting block as follows:

500A DSU Line Cord Colors

		T	R	T1	R1
L1/2, L1/3, L1/5 L1/4, SERIES 3	SERIES 2	B	Y	G	R

2 At the office location, set the KS-14510-L1 meter range switch to the OHMS X100 scale and zero adjust the meter.

3 Connect the meter to the 789A tool or the Dataport equivalent test points T and R. Read the resistance value.

Requirement: The resistance reading must be less than 4200 ohms and the value is recorded as RL1 on the CLRC. If the test is not an initial installation test, then the loop resistance must equal RL1 ±30 percent.

Note: On repeatered loops, the resistance of the bypassed repeaters in the loop must be included. Refer to Fig. 7 for the value of this resistance.

4 At the data station, remove the short from the T, R pair and place it across the T1, R1 pair on the connecting block as shown in Step 1.

5 At the office location, connect the meter to the 789A tool or the Dataport equivalent test points T1 and R1. Read the resistance value.

Requirement: The resistance reading must be less than 4200 ohms and the value is recorded as RL2 on the CLRC. If the test is not an initial installation test, then the loop resistance must equal RL2 ±30 percent. (Refer to Note in Step 3.)

6 If the requirements of Steps 3 and 5 are met, remove the short on the cable pair and proceed to the ac tests.

7 If the requirements of Steps 3 and 5 are ***not*** met, the faulty cable pair must be repaired or replaced.

AC TESTS

CHART 8

INSERTION LOSS

APPARATUS:

At the office

789A tool for OCU configuration or for Dataport configuration the ED3C947 tool for D3 banks, the J98726-MF CHAN UN EXT for D4 banks, or the J1C141MF-1, L1 CHAN UN EXT for SLC-96 terminals

P2ES or equivalent cord (specify 8- or 12-foot cord length for use with 7- or 11-foot bays).

HP-3550B test set or equivalent.

At the station

HP-3550B test set

135-ohm resistors(Z).

STEP	PROCEDURE

At the Central Office or SLC-96 Remote Terminal

1 Operate the controls on the HP-3550B as follows:

Oscillator:

FREQ to applicable test frequency (Table A)

RANGE to X1000 for 2.4-, 4.8-, and 9.6-kb/s service

X10K for 56-kb/s service

AMPLITUDE to minimum (ccw).

Note: Connect one side of the oscillator OUTPUT to the oscillator ground terminal.

Voltmeter:

FUNCTION to ON

RANGE to 0 dB.

Note: Connect the black terminal on the voltmeter input to the voltmeter ground terminal.

Patch Panel:

MEAS—CAL to CAL

IMPEDANCE to 135 OHMS (input and output)

FREQ to < 5 KC for 2.4-, 4.8-, and 9.6-kb/s service

< 5 KC for 56-kb/s service DB to 0.

Note: Connect the OUTPUT and INPUT center taps (CT) to the voltmeter ground terminal.

2 Connect the output of the HP-3550B to the T, R jack on the 789A tool or the Dataport equivalent using the P2ES cord.

3 With the patch panel MEAS—CAL switch in the calibrate position, adjust the oscillator AMPLITUDE control to obtain a 0-dBm reading on the voltmeter.

4 Operate the patch panel MEAS—CAL switch to MEAS.

At the Data Station

5 Connect the HP-3550B test set input to the T, R line pair at the customer terminal block with a twisted pair, make connections to ground terminals as given in Step 1, and operate the test set controls as follows:

Patch Panel:

MEAS–CAL to MEAS

IMPEDANCE to 135 OHMS (input and output)

FREQ to < 5 KC for 2.4-, 4.8-, or 9.6-kb/s service

< 5 KC for 56-kb/s service.

Voltmeter:

FUNCTION to ON

RANGE to 0 dB.

6 Decrease the voltmeter RANGE setting until a meter reading is obtained.

7 Read the received level and record the results at each applicable frequency setting on the CLR.

Requirement: Refer to Table A.

Note: The insertion loss (dB) = 0 dBm (transmit level) - received level (dBm). For example, received level = -20 dBm, then insertion loss = +20 dB.

8 Repeat Steps 1 through 7 at each test frequency for the T1, R1 pair.

Requirement: Refer to Table A.

9 If test results are good, disconnect test equipment from both ends and proceed to the noise measurement test procedures.

10 If test results do not meet the requirements, notify cable assignment desk and have value of EML checked on records.

CHART 9

BACKGROUND CIRCUIT NOISE

APPARATUS:

At the office

789A tool for OCU configuration or for Dataport configuration the ED 3C947 tool for D3 banks, the J98726-MF CHAN UN EXT for D4 banks, or the J1C141MF-1,L1 CHAN UN EXT for SLC-96 terminals

6F voiceband NMS with 50-kHz network (497F)

135-ohm resistor

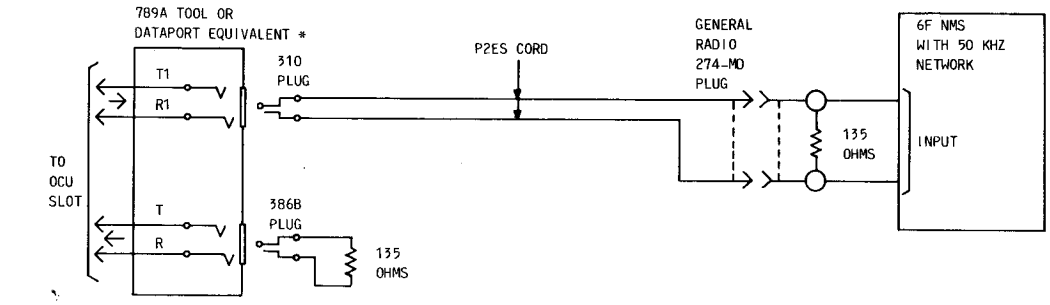
386B plug (310 plug with 135-ohm termination)

At the station

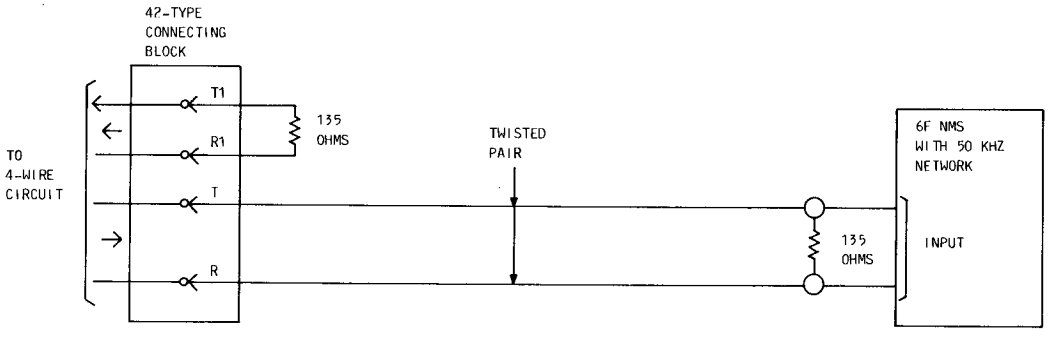
6F voiceband NMS with 50-kHz network (497F)

135-ohm resistors (2)

STEP	PROCEDURE
	At the Data Station
1	Connect the 6F NMS to the T, R pair as shown in Fig. 8.
2	Connect the 135-ohm resistor to the binding post (BP) input of the 6F NMS.
3	Connect a 135-ohm resistor between the T1, R1 pair on the customer terminal block.
	At the OCU
4	Insert the 386B plug into the T, R jack of the 789A tool or the Dataport equivalent.
5	Connect a 135-ohm resistor to the BP input of the 6F NMS.
6	Using the P2ES cord, connect the 6F NMS to the T1, R1 jack of the 789A tool or the Dataport equivalent.



OFFICE – OCU LOCATION



STATION – DSU/CSU LOCATION

* DATAPORT EQUIVALENT--ED-3C947 TOOL, J98726MF CHAN UNIT EXT, OR J1C141MF-1, L1 CHAN UNIT EXT

Fig. 8—Test Connection for Noise Measurement Tests

At Both Locations

7 Plug in the 50-kHz weighting network on the 6F NMS and calibrate the set.

8 After calibration is complete, set the FUNCTION switch to 600 OHM BRIDGING on the 6F NMS.

9 Adjust the DBRN dial to obtain a meter reading in the upper half of the meter scale. The background noise level is the sum of the DBRN dial setting and the meter reading.

Requirement: Refer to Table B.

10 If the background circuit noise requirement is met, proceed to the impulse noise test procedures.

11 If the background circuit noise requirement is ***not*** met, begin trouble repair work on the cable pair or request a new pair assignment.

TABLE B

BACKGROUND CIRCUIT NOISE LIMITS

BIT RATE (KB/S)	MAXIMUM NOISE LEVEL (DBRN)
56.0*	28
9.6	31
4.8	39
2.4	42

* For 56-kb/s repeatered loops, the limit applies to each repeater section.

Note: Many NMSs equivalent to the 6F (with 50-Kb noise weighting) have 135-ohm inputs. In using these sets, the 135-ohm resistor bridged across the NMS is not used. To account for use of a 135-ohm set, add 7 dB to the test requirements in Table B.

CHART 10

IMPULSE NOISE

APPARATUS:

At the office

789A tool for OCU configuration or for Dataport configuration the ED 3C947 tool for D3 banks, the J98726-MF CHAN UN EXT for D4 banks, or the J1C141MF-1,L1 CHAN UN EXT for SLC-96 terminals

6F voiceband NMS with 50-kHz network (497F)

135-ohm resistor

386B plug (310 plug with 135-ohm termination)

At the station

6F voiceband NMS with 50-kHz network (497F)

135-ohm resistors (2)

STEP	PROCEDURE
1	Verify that the equipment is connected as given in Steps 1 through 8 of paragraph 3.24.
	At Both Locations
2	Adjust the 6F NMS for the impulse noise threshold given in Table C.
3	Reset the counter to 00 and make a 15-minute run. At the end of this time, read the total number of counts recorded on the counter.
	Requirement: Refer to Table C.
4	If the impulse noise requirement is met, disconnect all test equipment and test leads from the circuit.
5	Remove the 135-ohm resistors from the customer terminal block at the station.
6	If the impulse noise requirement is ***not*** met, request a new nonloaded pair assignment.

TABLE C

IMPULSE NOISE LIMITS

BIT RATE (KB/S)	THRESHOLD (DBRN)	MAXIMUM NUMBER OF IMPULSE NOISE COUNTS/15 MIN
56.0*	44	7
9.6	47	7
4.8	55	7
2.4	58	7

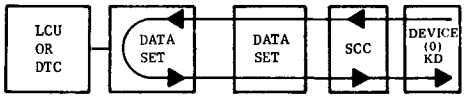
* For 56-kb/s repeatered loops, the limit applies to each repeater section.

Note: Many NMSs equivalent to the 6F (with 50-Kb noise weighting) have 135-ohm inputs. In using these sets, the 135-ohm resistor bridged across the NMS is not used. To account for use of a 135-ohm set, add 7 dB to the test requirements in Table B.

NOTICE

These pages are excerpts from "DATASPEED*" 4540 STATION ARRANGEMENTS TESTING AND TROUBLESHOOTING - SECTION 582-300-500, Issue 2, dated June 1980.

3.13 Far-End Digital Loopback Test to Test Center or LCU Data Set:



Caution: Caution of 3.11 applies.

If permission is given, perform Steps 1 and 3 of Chart 13.

Note 1: This test can only be performed from KD connected to port 1.

Note 2: This test does not require that Data Set Ready (DSR) from Data Set be on.

CHART 13

NEAR-END ANALOG AND FAR-END DIGITAL LOOPBACK TESTS

STEP	PROCEDURE	CORRECT RESPONSE	TEST FAILS
1	Depress the CLEAR key, then depress LOCAL (or RESET) key if not lit. Request a Local Test by depressing the L/TST key while CONTROL (or ALPHA) key is held down. (See Notes 1 and 2 on the next page.)	The "LOCAL TEST MODE" message shown below is displayed on the monitor. Display does not clear automatically in 20 seconds as it did with 40/4-type equipment. To perform analog loopback test: Go to 2. To perform far-end digital loopback test: Go to 3.	•If no message appears or S/R indicator is flashing: (a) Check to see that KD is optioned correctly. (See Section 582-300-200). (b) Check SSI cabling to SCC per SSI cable analysis in this section. •If monitor adjustments are needed, refer to Section 582-213-700.

All 45FG110-types:

LOCAL TEST MODE

TEST MSG:

THE QUICK BROWN FOX JUMPED OVER THE LAZY DOG'S BACK 0123456789 TIMES.

TO TEST LOOPBACK, PRESS S/R OR ENTER
TO RESET PRESS CLEAR
SEE MANUAL FOR DETAILS [ ]

THE QUICK BROWN FOX message appears on one line.

If the word "BAD" appears in this area, replace the display base.

45FG110/AA or 45FG110/AB type only:

(_ _ _) [ ]

If the wrong line code appears, check Option 408.

45FG110/AC/01 only:

SCC No. _ _
DEV No. _ _
CODE EBCDIC

CHART 13 (Contd)

NEAR-END ANALOG AND FAR-END DIGITAL LOOPBACK TESTS

STEP	PROCEDURE	CORRECT RESPONSE	TEST FAILS
1 (Contd)			

Note 1: If Step 2 is tried twice in succession, an "Operation Error, Aborted" message will appear. Repeat Step 4 again to resume testing.

Note 2: If the CLEAR key is depressed with the above message on the display screen, the keyboard will become locked. To unlock the keyboard, depress the CLEAR key again.

2	Near-end analog loopback Test from KD connected to SSI port #1 only: (Device 0 (space)) *Caution: If station is on-line with LCU, obtain permission from customer before performing this test.* Depress AL on 201, 208 or 209-type data set or slide test switch on 500A-type DSU to LL position or depress Local Loopback button on 48230 LADS. Depress CONTROL (or ALPHA) and R/TST together.	The message shown below is displayed. The TEST STATUS indicator #4 on SCC also turns on; then off. If optioned for single alarm, alarm will sound once and LOCAL indicator should light. If optioned for continuous alarm, alarm will sound repeatedly until LOCAL (or RESET) key is manually depressed. When test is complete, release AL button on 201, 208 or 209-type data set, or slide test switch on 500A-type DSU to center position, or release local loopback button on 48230 LADS. *Note:* If modem other than mentioned above is used, refer to operating manual included with that modem. The station passes the Analog Loopback Test. Return to Chart 12 Question 2, 3, 4 or 6 (as applies).	•If S/R indicator is flashing, replace 410311 circuit card in SCC. • If "LOOPBACK DATA CONTAINED ERRORS" message is received, go to Step 4. •If "DEVICE FAILED TO SEND DATA" message is received, perform Display Analysis, Chart 8. •If "INVALID DATA FROM DEVICE" message is received, go to Step 5. •If, after 5 seconds, a "NO DATA RECEIVED" message is received, go to Step 6. •If "NO CTS FROM DATA SET" is received, go to Step 7. •See Note 2 below.

THE QUICK BROWN FOX JUMPED OVER THE LAZY DOG'S BACK 0123456789 TIMES. ← Appears on one line. (See Note 1 below.)

Note 1: If any characters in the QUICK BROWN FOX message were changed before depressing S/R (or ENTER) key, those characters will appear in the above message. Up to 2-1/2 lines can be entered.

Note 2: If SCC is on line with LCU, and is sending and receiving large amounts of long text blocks, a "LOOPBACK CANNOT BE PERFORMED" message will appear on the display. Perform Steps 1 and 2 (to try again).

CHART 13 (Contd)

NEAR-END ANALOG AND FAR-END DIGITAL LOOPBACK TESTS

STEP	PROCEDURE	CORRECT RESPONSE	TEST FAILS
3	Far-end Digital Loopback Test from KD connected to SSI port #1 only (device 0 (space)), to LCU data set or DATA TEST CENTER: *Caution: Permission must first be obtained before performing this test if station is on-line with customer's equipment.* Instruct far-end attendant to depress DL on 201, 208 or 209-type data set or slide test switch on 500-type DSU to RT position or depress DC BUSBACK button on 48230 LADS. Depress CONTROL (or ALPHA) and R/TST together.	The message shown in Step 2 is displayed. When test is complete, have far-end attendant release DL button on 201, 208 or 209-type data set or slide test switch on 500A-type DSU to center position, or release DC BUSBACK button on 48230 LADS. *Note:* If modem other than mentioned above is used, refer to operating manual included with that modem. The station passes the Digital Loopback Test. Return to Chart 12, Question 7.	(Refer to "No" response column of Step 2.)

CHART 13 (Contd)

NEAR-END ANALOG AND FAR-END DIGITAL LOOPBACK TESTS

STEP	PROCEDURE	CORRECT RESPONSE	TEST FAILS
4	The following message is displayed when Step 2 or 3 is performed: **LOOPBACK DATA CONTAINED ERRORS** LOCAL TEST MODE TEST MSG: THE QUICK BROWN FOX JUMPED OVER THE LAZY DOG'S BACK 0123456789 TIMES. RE-TEST LOOPBACK, PRESS S/R OR ENTER TO RESET PRESS CLEAR SEE MANUAL FOR DETAILS 45FG110/AA or 45FG110/AB type only: (_ _ _) 45FG110/AC/01 only: SCC _ _ DEV_ _ CODE EBCDIC	(Does not apply, see "Test Fails")	If test fails the second time: •Check data set or data set cable if message occured during Analog Loopback Test (Step 2). When 208A data set is mounted on shelf in controller cabinet, the ventilation fan modification kit (451340) must be present and moving air through the data set. (See Section 582-300-200). •Check far-end data set or check facilities between data sets if message occurred during Far-End Digital Loopback Test (Step 3).
	Note: Retry Step 2 or 3 (as applies) once.	Correct response is given in Step 2 or 3.	•Perform Display Analysis, Chart 8.
5	"INVALID DATA FROM DEVICE" message is displayed when Step 2 or 3 is performed. *Note:* If "ERASE INPUT" key was depressed before S/R or ENTER, message is valid and Steps 1 and 2 (or 1 and 3) should be tried again.	(Does not apply, see "Test Fails")	•If ERASE INPUT was not depressed before S/R or ENTER: (a) Check SSI cabling to SCC per SSI Cable Analysis of this section. (b) Perform Display Analysis, Chart 8.

CHART 13 (Contd)

NEAR-END ANALOG AND FAR-END DIGITAL LOOPBACK TESTS

STEP	PROCEDURE	CORRECT RESPONSE	TEST FAILS
6	"NO DATA RECEIVED" message is displayed after five seconds when Step 2 or 3 is performed.	(Does not apply, see "Test Fails")	If message occurred during Step 2 or 3: • Make sure data set has power on and is conditioned as directed in Step 2 or 3. •Replace data set. •Replace data set cable. • Replace 410320 circuit card in SCC. •Replace 410311 circuit card in SCC.
7	"NO CTS FROM DATA SET" message is displayed when Step 2 or 3 is performed. *Note:* If test is part of Analog or Digital Loopback Test and no data set is present, message is valid.	(Does not apply, see "Test Fails")	•Make sure data set ac power is on. •Replace data set. •Replace data set cable. •Replace data set extension cable (if used). •Replace 410311 circuit card in SCC.

H. SSI Cable Analysis

3.14 When it is suspected that cabling between the controller (SCC) and device may be a cause of trouble or when the controller is equipped with a 45FG110/AB circuit card, it is noticed that the Status 3 indicator of the SCC, blinks 2 or more times within 15 minutes, the following troubleshooting procedures should be used:

(a) First try to isolate the cable causing the trouble by disconnecting device cables in groups until the trouble is no longer experienced. Then start reconnecting cables from last disconnected group until trouble reappears. Cable last connected, causing the trouble to reappear, is at fault.

(b) If cable exhibits outer jacket damage, (shield or wire insulators visible while flexing) cable should be replaced and the cause of the damage corrected.

(c) Visually inspect the seating of terminals in the connectors at both ends of the cable. Check crimping of terminals to wires; the lower crimp point must tightly grip the conductor and the upper crimp point must tightly grip the conductor insulation. Shielded cables have mylar tape wrapped around the conductor bundle under the shield. When the outer shield is removed in preparation for affixing terminals and connectors, the mylar tape must extend approximately 1/4-inch beyond the point of shield removal in order to prevent frayed shield ends from piercing conductor insulation.

Note 1: Intermittent operational failures may occur between a device and the controller when there is a significant difference in ground potential at the device and the controller ac outlets, and the SSI cable drains are connected at both ends. If the above situation should occur, it is recommended that the device end SSI cable drain terminal be removed from the connector with a 402840 extractor and taped back. If failures still occur, then reinsert terminal at device end and remove and tape back drain terminal at the SCC end.

Note 2: The next issue will include suggestions for alternate hardware to make required jumpers.

3.15 Short SSI cable lengths (up to 50 feet) or data set cables can be checked for shorts and continuity per the following methods:

(a) Unplug the cable under test at both the controller and device ends.

(b) See warning below. Using a standard continuity tester (lamp or buzzer type or ohmmeter):

(1) Measure that shorts do not exist between conductors.

(2) Measure each conductor for continuity. (Refer to Section 582-300-400 for wiring.) If cable is still suspected, replace cable. Do not perform test of 3.17 — 3.27.

Warning: If foreign voltages are present, they may damage an ohmmeter. Before using an ohmmeter, check that no voltage is present. If voltage is present, correct fault and do not attempt a shorts or continuity test until fault is corrected.

3.16 For long SSI cable runs, the following methods may be employed:

(a) Unplug the cable under test from both the controller and the remote device.

(b) See warning above. Using an ohmmeter (VOM) on the RX10 or RX100 range, measure that shorts do not exist between conductors or between a conductor and shield.

(c) When it is determined that the cable is free from internal shorts, perform SSI Cable Testing beginning at 3.17.

I. SSI Cable Testing

3.17 When checking SSI cable, the cable should be tested per the following cable tests. The cables which pass these tests will operate with an error rate of less than one error in 10^8 bits, or one bit error in 15 minutes, under normal conditions.

3.18 The following test equipment and materials are required for testing cable:

1 — Simpson 260 Volt-Ohm-Meter (VOM) (or equivalent)
2 — 6 inch jumper cables with insulated alligator clips
2 — 135 ohm ± 10 percent, 1/4 watt resistors
1 — WILCOM T194B Transmission and Noise Test Set
OR
1 — HP3550B Communication Test Set and 1-6F (J94006F) Voiceband Noise Set with 50KHZ network.

3.19 There are two types of cable tests, dc tests and ac tests. The dc tests consist of measuring foreign voltages, insulation resistances, and loop resistances. The ac tests consist of measuring crosstalk, loop loss, background circuit noise, and impulse noise. Tables "A" through "G" can be copied to provide separate records for different cables.

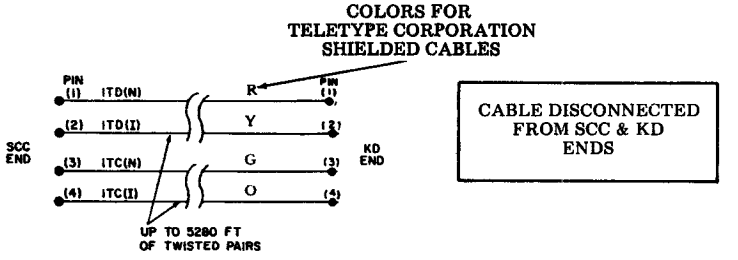


Fig. 15—DC Tests on Cable Pairs Between SCC and KD

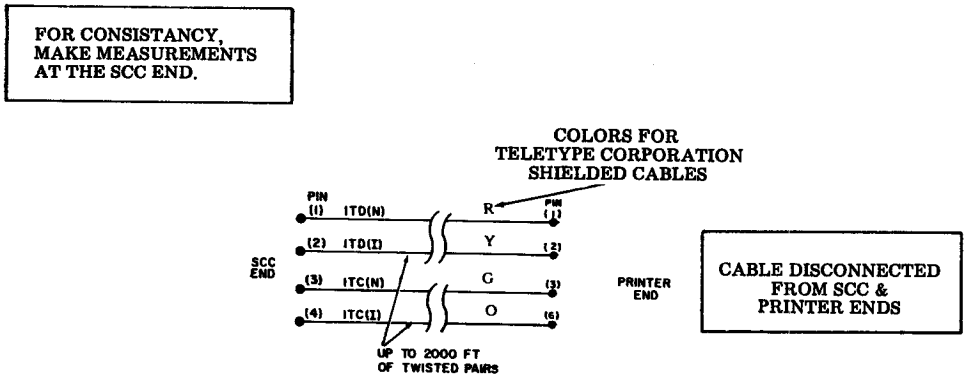


Fig. 16—DC Tests on Cable Pairs Between SCC and KD

DC Tests

3.20 The Loop Resistance tests require a Simpson 260 VOM and a jumper. See Fig. 15 or 16 (as applies) for test arrangement.

(a) If the cable length is known, use the formula "Loop resistance equals 2 times cable length times 0.025 ohms per foot". Then make measurement per Table A. If measured resistance is approximately equal to resistance determined by above formula, the cable passed the test.

Example: If cable is 2000 feet long, the approximate resistance should be 2 times 2000 (cable length) times 0.025 (ohms per foot) = 100 ohms.

(b) If the cable length is not known, make measurement per Table A. If measured resistance is less than 300 ohms for a KD cable or less than 140 ohms for a printer cable, the cable passed the test.

Table A — Loop Resistance Tests

Cable being tested: SCC _____ TO DEVICE _____

Measure the resistances between the following leads with the conditions given:	Measured Resistances
1. Short ITD (N) and ITD (I) with a jumper at the device end of cable. Measure the resistance across ITD pair at the SCC end.	1. _____ ohms
2. Remove jumper from ITD pair and place jumper across ITC pair at the device end of cable. Measure the resistance at the SCC end.	2. _____ ohms
3. Remove jumper from ITC pair and place jumper across ITC (I) and shield at the device end of the cable. Measure that resistance is less than 300 ohms for a KD cable or less than 140 ohms for a printer cable.	3. _____ ohms

The cable: Passed ☐ Failed ☐

3.21 The foreign voltage tests require a Simpson 260 VOM or equivalent. See Fig. 15 or 16 (as applies). Perform the tests in Table B.

The cable passes foreign voltage tests if all measured voltages are less than 0.1 volt dc.

Table B — Foreign Voltage Tests		
Cable being tested:	SCC _____ TO DEVICE _____	
Measure the voltage between the following leads:		Measured Voltages
1. ITD(N) to ITD(I)		_____ VDC
2. ITC(N) to ITC(I)		_____ VDC
3. ITC(N) to ground		_____ VDC
4. ITC(I) to ground		_____ VDC
5. ITD(N) to ground		_____ VDC
6. ITD(I) to ground		_____ VDC
7. Shield to ground		_____ VDC
This cable:	passed ☐	failed ☐

3.22 The Insulation Resistance Tests require a Simpson 260 VOM or equivalent. See Fig. 15 or 16 (as applies) for test arrangement. Perform the tests in Table C.

The cable passes the Insulation Resistance Tests if all measured resistances are greater than 300K ohms (300,000 ohms).

Table C — Insulation Resistance Tests		
Cable being tested:	SCC _____ TO DEVICE _____	
Measure the Resistance between the following leads		Measured Resistance
1. ITD(N) to ITD(I)		_____ Kohms
2. ITD(N) to ITC(N)		_____ Kohms
3. ITD(N) to ITC(I)		_____ Kohms
4. ITD(I) to ITC(I)		_____ Kohms
5. ITD(I) to ITD(N)		_____ Kohms
6. ITC(N) to ITC(I)		_____ Kohms
7. Shield to ground		_____ Kohms
8. ITD(N) to ground		_____ Kohms
9. ITD(I) to ground		_____ Kohms
10. ITC(N) to ground		_____ Kohms
11. ITC(I) to ground		_____ Kohms
This cable:	passed ☐	failed ☐

Steps 8 — 11 require jumper to short shield to ground.

AC Tests

3.23 The Cross-Talk Tests require either a WILCOM T194B Transmission and Noise Test Set or a HP-3550B Communication Test Set and two 135 ohm resistors. Connect the test set and resistors as shown in Fig. 17. If a WILCOM Test Set is used, perform the initial set up of 3.24 first. Perform the tests in Table D.

The cable passes the Cross-Talk Tests if all measured values are lower than -48 dBm. (eg, -49 dBm is lower than -48 dBm.)

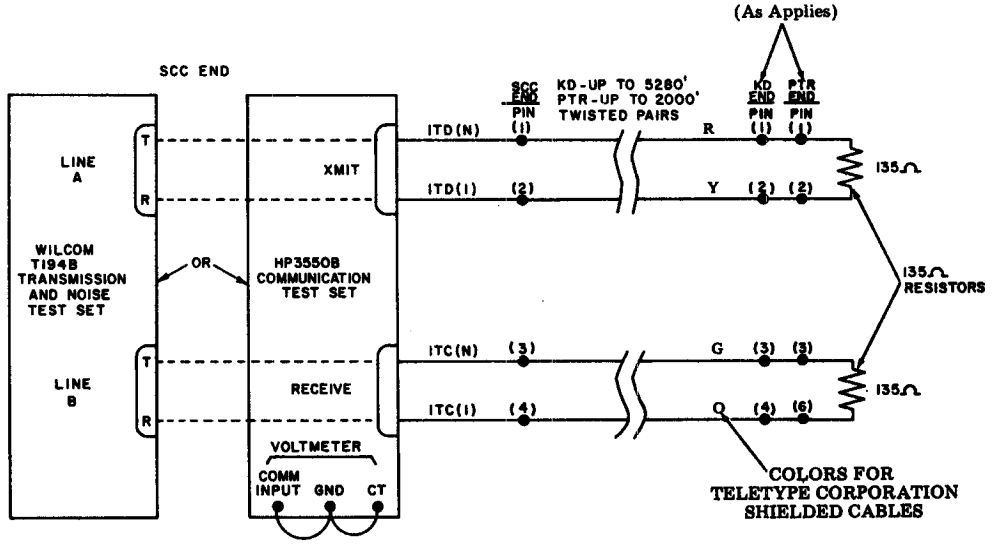


Fig. 17—Cross-Talk Measurements

3.24 WILCOM T194B Test Set — Initial Set Up

(a) Set FUNCTION switch to CAL OUTPUT position.
(b) Set SEND and RECEIVE IMPEDANCE switches to 135 position.
(c) Set BRDG/TERM switch to TERM position.
(d) Set SEND LEVEL and RECEIVE LEVEL switches to 0 dB. (use the red calibration scale to set the receive level).
(e) Set DISPLAY switch to SEND Hz position.
(f) Using FREQUENCY Hz switch, select the range of frequency.
(The three frequencies of TABLE D are 10 KHz, 50KHz and 100KHz)
(g) Select send frequency with the TUNING knob. The send frequency will appear in the digital display.
(h) Using send LEVEL VERNIER; adjust the output for a 0 dB reading on the meter scale.

Table D — Cross Talk Tests

Cable being tested: SCC _____ TO DEVICE _____

1a. For WILCOM T194B Transmission and Noise Test Set Only:
(Perform 3.24 first)

(1) Set FUNCTION switch to SEND A/REC B or SEND B/REC A to send signal on the desired pair of the SSI cable.

(2) Set WEIGHTING switch to 30-300 KHz position.

(3) Set both HOLD switches to OFF position.

(4) Set NORMAL/DAMP switch to NORMAL position.

(5) Set 1004 Hz NOTCH switch to OFF position.

(6) Set desired send frequency with the FREQUENCY Hz switch and TUNING knob. Observe on digital display. (Check if "X 10" LED is lighted)

(7) Adjust the RECEIVE LEVEL switches for a meter reading near 0 dB on the scale.

(8) Read the dBm value by adding the readings (use outer (red) scale) of the RECEIVE LEVEL switches and the meter.

(9) Repeat 3.24 a, f, h, then Table D Step 1a (1), (6), (7) and (8) for 50 KHZ and 100 KHZ.

1b. For HP-3550B Communications Test Set only:

(1) Connect the voltmeter common input (black) to the voltmeter ground terminal.

(2) Connect the output and input center tap (CT) to the voltmeter ground terminal.

(3) Input and output impedance to 135 ohms.

(4) Set frequency to > 5 KHz (greater than 5 KHz).

(5) Set patch panel dB control to 0.

(6) Set patch panel MEAS-CAL switch to CAL position, adjust the oscilliscope amplitude control to obtain a 0-dBm reading on the voltmeter.

(7) Set the MEAS-CAL switch to MEAS position.

2. Measure the cross-talk between cable pairs at the following frequencies:	Measured Cross-Talk (Requirements: Lower than -48 dBm)
1. 10 KHz	1. _____ dBm
2. 50 KHz	2. _____ dBm
3. 100 KHz	3. _____ dBm

The cable: Passed ☐ Failed ☐

3.25 The Loop-Loss Tests require either a WILCOM T194B Transmission and Noise Test Set or a HP-3550B Communication Test Set and two jumpers. Connect the test set as shown in Fig. 18. Perform the tests in Table E.

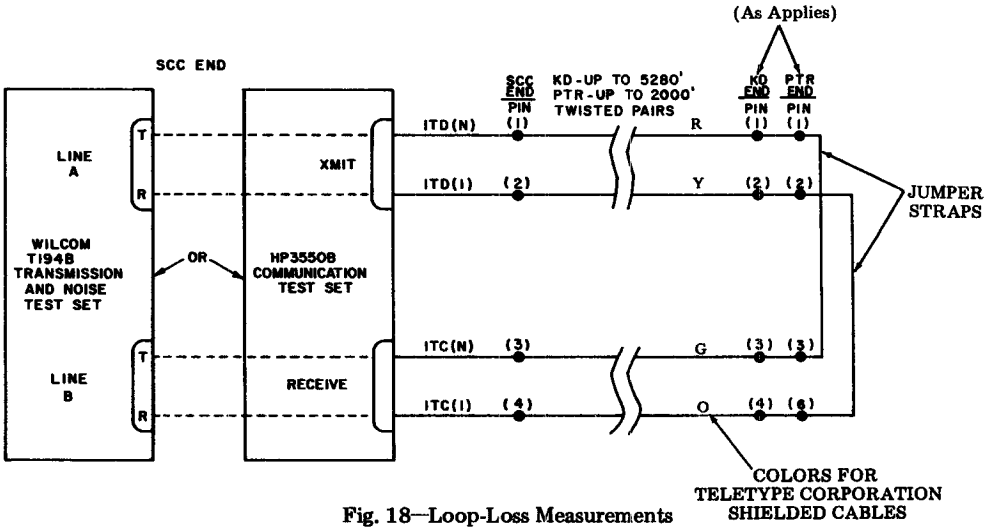


Fig. 18—Loop-Loss Measurements

Table E — Loop-Loss Tests

Cable being tested: SCC _____ TO DEVICE _____

1. Set up the WILCOM T194B or HP-3550B as instructed in Table D.

Note: For WILCOM Test Set only — perform steps (6), (7), and (8) of 1a, Table D for each frequency.

2. Measure the Loop-loss at the following frequencies:	Measured Loop-Loss	Maximum Loop-Loss Allowed for KD	Maximum Loop-Loss Allowed for Printer
a. 28KHz	_____dBm	24.5 dBm	7.5 dBm
b. 56KHz	_____dBm	30.5 dBm	10.4 dBm
c. 84KHz	_____dBm	34.5 dBm	12.5 dBm

The cable: Passed ☐ Failed ☐

3.26 The Background Noise Tests require either a WILCOM Transmission and Noise Test Set or a 6F Voiceband Noise Measuring set and one or two 135 ohm resistors. Connect the test set as shown in "Test 1" of Fig. 19. Perform the tests in Table F. The cable passes the Background Noise Level Tests if the readings are lower than 45 dBrn.

Note: Disconnect line B from test set when performing following test.

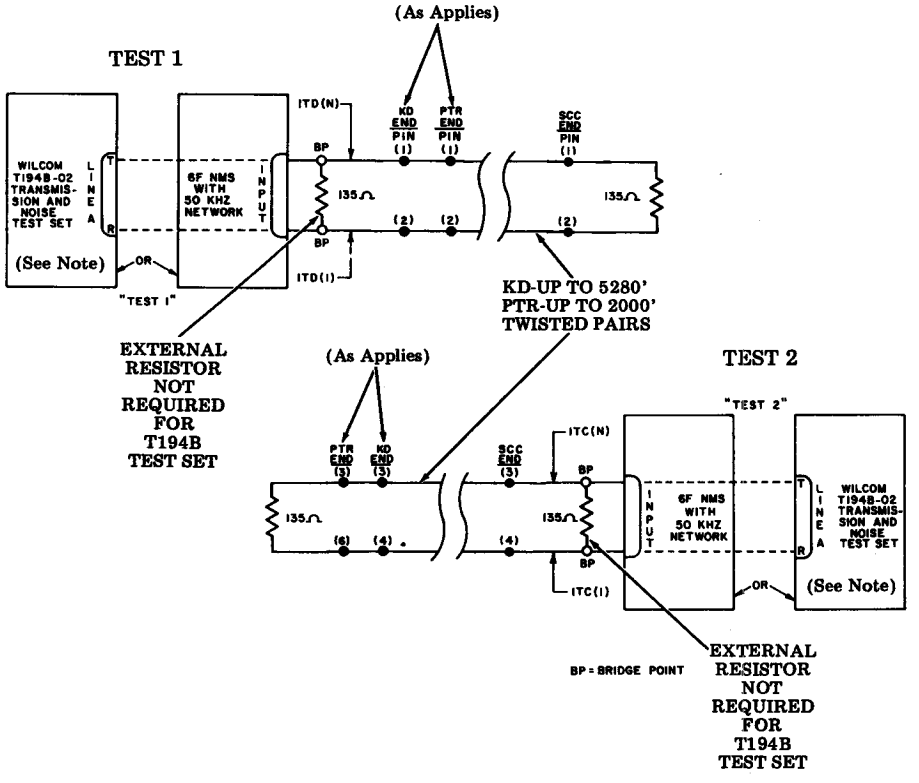


Fig. 19—Noise Measurements

Table F — Background Circuit Noise Tests

Cable being tested: SCC _____ TO DEVICE _____

1a. For WILCOM T194B Transmission and Noise Test Set ONLY:

(1) Set FUNCTION switch to SEND B/REC A position (however, sending on B is not intended).
(2) Set WEIGHTING switch to 50KHz position.
(3) Set RECEIVE IMPEDANCE switch to 135 position.
(4) Set BRDG/TERM switch to TERM position.
(5) Set 1004 Hz notch switch to OUT position.
(6) Set NORMAL/DAMP switch to NORMAL position. (Exception: Under severely fluctuating noise condition, set to DAMP.)
(7) Turn down send level (to avoid false reading) then adjust RECEIVE LEVEL switches for a meter reading near 0 dB on the scale. (Level may be so low that switch adjustments cannot permit an on-scale meter reading.)
(8) Read the background noise level by adding the RECEIVE LEVEL Switch settings (using the inner (black) scale) and the meter reading.
(9) Connect the test set as shown in "TEST 2" of Fig. 19. Again perform Steps 1a(7) and 1a(8).

1b. For 6F VOICE-BAND NOISE MEASURING SET ONLY:

Plug in the 50 KHz weighting network on 6F Voice band Noise Measuring Test Set and calibrate as follows:

(1) Set the Counter Separation switch to the 2 dB position.
(2) Set the Function switch to CAL-CTR-BAT and turn the power switch on.
(3) Verify that the meter indicates in the BAT GOOD area. Replace batteries that do not have good indication.
(4) Adjust the Counter 1 CAL control until the associated counter just counts (the count will be erratic when properly adjusted).
(5) Adjust the Counter 2, 3, and 4 controls by depressing the associated push button switch and adjusting the CAL control until the counter just counts as in Step 1b(4). During calibration, only one counter will operate at a time.
(6) Set the FUNCTION switch to CAL-MTR and adjust the meter CAL control for a meter indication at the CAL marking.
(7) Set the function switch to 600 ohm bridging. Adjust the dBrn dial to obtain a meter reading in the upper half of the meter scale.
(8) The background noise level is the sum of the dBrn dial setting and the meter reading.
(9) Connect the test set as shown in "Test 2" of Fig. 19. Again perform Steps 1b(7) and 1b(8).

"Test 1" Background noise level ____ dBrn
"Test 2" Background noise level ____ dBrn

The cable: Passed ☐ Failed ☐

3.27 The Impulse Noise Tests require either a WILCOM T194B Transmission and Noise Test or a 6F Voiceband Noise Measuring Set, and one or two 135 ohm resistors. Connect the test set as shown in "Test 1" of Fig. 19. Perform the tests in Table G. The cable passes the test if "Test 1" (or "Test 2") results in a count of 1 or less.

Table G — Impulse Noise Tests

Cable being tested: SCC _____ TO DEVICE _____

1a. For WILCOM T194B Transmission and Noise Test Set ONLY:

(1) Set up test set as instructed in Steps 1a(1) through 1a(6) of Table F.
(2) Set RECEIVE LEVEL switches using the inner (Black) scale to 65 dBrn.
(3) Set DISPLAY switch to IMPULSE COUNT position.
(4) Set IMPULSE COUNT TIME MINUTES to 30 position.
(5) With COUNTING lamp lit, run the test for 30 minutes.
(6) When COUNTING lamp turns off and COUNT COMPLETE lamp turns on, take a reading.
(7) Set DISPLAY switch to SEND Hz position and back to IMPULSE COUNT position. (This resets a digital display to zero.)
(8) Connect the test set as shown in "TEST 2" of Fig. 19. Run test as directed in Steps 5 and 6 of 1a.

1b. For 6F Voice Band Noise Measuring Set only:

(1) Set up and calibrate the 6F Voice Band Noise Measuring Set as instructed in Step 1b of Table F.
(2) Set the function switch to 600 ohm bridging. Adjust the impulse noise threshold to 65 dBrn by setting the dBrn dial to 35. Reset the counter to 00,
(3) After resetting the counter, run the test for 30 minutes and take a reading.
(4) Connect the test set as shown in "Test 2" of Fig. 19. Run test as directed in Steps 1, 2 and 3 of 1b.

"Test 1" count _____ "Test 2" count _____

The cable: Passed ☐ Failed ☐

NOTES

LOCAL AREA DATA CHANNELS
MAINTENANCE PROCEDURES

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1. GENERAL

1.01 This section describes the maintenance considerations and procedures used to locate a trouble condition on the metallic cable pairs that make up a Local Area Data Channel (LADC). These channels provide for baseband transmission of data signals between two customer terminal locations within a single serving wire center area.

Note: The term "pair" or "loop" as used in this section denotes the circuit facility used to implement the channel service. It is ***not*** necessarily the circuit facility between a customer and the telephone central office.

1.02 Whenever this section is reissued, the reason for reissue will be listed in this paragraph.

1.03 LADCs use nonloaded metallic facilities, exclusively, with limited amounts of bridged tap. The facilities may reside entirely within the customer premises or may be routed through the Serving Central Office (SCO). When the facilities are routed through a central office, some testing may be accomplished from the Local Tesk Desk (LTD). If the channel is not routed through the SCO, then a dispatch may be necessary whenever trouble is reported.

1.04 LADCs are provided as either 2-wire or 4-wire channels with corresponding 2-wire or 4-wire interface to the data set. Channels are specified in lengths ranging from 1 mile to 6 miles, in 1-mile increments. Channel length is determined by the overall length of the facilities used to furnish the particular channel service, measured from data set to data set.

1.05 LADCs should be treated as a Special Service. The Special Service Center (SSC) responsible for the territory involved should be the office that the customer is instructed to call in case of trouble. The SSC is responsible for coordinating all maintenance activities and for requesting the LTD at the SCO to perform any required testing. In the absence of an SSC, the local organization which normally receives trouble reports for data service should be designated as the Control Office.

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1.06 Trouble analysis procedures and information given in this section are based on the results of tests made under the following conditions:

(a) Self-tests made by the customer. These tests make use of the self-testing capabilities of data sets connected to LADCs. Generally, results of these tests should indicate the source of trouble.

(b) One employee tests made at the SCO or another convenient test access midpoint. These tests are dc tests made toward either end of the circuit for the purpose of trouble analysis. If the data sets are Telephone Company (TELCO) provided, they may remain connected to the circuit.

(c) End-to-end testing of the circuit. These tests are dc and ac tests made at the customer premises with the data sets disconnected from the circuit. These tests are performed during installation (benchmarks) or for the purpose of detailed trouble analysis.

1.07 The various tests to be performed on LADCs are outlined in Part 5 of this section. The step-by-step procedures for performing these tests and the test requirements are given in Section 314-410-312.

1.08 In the event that a cable pair must be replaced for any reason (eg, due to a fault on the pair), the channel must still meet all the design requirements and the installation test requirements for the particular channel length provided.

2. MAINTENANCE

A. Routine Maintenance

2.01 No routine maintenance is required on the cable pairs utilized to implement a LADC. Test results obtained during installation should be recorded to serve as benchmarks in case of trouble conditions on the channel.

B. Trouble Conditions

2.02 Cable pair faults are not alarmed. A trouble condition will normally be detected and reported by the customer to the TELCO which will in turn investigate the trouble condition.

2.03 The basic intent of a trouble investigation should be to avoid dispatching repair people to both ends, except as a last resort. Initial trouble sectionalization to the TELCO facilities should be performed by the customer. Testing by the TELCO should then be performed to isolate and clear the trouble, if necessary.

2.04 When a legitimate trouble report is received from the customer, telephone craft employees should perform the required tests as outlined in Part 5 of this section, based on the analysis procedures in Part 4. Not all tests will be required in most cases of trouble. The analysis procedures given in Part 4 of this section should be followed to trace the most likely cause of trouble condition and the tests to be performed.

3. CHANNEL PROTECTION UNIT

3.01 When customer-provided data sets are used, the channel must be equipped with a 500Z Channel Protection Unit at each end of a wire pair. This unit provides protective circuitry, with or without dc continuity, to protect the facilities against hazardous voltage and longitudinal imbalance.

3.02 Figures 1 and 2 show the protective circuit optioned for dc and ac, respectively. The dc option is used when the data sets require dc continuity for operational or maintenance purposes. The ac option is used when dc continuity is not required.

3.03 The presence of 500Z Channel Protection Units should be taken into account during testing and trouble isolation. The losses incurred by these units are already included in the insertion loss limits specified for the channels. If a protection unit is found to be defective (eg, 76A Fuse blown by lightning or a power cross), it should be replaced with a properly optioned new unit.

4. ANALYSIS PROCEDURES

4.01 This part outlines the analysis procedures shown in Fig. 3, that should be used to isolate and clear trouble on the metallic pairs that make up a local area data channel. The detailed tests and requirements are listed in Section 314-410-312. These procedures are coordinated by the SSC.

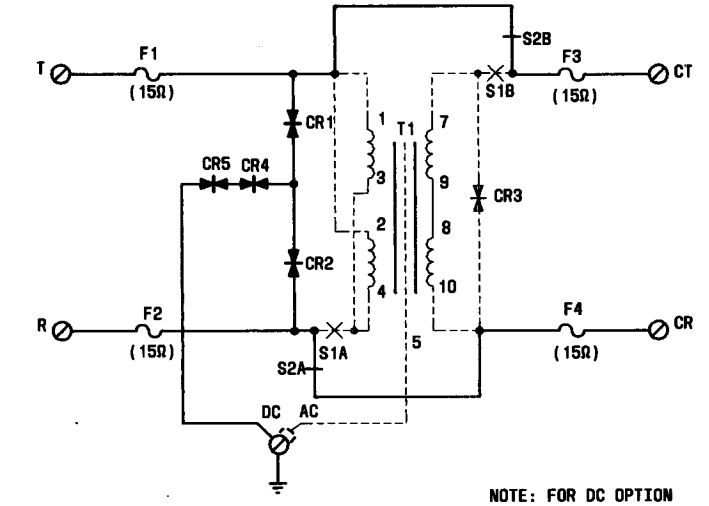

Fig. 1—DC Protective Circuit

4.02 The procedures begin when the SSC receives a trouble report from the customer. At this point the SSC should determine, from conversation with the customer, whether or not the trouble is the TELCO responsibility. Generally, the data sets used with LADCs will have some self-testing capabilities that should enable the customer to isolate the trouble to a particular data set or the metallic facilities. Customers are expected to use all of the data set testing features before reporting any trouble and should be encouraged to do so.

4.03 Following are some questions intended as a guide for the SSC when discussing a trouble with a customer. All questions are not expected to be applicable in every case.

- Describe the trouble—occasional errors, or does not work at all?
- Are data set power indicators ON, if any?
- Are data sets plugged in?
- Are data sets properly connected to the circuit?
- Have the self-testing features been exercised, if any? What was the outcome?
- How often does trouble occur?
- Any particular time of day that trouble symptoms are usually bad?
- Is trouble in one direction or both directions of transmission?
- Has this trouble been experienced before? If so, what was the outcome?
- Have changes been made to the system lately (eg, new equipment, new program, new operator, etc)?
- Any other pertinent information.

4.04 All available information collected from the customer should be analyzed to locate the

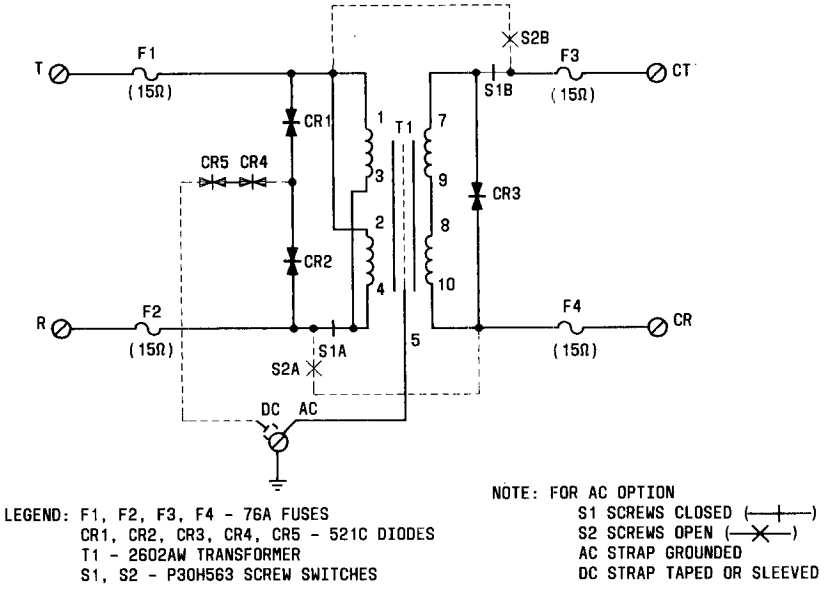

Fig. 2—AC Protective Circuit

most probable source of trouble. If results of this analysis indicate trouble in Customer Provided Equipment (CPE), the customer should be advised. If trouble is indicated in a TELCO-provided data set, the data set should be replaced in accordance with the proper practices. If channnel trouble is suspected, then the procedures outlined below apply.

4.05 The SSC should determine from the Circuit Layout Record Card (CLRC), or equivalent, whether any testing can be done from the LTD at the SCO (or from another convenient test access midpoint). If there is no test access, proceed to 4.09.

4.06 If there is test access to the circuit, the SSC should request the LTD at the SCO (or equivalent) to perform dc Tests A, B, and C, which are listed in Table A. The tests are performed toward each data set location for the purpose of trouble isolation. (If the data sets are customer-provided, they should be disconnected.) Test access from the LTD is obtained at the Main Distributing Frame (MDF) via patch cords to the LTD test trunk.

4.07 If the results of Tests A, B, and C toward both data stations meet requirements, check the cross-connections and then restore the circuit continuity. Request the customer to retest the data communications system to make certain that the trouble condition still exists before dispatching any craft employees and refer to paragraph 4.09.

4.08 If the results of Test A, B, or C fail to meet requirements, isolate the trouble and repair or replace the cable pair(s), if required. Make sure all the test requirements for the particular channel length are met before returning service to the customer.

4.09 Dispatch craft employee(s) to the data set location(s) to perform end-to-end testing. Table A lists the tests and the test equipment required. These tests are to be performed during channel installation and on trouble cases as required.

Procedures for the tests are given in Section 314-410-312.

Note: The craft employee(s) must be equipped with the test equipment listed in Table A, or equivalent. If existing data sets are TELCO-provided, spare data sets of the proper list code and with the proper options installed should also be available to the craft employee(s).

4.10 If any of the tests fail to meet requirements, isolate the trouble and repair or replace the cable pair(s), if required. Make sure all the test requirements for the particular channel length are met before returning service to the customer.

4.11 If the test results meet requirements and the data sets are CPE, return the service to the customer. If the test results meet requirements and the data sets are TELCO-provided, replace the data sets (one at a time) with properly optioned spares and perform the data set installation tests recommended in the appropriate Bell System Practices (BSPs).

4.12 If the data set installation tests are successful, the trouble has been cleared and the service can be returned to the customer. If the tests fail, request the aid of DATEC through normal lines of supervision.

5. TESTING

5.01 This part describes each test to be performed on LADCs. The procedures and requirements are given in Section 314-410-312.

5.02 The tests, which are listed in Table A, consist of dc and ac measurements performed between the two data stations with the data sets disconnected. The dc measurements may also be performed between a data station and the LTD when the channel is routed through the SCO. All of the tests listed in Table A should be performed during installation. For maintenance, they are performed as required.

Apparatus Required

5.03 The following is a list of apparatus required for performing these tests on an end-to-end basis:

- Two 6F Noise Measuring Sets (NMSs) with C-message network (497D), or equivalent
- Two Hewlett-Packard 3551A Test Sets or equivalent
- One KS-14510-L1 multimeter or equivalent
- Two 135-ohm resistors per wire pair.

5.04 The following information is required before starting the tests:

- Determine from the CLRC if the facility is 2 wire or 4 wire. If 2 wire, only the T, R leads are tested. If 4-wire, both the T, R and T1, R1 leads are tested.
- The cable pair(s) loop resistance, measured during initial installation tests and recorded on the CLRC. [If the measurement result is not available, measure the loop resistance (Test C) and record on the CLRC.]
- The end-to-end Expected Measured Loss (EML) for an initial installation, or the Actual Measured Loss (AML) if testing is performed for trouble analysis.

DC TESTS

Test A—Foreign Voltage

5.05 This test is made to check that no foreign voltage is present on the line pairs. A foreign voltage may indicate that a cable fault exists. (In some cases the foreign voltage could be caused by a data set or other source at one end of the circuit.)

5.06 The test is made between the following leads: T to R (T1 to R1); and T, R (T1, R1) to ground. There should be no significant voltage reading (less than 1 volt) between any of these leads.

Test B—Insulation Resistance

5.07 This test is made to ensure adequate isolation between conductors, and between conductors

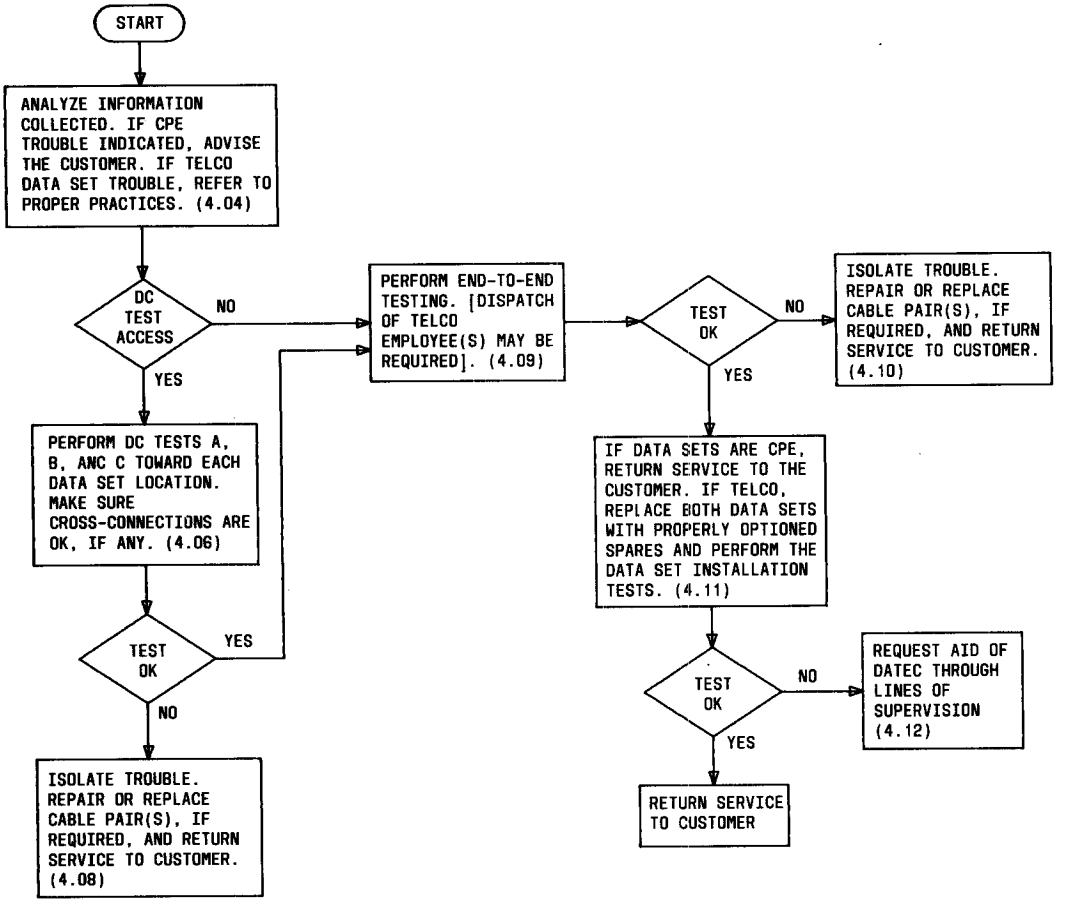

Fig. 3—Local Area Data Channels—Trouble Clearing Procedures

TABLE A

OVERALL CHANNEL TESTS

Name of Test	Test Apparatus Required	Probable Cause of Test Failure
A. Foreign Voltage	KS-14510-L1 Multimeter or LTD	Short circuit to another cable pair
B. Insulation Resistance	KS-14510-L1 Multimeter or LTD	Short or ground in cable pairs
C. Loop Resistance	KS-14510-L1 Multimeter or LTD	Open or short in cable pairs, or splicing error
D. Insertion Loss	Two HP-3551A Test Sets	Inaccurate cable records, load coils, or excessive bridged tap
E. Background Noise	Two 6F NMSs	Pair imbalance or crosstalk
F. Impulse Noise	Two 6F NMSs	Pair imbalance or crosstalk

and ground. The test measures the insulation resistance between the line leads as follows:

- T and R; R and R1
- T and T1; R and T1
- T1 and R1; T and R1
- T and GRD; R and GRD
- T1 and GRD; R1 and GRD.

Test C—Loop Resistance

5.08 The loop resistance measurement checks the dc resistance of the transmit and receive cable pairs while each is shorted at one end of the circuit. The measurement reading is taken at the other (nonshorted) end. If this is an installation test, the dc resistance for the cable pairs between the SCO and each data station (or between data stations) should be recorded on the CLRC for future reference.

5.09 If the dc measurements do not meet the requirements given in Section 314-410-312 and a faulty cable is suspected, the cable fault-locating procedures given in Section 634-310-501 can be used to locate the trouble. This procedure is normally done by the cable repair crew.

AC TESTS

Test D—Insertion Loss

5.10 The insertion loss measurement is made using a test signal at various frequencies. The test is used to check that the insertion loss specifications for the particular channel length being tested are met. It also verifies that the cable pairs and associated bridged taps are not loaded.

5.11 The HP-3551A or equivalent test sets at each end of the circuit are used to generate the test signals and to measure the level of the received signals.

5.12 If the insertion loss measurement fails to meet the test requirements as based on the EML, the problem may be due to inaccurate cable records, load coils which were not removed, or bridged taps of excessive length.

Test E—Background Noise

5.13 The background and impulse noise measurements are made on the receive side of the channel at each end of the circuit. Both the transmit and receive sides are terminated with 135-ohm resistors. The 6F NMS is connected to the receive side, with the FUNCTION switch set to the 600-OHM BRIDGING position.

5.14 Instructions for operating the 6F NMS are given in Section 103-626-100. Noise measurements can be made at any time; however, it is preferable that they be made during a peak traffic load or busy-hour period.

Test F—Impulse Noise

5.15 The impulse noise measurement is normally made after the background noise test is completed and uses the noise counter of the 6F NMS. The NMS is set to operate for a period of 15 minutes at a particular threshold value.

6. REFERENCES

6.01 The following sections can be referenced for additional information:

SECTION	TITLE
103-626-100	6F and 6FR Voiceband Noise Measuring Sets — (J94006F and J94006FR) — Description, Operation, and Maintenance
634-310-501	Locating Cable Faults With the 96A Test Set
314-410-312	Local Area Data Channels — Tests and Requirements
880-102-100	Local Area Data Channels — Engineering Guidelines

LOCAL AREA DATA CHANNELS
TESTS AND REQUIREMENTS

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1. GENERAL

1.01 This section provides the test procedures to be performed on a Local Area Data Channel (LADC) during installation and maintenance periods. These channels provide for baseband transmission of data signals between two customer terminal locations, within a serving wire center area.

1.02 Whenever this section is reissued, the reason for reissue will be listed in this paragraph.

1.03 LADC's use nonloaded metallic facilities exclusively, with limited amounts of bridged tap. The facilities may reside entirely within the customer premises or may be routed through the Serving Central Office (SCO). When the facilities are routed through the SCO, some testing may be accomplished from the Local Test Desk (LTD).

1.04 The tests covered are the following:

LTD (One Employee) Tests

Test A—Foreign Voltage: This procedure checks for foreign voltage on the cable pairs. The test may be made at a data station, the SCO, or another convenient test access midpoint.

Test B—Insulation Resistance: This test checks the resistance between the cable pairs, and between the cable pairs and ground. The test may be made at a data

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station, the SCO, or another convenient test access midpoint.

Test C—Loop Resistance: The loop resistance procedure verifies that the loop resistance of each cable pair meets the maximum DC resistance requirement for installation. For subsequent tests, this resistance value should meet the bench-mark resistance value recorded on the CLRC.

Test D—Insertion Loss: This measurement is made to verify that the channel meets the maximum insertion loss requirements for installation. This test also checks that load coils are not present on the cable pairs and associated bridged taps.

Test E—Background Noise: This test is made using the 6F Voiceband Noise Measuring Set (NMS) equipped with a 497D weighting network. This set is used to measure both, background noise and impulse noise counts. For best results, the measurement should be made during a busy-hour period in the central office.

Test F—Impulse Noise: The impulse noise test follows in sequence along with the background noise test. The same apparatus and equipment are used for making both tests.

1.05 Tests A, B, and C are DC measurements that ***must*** be performed during installation periods. These tests may be made from one of the data stations or from a convenient test access midpoint, such as the SCO. During maintenance periods the tests are performed as required.

1.06 Tests D, E, and F are AC measurements that ***must*** be performed during installation periods. These tests are made at the data stations on and end-to-end basis. During maintenance periods the tests are performed as required.

A. Testing Responsibility

1.07 Initial trouble sectionalization to the TELCO provided service should be performed by the customer. Use of any and all data set testing features by the customer should be encouraged.

B. Test Access

1.08 When a LADC is routed through the SCO, DC tests A, B, and C may be made at the LTD. Access is obtained at the Main Distributing Frame (MDF) using MDF test cords which connect to LTD test trunks. When long test trunks are used, the resistance of the test trunks must be measured and subtracted from the overall loop resistance.

1.09 A typical arrangement showing test access to a LADC routed through a SCO is shown in Fig. 1. The pair identification T, R, and T1, R1 is for 4-wire channels. However, channels are also offered on a 2-wire basis and when provided, only the T, R leads are tested.

1.10 For end-to-end testing, test access is obtained at the data station terminal block. If 500Z channel protection units are used, the AC tests D, E, and F should be performed from the customer side (CT and CR terminals). Refer to Part 4.

2. TEST EQUIPMENT

2.01 This part provides a listing of the test equipment required for testing LADCs. In many instances equivalent test equipment may be used if the suggested test equipment is not available. Some examples of equivalent test equipment are given when applicable.

A. Apparatus Required for CO Testing

2.02 The test apparatus required when testing from the SCO is entirely contained in the LTD, 14-type, or 16-type. (One portable volt-ohm-milliammeter (VOM), KS-14510-L1, or KS-16979-L1, or equivalent, if an LTD is not available.)

B. Apparatus Required for End-to-End Testing

2.03 The following apparatus is required when testing end-to-end between the two data stations:

- One KS-14510-L1 multimeter or equivalent
- Two HP-3551A test sets or equivalent
- Two 6F NMSs or equivalent, with C-message and flat weighting network 497D

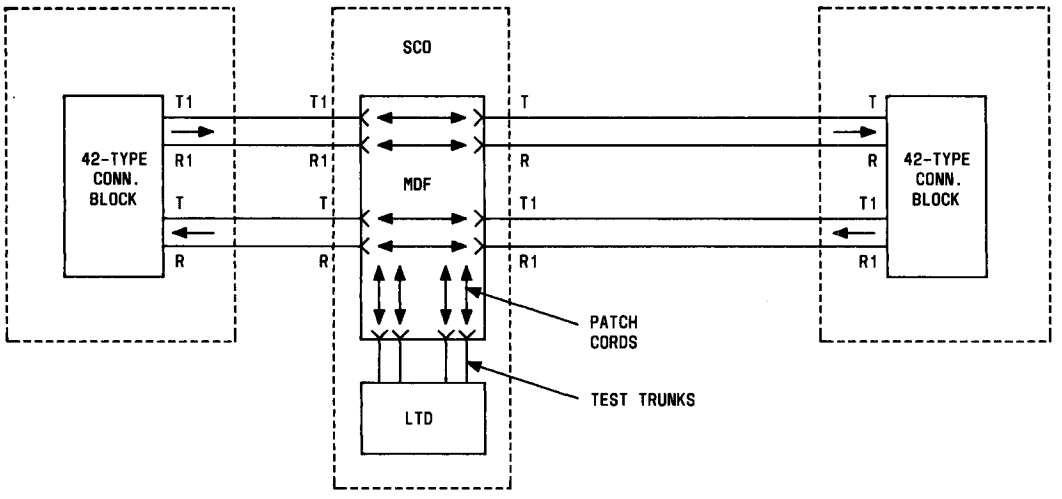


Fig. 1—Test Access to a Local Area Data Channel Routed through the Serving Central Office

- Two 135 ohm resistors, per wire pair.

3. OVERALL CHANNEL TESTS

3.01 This part provides the test procedures to be followed during installation and maintenance of LADCs. The procedures consist of DC and AC measurements performed between the two data stations, with the data sets disconnected. If any of the test requirements are not met, proceed according to instructions given in the Test Procedure or Section 314-410-311.

Required Tests

3.02 All of the tests (A through F) covered in this part ***must*** be performed during initial channel installation in the order given. Testing should be completed far enough in advance of the data sets installation, to allow time to locate and correct problems that may exist. For maintenance, perform the tests as required.

DC Tests

3.03 The following tests are performed on the cable pairs to locate foreign voltage, opens, shorts, crosses, or grounds:

Test A—Foreign Voltage
Test B—Insulation Resistance
Test C—Loop Resistance

Test A—Foreign Voltage

3.04 Test Procedure:

STEP	PROCEDURE
1	At each data station, disconnect the data set from the circuit and leave the cable pairs open-circuited.
2	At one data station, set the KS-14510-L1 meter range switch to the 60 VOLT DC scale.

STEP	PROCEDURE
3	Connect the meter to the following cable pairs and check for a voltage reading: T and R T1 and R1* T and GRD R and GRD T1 and GRD* R1 and GRD* * 4-wire channels ***Requirement:*** Voltage reading less than ±1 Vdc
4	If voltage readings meet the above requirement, proceed to the insulation resistance test procedure.
5	If a voltage reading exceeded the requirement on any wire or pair, the faulty pair must be repaired or replaced.

Test B—Insulation Resistance

3.05 Test Procedure:

STEP	PROCEDURE
1	At each data station, verify that the cable pairs are open-circuited and not shorted to each other or ground.
2	At one data station, set the KS-14510-L1 meter range switch to the OHMS by 10,000 scale and zero adjust the meter.
3	Measure insulation resistance between: T and R, R and R1* T and R1*, R and T1* T and T1*, T1 and R1* * 4-wire channels ***Requirement:*** Each insulation resistance reading must be greater than 300 Kohms.
4	Measure insulation resistance between: T and GRD R and GRD

STEP	PROCEDURE
	T1 and GRD* R1 and GRD* *4-wire channels ***Requirement:*** Each insulation resistance reading must be greater than 300 Kohms.
5	If the requirement of Steps 3 and 4 are met, proceed to the loop resistance test procedures.
6	If the requirement of Steps 3 and 4 are ***not*** met, the faulty cable pair must be repaired or replaced.

Test C—Loop Resistance

3.06 Test Procedure:

STEP	PROCEDURE
1	At one of the data stations, short the T, R pair.
2	At the other data station, set the KS-14510-L1 meter range switch to the OHMS X100 scale and zero adjust the meter.
3	Measure the resistance of the T, R loop. ***Requirement:*** The resistance reading must be less than or equal to the limit specified for the channel length provided, and the value is recorded as RL1 on the CLRC. If the test is not an installation test, then the loop resistance must equal RL1 ±20 percent. Refer to Table A for the DC loop resistance requirement.
4*	Remove the short from the T, R pair and place it across the T1, R1 pair.
5*	Measure the resistance of the T1 and R1 loop. ***Requirement:*** The resistance reading must be less than or equal to the limit specified for the channel length provided and the value is recorded as RL2 on the CLRC. If the test is not an installation test, then the loop resistance must equal RL2 ±20 percent. Refer to Table A for the DC loop resistance requirement.
6	If the requirement of Steps 3 and 5 are met, remove the short on the cable pair and proceed to the AC tests.
7	If the requirement of Steps 3 and 5 are ***not*** met, there may be a faulty cable pair. If faulty, the cable pair must be repaired or replaced.

STEP	PROCEDURE

Note: When the channel is routed through the SCO the loop resistance of each cable pair ***must*** be measured at the LTD and recorded on the CLRC for future reference. The end-to-end total DC resistance should be less than or equal to the limit specified in Table A for the channel length provided.

* 4-Wire Channels

TABLE A

DC LOOP RESISTANCE REQUIREMENTS

CHANNEL LENGTH (MILES)	MAXIMUM MEASURED DC RESISTANCE (OHMS)
1	500
2	1000
3	1500
4	2000
5	2500
6	3000

AC Tests

3.07 The following tests are performed on the channel to ensure that the insertion loss and noise requirements are met:

Test D—Insertion Loss
Test E—Background Noise
Test F—Impulse Noise

If the noise requirements cannot be met, the problem may be caused by pair imbalance. Refer this type of problem to the cable repair group.

Test D—Insertion Loss

3.08 When performed during initial installation, this test will verify that the channel meets the insertion loss requirements, and that load coils are not present on the cable pairs and associated bridged taps. The actual measured loss (AML) should be less than or equal to the insertion loss requirements given in Table B for the particular channel length being provided. The AML should be recorded on the CLRC as a bench-mark value. Insertion loss measured during a maintenance test must be within 3 db of value measured at installation; however, insertion loss must always be less than or equal to the limits specified in Table B.

3.09 This test requires two HP-3551A test sets or equivalent (one at each end).

3.10 Test Procedure:

STEP	PROCEDURE
1	After turning power ON and allowing the set to warm up for five minutes, operate the controls on each HP-3551A as follows: FUNCTION to REC TERM (blue) IMP to 135 RECEIVE to TONE NORMAL
2	Depress the DISPLAY & MONITOR SEND LEVEL pushbutton switch and set the SEND LEVEL RANGE dBm switch vernier to -10 dBm.
3	Depress the DISPLAY & MONITOR SEND FREQ pushbutton switch and set the SEND FREQUENCY RANGE switch and vernier to the applicable test frequency from Table B.
4	Connect the output terminals (black) to the transmit pair (T1, R1 for a 4-wire channel).
5	Connect the input terminals (blue) to the receive pair (T, R for a 4-wire channel).
6	Depress the DISPLAY & MONITOR RECEIVE LEVEL pushbutton switch to display the received test signal level. ***Note:*** To display the received test signal frequency, the DISPLAY & MONITOR RECEIVE FREQ pushbutton switch must be pressed in.
7	Read the received level and record the insertion loss on the CLRC or equivalent. ***Requirement:*** Refer to Table B ***Note:*** The Insertion Loss (dB) = Transmit Level (dBm) - Received Level (dBm). For example, if Transmit Level = -10 dBm and Received Level = -25 dBm, then Insertion Loss = -10 - (-25) = 15 dB.
8	Repeat Steps 3, 6, and 7 at each test frequency indicated in Table B for the particular channel length provided.
9	If test results meet requirements, disconnect test equipment from both ends and proceed to the noise measurements test procedures.
10	If test results do ***not*** meet the requirements, notify cable assignment desk and have the values of the expected measured losses (EML) checked on records.

TABLE B

INSERTION LOSS REQUIREMENTS FOR INITIAL INSTALLATION TESTS

CHANNEL LENGTH (MILES)	TEST FREQUENCY (KHz)	* MAXIMUM MEASURED LOSS (dB)
1	1.0	10.5
	2.4	12.0
	4.8	15.0
	9.6	19.0
	19.2	22.5
2	1.0	14.5
	2.4	16.5
	4.8	20.5
	9.6	27.5
	19.2	35.5
3	1.0	18.0
	2.4	21.0
	4.8	27.0
	9.6	36.5
	19.2	50.0
4	1.0	21.0
	2.4	26.0
	4.8	34.0
	9.6	46.0
5	1.0	23.5
	2.4	30.5
	4.8	39.5
	9.6	53.5
6	1.0	26.5
	2.4	33.0
	4.8	43.5
	9.6	58.5

*includes the 500Z channel protection unit losses

Test E—Background Noise

3.11 The background noise test will require two measurements: one using C-message weighting and the other using flat weighting. The desired weighting is obtained by proper orientation of the 497D weighting network when plugging it into the 6F NMS. At each end of the circuit, the following equipment or apparatus will be required:

One 6F NMS or equivalent, with C-message and flat weighting network (497D).

One 135 ohm resistor, per wire pair.

3.12 Test Procedure:

STEP	PROCEDURE
	Perform the following steps at both ends of the circuit:
1	Connect the 6F NMS and a 135 ohm resistor to the T, R pair as shown in Fig. 2.
2*	Connect the other 135 ohm resistor between the T1, R1 pair.
3	Plug in the C-message weighting network 497D on the 6F NMS and calibrate the set.
4	After calibration is complete, set the FUNCTION switch to 600 ohm/BRIDGE.
5	Adjust the DBRN dial to obtain a meter reading in the upper half of the meter scale. The background noise level is the sum of the DBRN dial setting and the meter reading. ***Requirement:*** Less than or equal to 11 dBrnC
6	Reposition the 497D network for flat weighted measurements, calibrate the set, and make sure the FUNCTION switch is set to 600 ohm/BRIDGE.
7	Adjust the DBRN dial to obtain a meter reading in the upper half of the meter scale. The background noise level is the sum of the DBRN dial setting and the meter reading. ***Requirement:*** Less than or equal to 28 dBrn
8	If BOTH background noise requirements are met, proceed to the impulse noise test procedures.
9	If any background noise requirement is ***not*** met, begin trouble repair work on the cable pair or request a new pair assignment.

* 4-wire channels

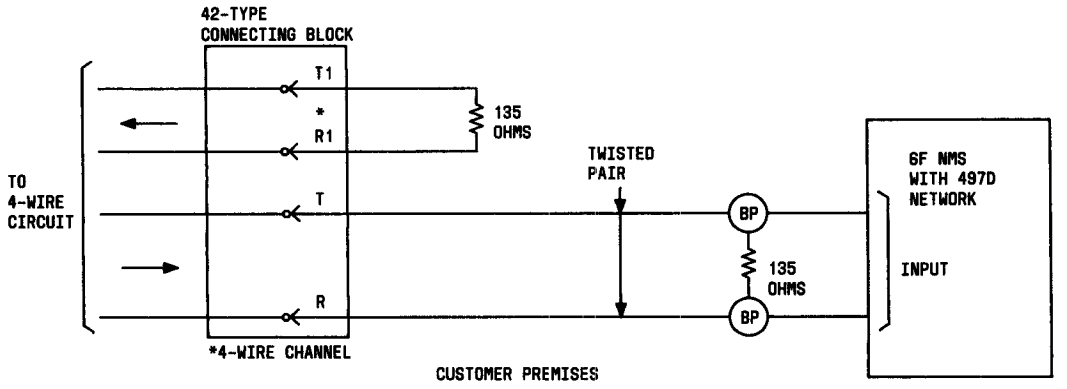


Fig. 2—Test Connection for Noise Measurements

Test F—Impulse Noise

3.13 Test Procedure:

STEP	PROCEDURE
1	Verify that the equipment is connected for flat weighted measurements, as given in Steps 1, 2, and 6 of 3.12.
	At both locations
2	Adjust the 6F NMS for an impulse noise threshold of 44 dBrn.
3	Reset the counter to 00 and make a 15 minute run. At the end of this time, read the total number of counts recorded on the counter.
	Requirement: Less than or equal to 15 counts/15 minute.
4	If the impulse noise requirement is met, disconnect all test equipment and test leads from the circuit.
5	Remove the 135 ohm resistors from the station terminal block.

STEP	PROCEDURE
6	If the impulse noise requirement is ***not*** met, request a new pair assignment.

3.14 If all the test requirements in part 3 are met, the channel should be suitable for service.

4. CHANNEL PROTECTION UNIT

4.01 This part contains descriptive information and procedures required for installing and maintaining the 500Z Channel Protection Unit (CPU) (Fig. 3), which is required at each end of a wire pair when customer provided data sets are used. ***Use of this unit does not negate the need for standard station protection as described in Section 460-100-400.***

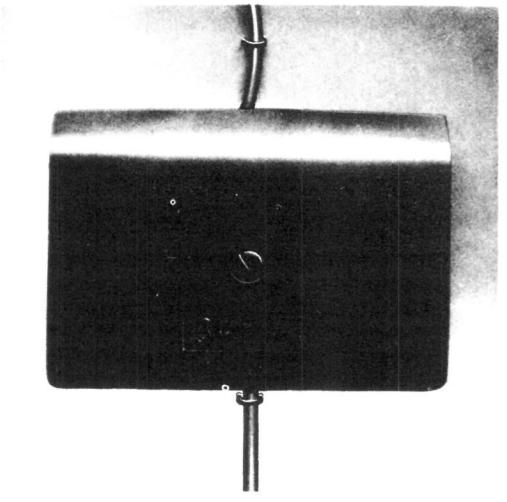


Fig. 3—Typical Installation of a 500Z Channel Protection Unit

A. Description

4.02 The 500Z CPU is a passive device designed to protect the facilities against hazardous voltage and longitudinal imbalance. The CPU provides a 2-wire interface between the data set and the telephone line. Where a 4-wire interface is required, two 500Z CPUs must be used.

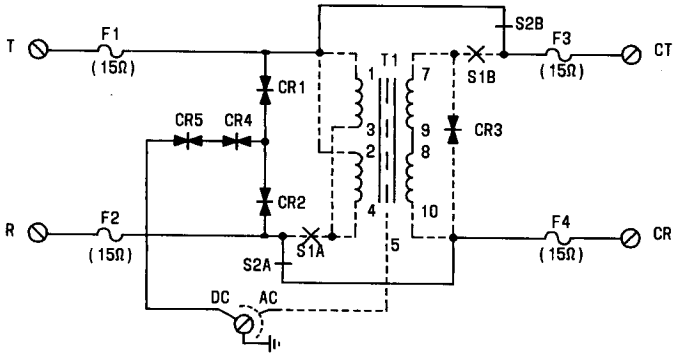
4.03 Figures 4 and 5 show the CPU protective circuit optioned for DC and AC, respectively. The DC option is used when the data sets require DC continuity for operational of maintenance purposes. The AC option is used when DC continuity is not required. One of the two options must be installed prior to placing the channel in service. The option to be installed should be specified on the service order.

4.04 The CPU protective circuit consists of an Isolation Transformer (T1), fuses F1 through F4, diodes CR1 through CR5, and screw switches S1 and S2. Each screw switch provides two screws (designated A and B) to be used for installing the DC or AC option in accordance with the procedures listed in 4.09.

4.05 The 500Z CPU, when assembled, is 4 inches long, 2.75 inches wide, 1.6 inches high, and weighs about 7 ounces. The CPU consists of a metal baseplate, a light gray plastic cover with center captive screw, and a printed wiring board (PWB). Two keyhole slots are provided in the baseplate for mounting the unit to a wall, a standard conduit box, or other flat surface. The light gray plastic cover of the CPU is made of flame retardant plastic and should not be intercharged with other covers (ivory or light olive gray) which may not have flame retardant characteristics.

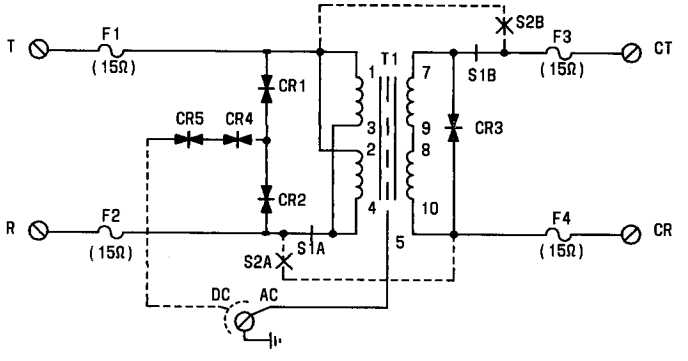
4.06 Two screw terminals (size No. 4 screws) are provided on the component side of the PWB for connecting the telephone line, and two screw terminals (size No. 4 screws) are provided on the printed wiring side of the PWB for connecting the station line. In addition, a third screw terminal is provided on the component side of the PWB for connecting the DC or AC grounding strap to a ground line.

4.07 The PWB can be inserted in the baseplate by placing one of the keying notches in the



NOTE: FOR DC OPTION-
S2 SCREWS CLOSED (—|—)
S1 SCREWS OPEN (—✕—)
DC STRAP GROUNDED
AC STRAP TAPED OR SLEEVED

Fig. 4—DC Protective Circuit



NOTE: FOR AC OPTION-
S1 SCREWS CLOSED (—|—)
S2 SCREWS OPEN (—✕—)
AC STRAP GROUNDED
DC STRAP TAPED OR SLEEVED

Fig. 5—AC Protective Circuit

PWB in the proper keying tab on the baseplate while pulling out on the other tab permitting the PWB to be snapped into place. The process is reversed for removing the PWB. The PWB is installed in the baseplate with only the customer tip (CT) and customer ring (CR) terminals accessible with cover removed. However, the PWB can be ***temporarily*** inserted in the baseplate with the tip (T) and ring (R) terminals accessible during installation and maintenance.

B. Installation

4.08 The installation of the 500Z CPU should comply with general practices to ensure orderly station arrangement and should be located in the vicinity of the station equipment.

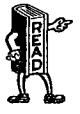
(1) All installation connections and tests must be performed prior to connecting station equipment to the CPU.

(2) The loss and noise measurements must be performed with the CPU in place and properly optioned.

4.09 Install the 500Z CPU as follows:

(1) On the CPU, loosen the captive screw located in the center of the plastic cover and remove the cover. (Do not remove screw from cover which is to be reused on same unit.)

(2) Remove the PWB from the baseplate by pressing outward on one of the two metal tabs of the baseplate.



Do not remove the foam insulator from the PWB. This insulator is provided to prevent contact with the telephone line printed wiring circuits.

(3) Position the baseplate against the mounting surface at the correct location for the CPU. Secure the baseplate in place with two screws through the two keyhole slots provided.

(4) Temporarily insert the PWB in the baseplate with the T and R terminals and the S1 and S2 screw switches accessible.

(5) Install the DC or AC option specified on the service order (CPU is shipped with the AC option installed).

(a) For DC option:

- Tighten (clockwise) both screws in switch S2 on the PWB until contact is made.
- Loosen (counter clockwise) both screws in switch S1 by one complete turn.
- Connect the DC strap to the ground screw terminal.
- Insulate the AC strap with electrical tape or sleeving to prevent electrical contact with other components.

(b) For AC option:

- Tighten (clockwise) both screws in switch S1 on the PWB until contact is made.
- Loosen (counter clockwise) both screws in switch S2 by one complete turn.
- Connect the AC strap to the ground screw terminal.
- Insulate the DC strap with electrical tape or sleeving to prevent electrical contact with other components.

(6) Using an ohmmeter, ensure that the proper option is installed. A reading of approximately 30 ohms between the T and CT terminals, and between the R and CR terminals, indicates that the DC option is being used. No DC continuity should be observed between the same terminals when the AC option is used.

(7) Leaving enough wire length for the PWB to be repositioned so that the CT and CR terminals are accessible, connect the T and R leads from the telephone line to the T and R terminals on the PWB and a ground lead to the ground terminal (located next to the R terminal on the PWB). Standard station wire connected to a station protector ground terminal can be used for the ground lead. When a station protector not present, refer to Section 460-100-400 Table D, to determine another acceptable grounding point.

(8) Perform the required insertion loss and noise tests at the customer interface (CT and CR terminals of the PWB), in accordance with proper procedures.

(9) After completion of testing, reposition the PWB in the baseplate so that the CT and CR terminal screws are accessible. Do not connect the customer interface leads to the CPU unless requested by and under the direction of the customer.

(10) Install the plastic cover on the CPU and secure the cover in place with the screw provided.

C. Maintenance

4.10 The following maintenance information is provided to assist the TELCO employee during maintenance visits to a station using a 500Z CPU. In all cases, the station equipment line must be disconnected in order to make tests and/or replace a defective CPU. The following precautions must be taken.

(1) Obtain permission from the customer before disconnecting the customer interface leads.

(2) Where possible, it is recommended that the power on the station equipment be turned OFF before the CT and CR leads are disconnected.

(3) After all testing is completed, make sure that the customer interface leads are reconnected properly.

4.11 Maintenance of a 500Z CPU station at the customer premises is limited to local testing, testing with serving or test offices, or replacing a defective unit.

Note: Do not attempt individual component repair or replacement on the PWB.

4.12 When a CPU is found to be defective (eg, 76A fuse blown by lightning or power cross) a properly optioned new unit should be installed.

4.13 If replacing the CPU does not correct the problem, perform a visual inspection and make sure that the applicable AC or DC option is properly installed. Correct any trouble found during the inspection.

5. REFERENCES

5.01 The following sections can be referenced for additional information:

SECTION	TITLE
100-520-101	KS-14510 Meter (Portable Volt-Ohm-Milliammeter) — Description and Operation
103-626-100	6F and 6FR Voiceband Noise Measuring Sets—(J94006F and J94006FR)—Description, Operation, and Maintenance
310-410-311	Local Area Data Channels—Maintenance Procedures
460-100-400	Station Protection and Grounds
634-310-501	Locating Cable Faults with the 96A Test Set
880-102-100	Local Area Data Channels—Engineering Guidelines

PART VI

OTHER DATA SERVICES

"DATAPHONE®" SELECT-A-STATION SERVICE

OVERALL SYSTEM DESCRIPTION

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1. GENERAL

1.01 This section covers the overall system description of the DATAPHONE® Select-A-Station service. This service provides for a private line, data only, multistation network over voice bandwidth channels. The descriptive information in this section includes the various equipment and circuit configurations that are used in providing this service.

1.02 Whenever this section is reissued, the reason for reissue will be given in this paragraph.

1.03 DATAPHONE Select-A-Station service is intended for applications where a master station communicates with a number of remote stations one at a time and usually in rapid sequence. Point-to-point connections are set up between the master station and each remote station to allow the exchange of voice bandwidth data. A dc continuity connection between the master and remote stations cannot be furnished. Broadcast polling (simultaneous transmission from the master station to all remote stations) is also not provided.

1.04 Transmission between the master station and a remote station can be either duplex or half-duplex. However, when half-duplex transmission is used on a 2-wire local loop, echo and return loss must be considered. When separate bands (within the same voiceband) are used for each direction of transmission, these parameters are not considered.

1.05 An 833A data station at the master station contains selector control units (SCUs) that provide control signals and other functions to one or more data station selectors (DSSs) located in central offices. This signaling is accomplished either by frequency division of the voiceband channel or

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by a combination of frequency and time division multiplexing. Control signaling to the DSS can only be accomplished from the master station. Control signaling is in band and does not require a separately ordered channel from the master station to the central office.

1.06 This service differs from existing private line multipoint circuits in the following areas.

- Solid-state equipment is used to effect connections to remote stations in place of a resistive bridge.
- Remote stations are completely independent of each other.
- The transmission levels and parameter limits are modified from existing multipoint private line services.
- The maintenance considerations are simplified due to improved equipment design and station segregation.

1.07 A glossary of the most commonly encountered terms and acronyms relating to DATAPHONE Select-A-Station service is given in Part 10 of this section.

2. FUNCTIONAL DESCRIPTION

2.01 Figure 1 shows the overall circuit arrangement of a DATAPHONE Select-A-Station system. The data transmission connections between the customer master station and the remote stations are made by DSSs in central offices. An 833A data station containing SCUs (one for each multistation circuit) is located at the customer master station. A group of dc interface leads between the SCU and the customer equipment provide control over the operation of the DSSs to various degrees, depending upon the service offering and DSS options used. Refer to 2.04 for more information on service offerings and options. The SCU transmits the required control signaling to DSSs in response to the dc control voltages from the customer equipment. The SCU then receives supervisory signaling from DSSs and provides this to the customer equipment as a dc control voltage. Detailed information on the dc interface leads is given in Section 598-083-105.

2.02 The customer has full responsibility for the overall communication of data once the connection to a particular remote station is made. The customer provides the terminal equipment at both the master and remote stations, dependent upon application requirements. The voiceband data transmission allowed over the end-to-end channel can be any form providing it will perform properly in the presence of the various channel parameter limits given in Part 4 of this section.

2.03 One part of the end-to-end channel consists of 4-wire facilities from the SCU at the master station to the primary DSS at the central office. This part of the channel facility is referred to as a primary link. The channel connection between the primary DSS and other DSSs (secondaries) are also 4-wire facilities and are referred to as secondary links. The facility connection from a DSS to a remote station can be either 2-wire or 4-wire, depending upon the type of remote termination. Normally, 2-wire facilities will be terminated in 150A channel service units (CSUs) while 4-wire facilities will terminate in data auxiliary set (DAS) 829-type. The customer-provided equipment connected to the 4-wire termination at the master station must be a valid 4-wire modem (no hybrids) in customer-provided equipment (CPE) to ensure proper operation of the circuit.

A. Types of Service Offerings

2.04 A total of two service offerings and five DSS options can be selected by the customer to accommodate customer operating procedures and system structure. These service offerings and DSS options are as follows:

(a) Sequential offering

- Automatic step DSS option
- Automatic step DSS option with reset
- Controlled step DSS option.

(b) Addressable offering

- Single address DSS option
- Double address (error control) DSS option.

Note: Both service offerings and all DSS options have the advantage that no remote station can control the operation of the DSSs.

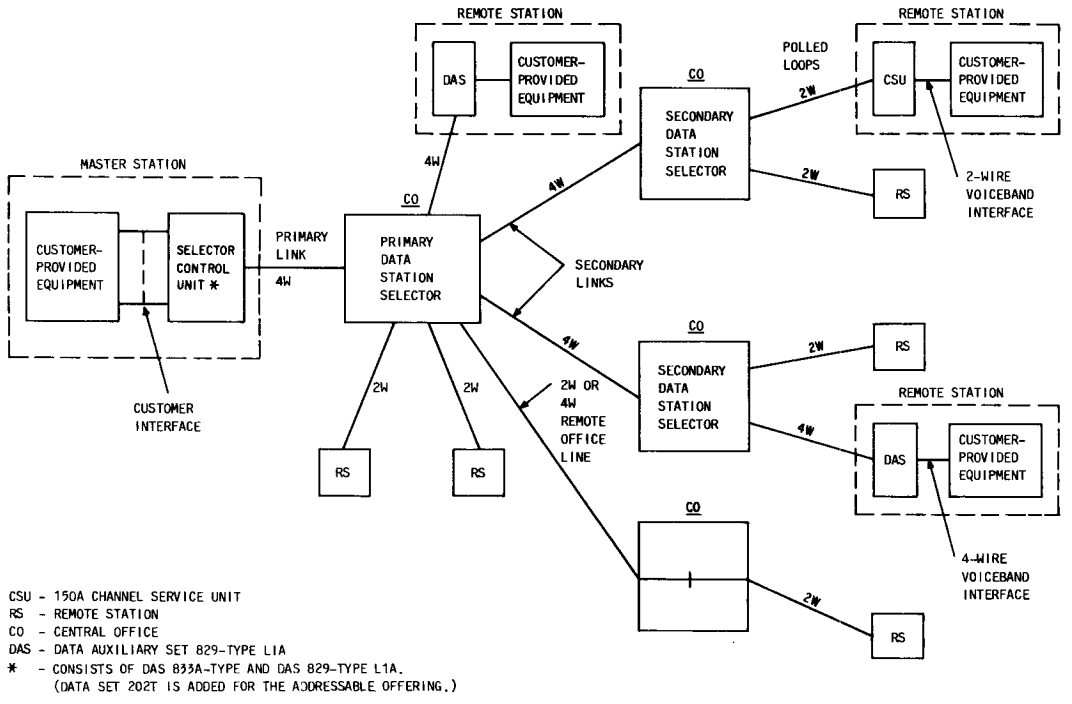

Fig. 1—DATAPHONE Select-A-Station Service—Overall Block Diagram

This provides maximum security of the system from outside interference.

The above service offerings and DSS options allow five types of operation. A summary of the features of each type of operation is given in 2.05 through 2.23.

B. Sequential Service Operation

2.05 A functional block diagram of the sequential service is shown in Fig. 2. The DSS operation is described first, followed by a description of how the master station works with the DSS.

2.06 The DSS works automatically in the automatic step and automatic step with reset options. The digital control circuit (RL4 circuit pack [CP]) generates an address and activates the port card. The RL4 CP also activates the analog control circuit (RL5 CP) which sends a signal to port zero. Port zero remains connected for a fixed time (20 milliseconds [ms] to 10.24 seconds) so the remote station can return the signal. The digital control circuit (DCC) then generates the next address, and RL5 CP sends a signal to the next port (port 1). This process continues in sequence until the end of the cycle (a maximum of 128 ports). After the last port connection is dropped, there is a quiet (no signal) period lasting one-half the port connection time. The DCC then generates a frame tone lasting one and one-half times the port connection time. This frame tone is sent to the SCU to notify the master station that a new cycle is beginning. The detection time is about 24 ms. The SCU, which consists of DAS 833A-L1B and DAS 829-type L1A, detects the frame tone and passes it to the CPE as a dc voltage.

Automatic Step DSS Option

2.07 The automatic step DSS option of the sequential offering is designed for customers whose order of connections is fixed, whose message is

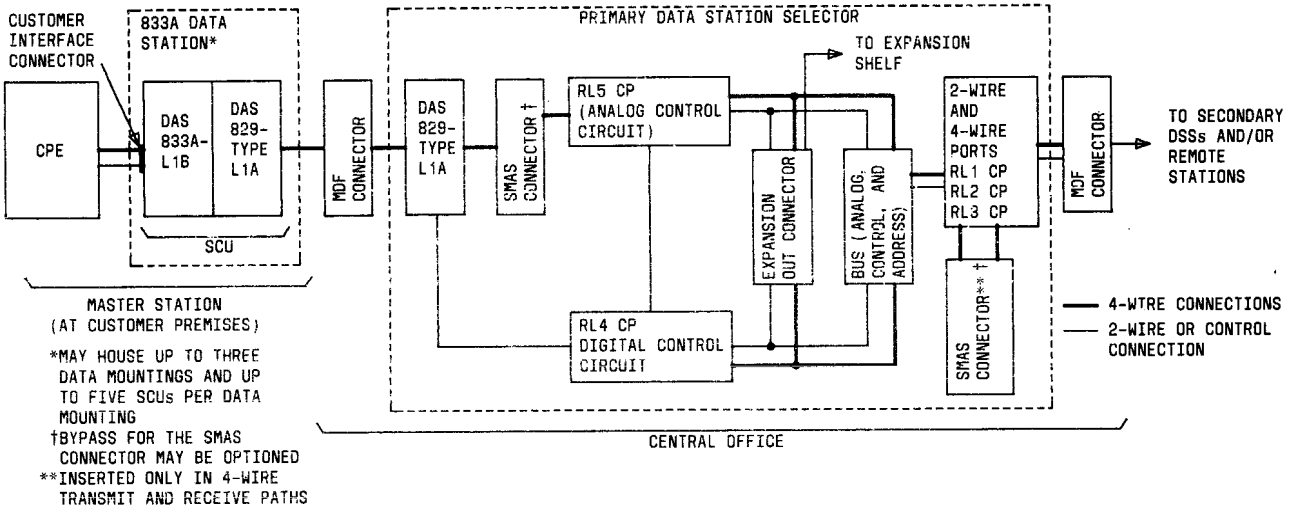

Fig. 2—Functional Block Diagram of Sequential Service Offering

fixed, and who have the capability to time the connections. In this type of operation the access or connection time is set at installation of the DSS by customer specification. The time period can be set from 20 ms to 10.24 seconds in 51 discrete steps. The number of ports-per-cycle is set at installation for each DSS by means of DSS option switches. This port assignment is made in steps of 8 ports up to 128 ports. No in-service control is provided over the operation of the DSS.

2.08 In order to operate properly, the master station must know when each response begins and which remote station the response comes from. The frame signal is provided to synchronize the master station with the DSS. This signal appears over a dc interface lead (after the 24 ms detection time) and on the customer end-to-end receive pair at the master station. A quiet interval is provided prior to the frame signal to ensure that an unwanted signal from a remote station is not timed and interpreted as a valid frame signal.

2.09 A DSS optioned for automatic step is not recommended for use as a primary DSS in a tandem DSS arrangement since in-service control of the connection time is not available. Connection time control is needed to tandem since a primary DSS output port connecting to a secondary DSS must be held much longer than for a single remote station. A DSS optioned for automatic step can be used as a primary in a nontandem circuit. It can also be used as a secondary DSS in a tandem circuit.

Automatic Step DSS Option With Reset

2.10 The type of operation available with this DSS option has the same features and restrictions as the automatic step DSS option plus a reset feature. In response to a command from the CPE, the SCU generates a control signal. The duration of the control signal must be 10 ms. This causes the DSS to disconnect from the port and begin the cycle again with the quiet period. Thus, the cycle can be reset at any time and as often as necessary, but will always begin with port zero.

2.11 This DSS option can be selected by the customer to provide a means for rapid resynchronization of priority connections to stations at the beginning of the cycle. The stations can be assigned so that the priority stations are at the beginning of the connection cycle and can be connected more often by resetting at the proper point. The reset function can also be used for rapid resynchronization in case time or station identification is lost during some point in the polling cycle.

2.12 These two types of automatic step operation are the least flexible of the various types of operation in that the time duration of each connection is fixed at the DSS. The DSS steps (switches) automatically to the next station in sequence at the end of the fixed connection time. It is expected that the message length from each remote station be reasonably constant to make efficient use of these DSS options.

Controlled Step DSS Option

2.13 This option allows the customer to control the connection time to a port and allows a highly practical tandem arrangement of data station selectors. The connection time is not preassigned, which permits the customer to vary the connection time to any remote station as needed. The SCU generates a primary and/or secondary control signal to signal the DSS to step to the next port. A primary DSS will step after receiving a 10 ms primary control signal and a secondary DSS will step after receiving a 10 ms secondary control signal. These distinct control signals ensure that the primary DSS can be held on the port that connects to the secondary DSS, while secondary control signals are sent to control the operation of the secondary DSS. The minimum connection time for any port in the controlled step option is 20 ms. The control signal must be 10 ms in duration and the customer must wait an additional 10 ms before another control signal can be sent to avoid false operation. Customer end-to-end data may be transmitted during this interval. In a tandem arrangement, the primary DSS can be controlled to step through the rest of its ports after a secondary cycle is completed.

2.14 The frame signal is sent for the equivalent of two port steps. This signal appears at the beginning of each cycle of each associated DSS. To obtain a valid frame indication, two control signal transmissions are necessary. One control signal is sent to obtain the frame signal. The frame signal must then continue after the second control signal is sent. This indicates a valid frame to the customer, and the next control signal steps the DSS to port zero.

2.15 As mentioned previously in the automatic step operation, the customer specifies at the time of initial installation (or when service is changed) the number and the ordering of output ports that each DSS will cycle through. Each DSS can cycle through any multiple of eight ports up to a maximum of 128 ports.

C. Addressable Service Operation

2.16 This service offering allows the customer to vary both the message time and the order of station connections on an in-service basis. A DSS set up for addressable service may be used as a primary or secondary DSS in a tandem arrangement.

> *Note:* Instruction(s) or code words will be referred to generally as addresses. These addresses should not be confused with specific port addresses.

2.17 Figure 3 shows a functional diagram of the addressable service. A connection is dropped by the DSS when a control signal is received from the SCU (at the master station). RL8 CP (which replaces RL4 CP in this service) generates an acknowledgement signal which is sent back to the SCU. The address digital control circuit, RL9 CP, turns on the address receiver in data set 202T to accept instructions (addresses) from the SCU. After receiving a valid instruction, the DSS stops sending the acknowledgement signal and shuts off the address receiver. According to the instructions, RL8 CP either implements a DSS function or instructs RL5 CP to set up a connection to a port. The DSS will stay connected to a port until another control signal is sent by the master station.

Address Error Control

2.18 Errors in an address received by the DSS are detected by a parity check comparison circuit that is part of RL9 CP. When an error is detected, the DSS will inhibit the connection to a port and continue to send the acknowledgement tone to the SCU. The customer equipment must recognize this condition and cause the SCU to send a control signal followed by the valid address. The DSS will also detect some customer-generated errors. For example, if the instruction following the address of port 125 exceeds the optional number of ports-per-cycle, an error will be detected.

Special Functions

2.19 Three addressable ports on each DSS are reserved for special functions. Port 125, when addressed, causes the DSS to go into a sequential mode. Port 126 is used for special control functions that are discussed in 2.21. Port 127 connects a 1-kHz test tone. Therefore, in the addressable service offering only ports 0 through 124 on each DSS are available for assignment to a remote station. In a primary DSS, these ports are available to assign to remote stations or secondary DSSs.

> *Note:* Each of the special control functions is ended by the DSS when it receives a control signal.

2.20 The sequential mode of the addressable offering is provided so that a number of stations can be connected in a fixed order without the need to send specific port addresses. This allows a reduction in overhead time that would otherwise be needed for addressing. In the sequential mode the operation of the DSS is similar to that of the automatic step option of the sequential service. Port 125 address followed by the address of the port where the sequence starts is sent by the master station. Then the DSS stops sending the acknowledgement tone and begins stepping through the ports automatically, starting at the port designated by the address. If no control signal is received, the DSS will continue stepping through the ports until the end of the cycle. At the end of the cycle, the DSS connects immediately to port zero and begins the sequence again. No frame indication is provided. The cycle can be resynchronized at any time by sending a control signal followed by port 125 address and the starting port address. The port connection time and the number of ports-per-cycle are set as described in 2.07. However, the maximum number of ports is limited to 125 in the sequential mode. The last setting adds only 5 ports over 120 instead of 8 ports. The DSS will not cycle automatically through the special function ports 125 to 127. If secondary DSSs are in the system arrangement, they should be connected to ports that are not in the primary sequential mode cycle. Ports that connect to secondary DSSs may need to be held for longer periods of time. Ports 120 to 124 should be reserved for secondary DSSs since it is most convenient to exclude these from the sequential mode cycle. If more than five secondary DSSs are in the system,

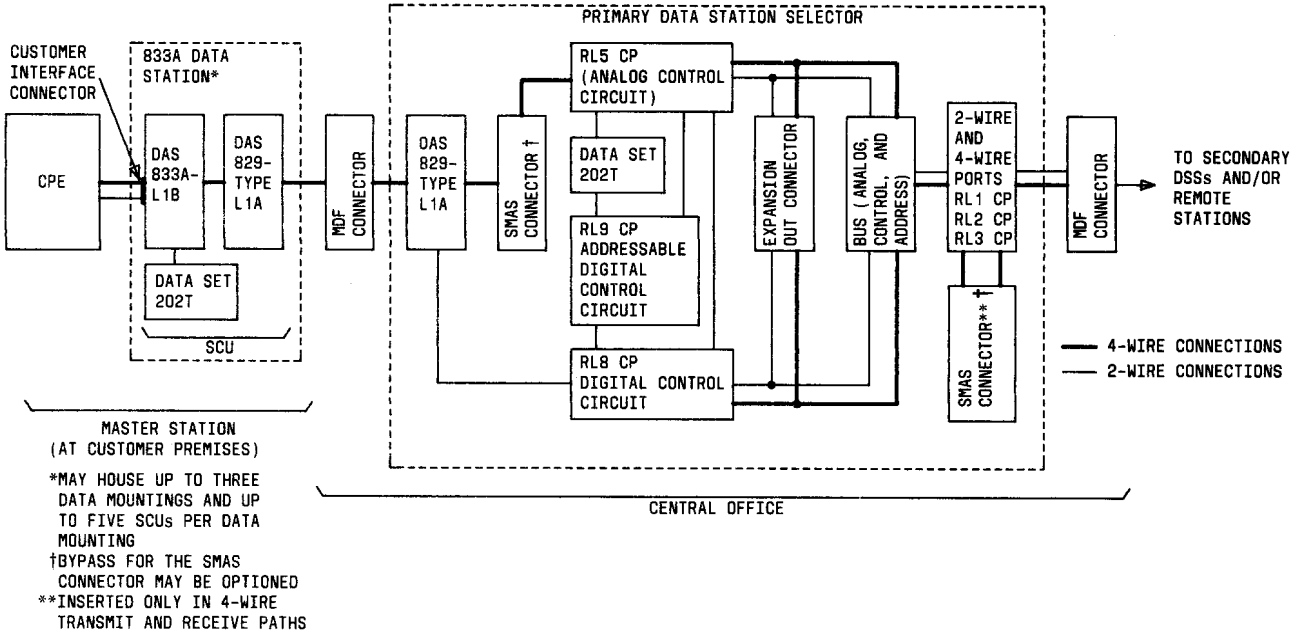

Fig. 3—Functional Block Diagram of Addressable Service Offering

the appropriate number of ports in groups of 8 should be reserved for the secondary DSS.

2.21 Port 126 is used to activate two special control functions. These are as follows:

- The digital loopback command instruction
- The report DSS status command instruction.

To activate the digital function, the SCU sends the port 126 address followed by the digital loopback command instruction. The data receive and data transmit leads of the data set 202T in the DSS are then connected together so the circuit loops back toward the SCU. A data check can then be made of the data set 202T and the transmission performance of the channel. To activate the report DSS status function, the SCU sends the port 126 address followed by the report DSS status command instruction. The DSS then sends back two code words (addresses). The first word indicates the port connection time for the sequential mode. The second word indicates the number of ports-per-cycle for the sequential mode.

> ***Note:*** The command instruction words were chosen so as to minimize the possibility of mistaking one word for the other.

2.22 Address 127 causes the DSS to transmit a continuous 1-kHz test tone to the SCU. The 1-kHz tone provides a check that the DSS is operating properly on a single address. An error is more likely to occur in transmitting the port 127 address than any other address. If the error is not detected or inhibited by the DSS, false reception of the test tone is least likely to interrupt service.

Options

2.23 If a more powerful error detection scheme is desired than that described in 2.18, the double address error control option may be requested by the customer. This DSS option requires that each address be sent twice in order to activate the DSS. The two addresses must be identical to each other or an error will be detected. If two different addresses are used (such as the special functions), the first address must be sent twice in sequence and the second address must be sent twice in sequence.

3. EQUIPMENT CHARACTERISTICS

3.01 This part covers the characteristics and features of the major equipment components of DATAPHONE Select-A-Station service. These include an 833A data station containing an SCU for each circuit, a DSS, and a 150A CSU or DAS 829-type L1A. The engineering rules and design of the primary and secondary links are described in Section 880-480-010.

833A Data Station

3.02 Each SCU provides for connection control of a single circuit consisting of a primary DSS and possibly some secondary DSSs. The SCU is physically designed for mounting in a multiple arrangement since the customer master station generally requires a number of these circuits.

3.03 An 833A data station consists of one or more 56A1 data mountings, each housing a dual power supply, tone oscillator, and up to 5 SCUs. The SCU consists of a DAS 833A-L1B and a DAS 829-type L1A which are plug-in modules for the sequential service. To provide the addressable service, a data set 202T must be added to the SCU. DAS 829-type L1A is used to provide a standard 4-wire termination to the channel while DAS 833A-L1B contains a customer interface connector, tone detectors, and control logic circuits. The data set 202T contains the modulation and demodulation circuits that are required for addressable operation.

3.04 One of the five SCUs can be used as a spare. This spare SCU may be shared among several data mountings provided the data mountings are housed directly above or below one another. This will allow the short interconnecting cables to be used.

DAS 829-Type L1A

3.05 DAS 829-type L1A provides a 4-wire channel termination, hazardous voltage protection, longitudinal balance protection, channel equal-level loopback (manual control only in the 833A data station), level adjustment in the transmit and receive paths, and amplitude equalization.

3.06 The DAS 829-type L1A is available in three basic codes, depending upon the local facilities to which it connects. The three DAS types for

DATAPHONE Select-A-Station service are coded DAS 829A-L1A, 829B-L1A, and 829C-L1A. The rules for selecting the proper DAS are given in Section 598-082-100.

3.07 Each DAS-type L1A consists of component apparatus mounted on a printed wiring board (PWB) that plugs into the 56A1 data mounting. The front face of the PWB contains jacks (and accepts a standard 310 plug) for testing and monitoring the transmit and receive circuits. DAS 829B-L1A and DAS 829C-L1A also have a receive input jack for adjusting the receive level.

3.08 The DAS 829-type L1A, while similar in appearance to existing DAS 829s, has several circuit changes. These changes are as follows:

(a) A loopback (LB) indicator light emitting diode (LED) is added to the front panel providing a means to verify that loopback has occurred.

(b) Power can be supplied from either a -48 Vdc or a 24 Vac supply. An option strap arrangement is added to select the type supply unit.*

*The stamped designation of -48V or N (for normal) indicates the applicable option to be used.

(c) The tone activated loopback circuit can be disabled by strapping pin 40 to pin 31 on the backplane wiring. When not strapped, the tone loopback circuit is enabled.

(d) An option strap arrangement is added to select a gain of either 8 or 16 dB in the loopback path. When used in the 833A data station, the 16-dB option should be used.

(e) Access provided by the TRANS MON jack is moved to the drop side of the transmit pair. The TRANS MON jack is now wired directly to the DT1 and DR1 terminals.

Note: The DAS 829-type L1 (MD) must not be used in this service since they do not provide the additional features noted above.

DAS 833A-L1B

3.09 Each SCU includes a DAS 833A-L1B which contains control logic circuits, tone detectors, a customer interface connector, and several switches and indicator lamps to control and indicate maintenance functions. The control logic circuit places the SCU in the end-to-end or signaling states based upon the control voltages on the dc interface leads. The tone detector detects the primary and secondary frame signals to verify proper connection operation at the DSS.

3.10 The customer interface connector is a 25-pin connector providing customer access to the end-to-end voiceband channel and the dc interface leads. This connector is the point of connection between the SCU and the customer data terminal. A customer-provided interface cable is required for each SCU in the data station arrangement. This cable must not exceed 50 feet in length.

Data Set 202T

3.11 Data set 202T is a transmitter receiver for the address information sent between the DSS and the master station. Frequency-shift-keying modulation is used to send and receive the information. The faceplate of the plug-in module has six indicator lamps and three switches. The indicator lamps monitor test functions. The three test switches implement the analog loopback, local self-test, and remote test functions.

Data Station Selector (DSS) J70180AA

3.12 The DSSs are located in telephone central offices and each connects the customer master station to one of a number of 2- or 4-wire ports. The basic function of the DSS is to break a connection between the primary link and one output port and connect it to another output port. For the automatic step DSS option of the sequential offering, the connection is controlled by an internal timer in the DSS. For the controlled step DSS option of the sequential offering, the connection is controlled by a signal from the SCU. In both types of operation, the DSS transmits frame signals to the master station at the beginning of the polling (switching) cycle. In the addressable service, the connection is controlled by a signal from the master station. No frame signal is provided. Instead, an acknowledgement signal is sent by the DSS after receiving the control signal. This enables the customer station equipment to recognize the fact that the DSS is ready to accept an address.

3.13 The DSS provides a 4-wire channel termination at its input and a 2- or 4-wire channel termination at the output ports. The termination at the input is provided by a DAS 829-type L1A. The 4-wire termination at the output is provided by a single circuit pack (RL2 or RL3) which contains transmission circuitry similar to DAS 829-L1A but without the tone activated equal level loopback feature. This feature is not provided because testing will be carried out from the primary link toward the primary and secondary DSSs. Also, it is not desirable to remove the DSS from service by placing a loopback tone on the channel from a remote station since this affects the security of the service. Equal level loopback of secondary links can be accomplished at a primary DSS 4-wire output using manual patching through an amplifier that is part of the optional verify circuit pack (RL7).

3.14 The DSSs can be arranged in several ways in the central office. The basic DSS consists of a dual-shelf assembly for housing common and port plug-in units. The common equipment consists of a DAS 829-type L1A at the input, an analog control circuit pack RL5, a digital control circuit pack (RL4 for sequential, RL8 for addressable), and a power supply RG3. The DSS line equipment consists of the 2-wire RL1 and 4-wire port circuit packs (RL2 or RL3). A verify circuit pack (RL7), is also available as a maintenance aid. This unit can be shared among several DSS assemblies by plugging into the appropriate DSS or one can be supplied for each DSS assembly.

3.15 The 2-wire port circuit pack serves up to four 2-wire output ports, while the 4-wire port circuit pack serves only one 4-wire output port. A fully equipped DSS 2-shelf start-up arrangement can serve eighty-four 2-wire ports or twenty-one 4-wire ports or various combinations. Physically, a 4-wire port circuit pack displaces one 2-wire port circuit pack which contains four 2-wire output ports. Additional DSS assemblies can be added to the "start-up" DSS. One shelf of an additional (growth) DSS assembly can increase the total capacity to one-hundred and twenty-eight 2-wire ports. The full additional DSS assembly can also be used to increase the total capacity to forty-three 4-wire ports or various combinations of 4- and 2-wire ports. Further additions of DSS assemblies can be made to increase the number of 4-wire ports in increments of 22 to a total of 128 ports. An expansion control circuit (ECC) pack (RL6) is required when using the additional DSS assembly.

3.16 The 4-wire port circuit pack is used to connect a primary DSS (a DSS connected to the master station) to a secondary DSS. The 4-wire port circuit pack is also used from a DSS to a 2-wire remote station where 4-wire interoffice facilities are used. It is also used to connect the 4-wire facilities from the DSS to the remote local office and from a DSS to a 4-wire remote station.

3.17 The 2-wire port circuit pack is used to serve 2-wire remote stations over a 2-wire local loop or a 2-wire loop plus a 2-wire interoffice facility on a remote office line.

3.18 A power distribution panel is located between the two shelves that comprise the DSS assembly. This power section contains fusing, power supplies, and alarms. The power supplies receive their input voltage from the central office (-48 Vdc) battery supply.

150A CSU

3.19 At a 2-wire remote station the 150A CSU is the point of connection with the customer equipment. This unit is a passive device for terminating a 2-wire metallic loop facility. The CSU provides a balanced termination, padding, current surge protection, hazardous voltage protection, and dc voltage isolation between the channel and the customer terminal. The CSU requires no external customer supplied power. The customer terminal is restricted in that no more than one milliamp of dc current can flow through the CSU termination.

3.20 The CSU includes padding to facilitate signal level adjustment at initial installation. When the CSU is installed, the installer opens a screw switch on the CSU. This switch places a capacitor into the circuit blocking the dc current flow in the local loop. This releases a relay in the DSS which, in turn, applies a -18 dBm, 1-kHz tone to the line at a -5 transmission level point (TLP). The attenuator pad on the CSU can then be adjusted for a proper receive level of -30 dBm (-17 TLP) at the customer tip (CT) and customer ring (CR) terminals. After the adjustment is completed, the screw switch is closed allowing dc current to flow. The relay in the DSS is now operated and removes the 1-kHz tone from the local loop. This feature

allows the installer to complete installation of the remote terminal without central office assistance. Additional information on the 150A CSU is given in Section 590-101-000.

4. TRANSMISSION REQUIREMENTS

4.01 This part covers the transmission plan that includes the transmission levels and parameter limits for the individual links in the network. There is a departure from the standard 3002 channels that are used for private line circuits in most instances. The primary objective of this plan is to establish transmission requirements that meet the requirements of the service offering. This will ensure reliable transmission of control signaling between the master station and the DSSs and between the master and remote stations for end-to-end data transmission.

4.02 The transmission plan specifies the data levels (expressed also in TLPs) at the DSSs and at the stations. The limits of various data transmission parameters are assigned among the individual links of the circuit to avoid the need for end-to-end (customer station to remote station) tests whenever a new remote station is added to the circuit. Each link is lined up separately.

TRANSMISSION LEVEL PLAN

4.03 Establishment of standard signal powers at certain points in a circuit is fundamental to overall circuit design work. Controlling these signal powers will guard against overloads and crosstalk on adjacent circuits. It also ensures that a good signal-to-noise ratio is maintained overall.

4.04 Accurate measurement of the transmission characteristics of voiceband data circuits depends upon knowledge of the correct test levels to be transmitted and received. The power of the test signal with respect to the TLP at which it is applied will have a major influence on the test results obtained.

4.05 The circuit layout record card (CLRC) issued by the telephone companies may indicate the expected 1004-Hz loss of the circuit between various test points in two ways:

(a) By the designation of the TLP

(b) By the designation of the data level (data modem power).

4.06 Figure 4 shows the data transmission levels expressed in data level and in TLP for a connection to a 2-wire station served from a secondary DSS. The levels for a connection to a 2-wire station on a primary DSS are the same (but no secondary link is involved). The transmission losses given are those with a 600-ohm impedance at the master station, the remote station interface, the 4-wire jack access points of the DSS, and a 900-ohm impedance at the 2-wire line termination of the DSS.

4.07 The basic features shown are the 0 dBm (+13 TLP) transmit level at the remote stations and the fixed loss. The receive level at the DSS is -12 dBm (+1 TLP) for a 2-wire circuit or -16 dBm (-3 TLP) for a 4-wire circuit. The loss in the CSU is adjusted to this value, depending on the loop loss.

4.08 The transmit and receive data levels at the customer interface of the master station are 0 dBm transmit and -16 dBm receive (the same as those for 3002 private line channels). Level adjustment capability is provided in each direction of transmission to accommodate various types of local facilities and distances from the serving central office (CO). The transmit level onto the cable is normally adjusted to range from -8 dBm to -6 dBm. The receive level is adjusted to obtain the required receive level of -16 dBm. The 4-wire levels shown in Fig. 4 at the input and output jacks of the DSSs are -8 dBm transmit and -16 dBm receive.

> ***Note:*** The transmit level from the DSS when connected to a 2-wire local loop is 10 dB less (that is, -18 dBm). This ensures that the echo signal from the hybrid network in the DSS towards the master station is (on the average) 15 dB below the return signal from the remote stations.

4.09 Figure 5 shows the transmission plan for interoffice facilities. It also shows two examples of the remote station being served by a DSS in a central office other than the station serving office. The levels given show that the transmit and receive levels on the local loop are the same as when the local loop is connected directly off a DSS. If a DSS is then moved to

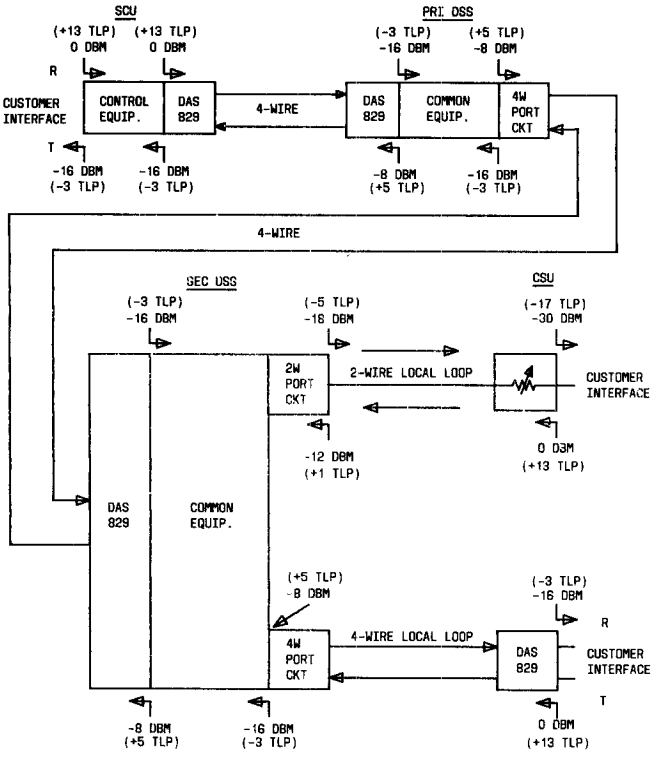

Fig. 4—Data Transmission Levels on 2- and 4-Wire Local Loops

the remote office, adjustments to the remote station are unnecessary, assuming that the local facilities from the local office are not changed.

Transmission Parameter Limits

4.10 The transmission parameter limits for DATAPHONE Select-A-Station service are based on the characteristics of the network described in Parts 2 and 3 and shown in Fig. 4 and 5. The overall network consists of two or three individual links, connected in tandem through DSSs, the primary link, the secondary link, and the polled link.

4.11 For the automatic step DSS option of the sequential offering, where tandeming of DSSs is not possible, the circuit consists of two links, a primary link and a polled link. Each of the links of the circuit are designed and measured separately. End-to-end measurements are not made at installation. This avoids taking all the stations out of service when making the measurements. Therefore, it is important that the combined effect of the transmission impairments on each link for each parameter will meet the limits given in Table A. This ensures that measurements on the individual links are sufficient to meet the end-to-end objectives.

> ***Note:*** End-to-end transmission tests from the master station to the remote stations are not to be made.

PRESERVICE TESTS

4.12 After the installation of individual links (including the station and CO equipment) has been completed, a series of tests called "lineup"

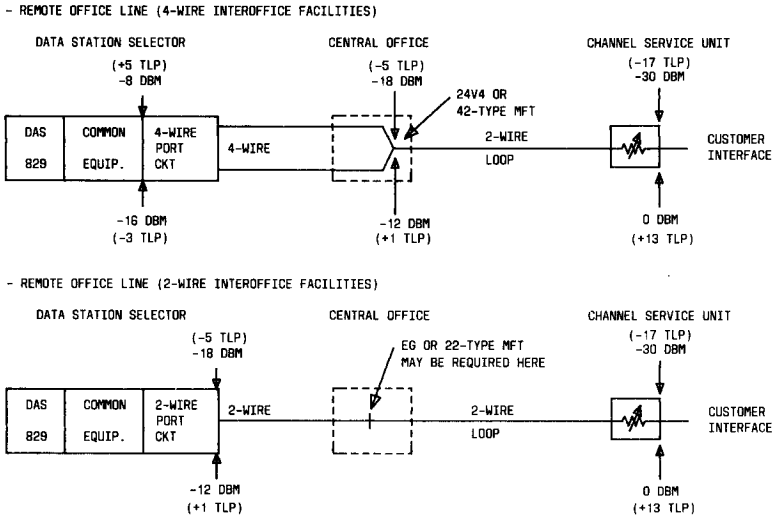

Fig. 5—Data Transmission Levels on Interoffice Facilities

TABLE A

TRANSMISSION PARAMETER LIMITS - 2-WIRE POLLED LINK

MEASUREMENT TEST	PRIMARY LINK	SECONDARY LINK	OBJECTIVES FOR POLLED LINK*
1004-Hz Loss Variation			
Circuit Order	±0.5 dB	±0.5 dB	±1 dB
Long Term Variation	±2.0 dB	±1.0 dB	±2 dB
C-Notched Noise			
1004-Hz Signal to C-Notched Noise Ratio	26 dB	26 dB	26 dB
Impulse Noise			
Number of counts in 15 minutes at the following threshold levels			
71 dBrnC0	10	10	10
75 dBrnC0	6	6	6
79 dBrnC0	3	3	3
Attenuation Distortion (ref 1004 Hz)			
500-2800 Hz	−1 to +3 dB	−1 to +3 dB	−2 to +8 dB
300-3000 Hz	−2 to +6 dB	−2 to +6 dB	

*Not to be measured

or "circuit order" are performed. These tests must be made to ensure that link parameter limits are met and that station and CO equipment are operating properly.

4.13 All test results should be recorded on a Data Transmission History Card such as Form E-5596. A separate Form E-5596 should also be used to record loopback measurement tests performed at the test center. These test results will serve as benchmarks to be used during maintenance periods and trouble isolation testing.

4.14 Four preservice tests on the primary links, secondary links, and remote office lines are required to check that the limits given in Table A on the following parameters have been met.

(1) 1004-Hz loss

(2) C-notched noise

(3) Impulse noise

(4) Attenuation distortion.

The procedures for making these tests are given in Section 590-105-101 TOP and Section 598-083-106 TOP.

1004-Hz Loss

4.15 The nominal 1004-Hz receive level is -30 dBm for a 2-wire termination and -16 dBm for a 4-wire termination based on a transmit level of 0 dBm at the distant interface. However, variations can be expected. Short-term loss variation may be caused by dynamic regulation of carrier system amplifiers, switching to standby facilities, and some maintenance activities. "Short term" is meant to be a few seconds or less. Short-term variations are considered to be gain hits, gain changes, or dropouts. Long-term variations are primarily caused by temperature changes affecting local plant; component aging, amplifier drift, and other phenomena. "Long term" is meant to be periods of days, weeks, or even longer. Long-term variations should not exceed ±6 dB with respect to the nominal receive level for 3-link portions of a network and ±4 dB with respect to the nominal receive level for 2-link portions of a network.

C-Notched Noise

4.16 The C-message noise often is not the principal noise experienced when a signal is present. Quantizing noise in digital carrier systems and the effect of compandors in both digital and some analog systems result in signal dependent noise. The ratio of the received power of a 1004-Hz test tone to the received C-message noise power is therefore not a reliable indication of the signal-to-noise ratio.

4.17 C-notched noise is a measure of the amount of noise on a channel when a signal is present. In making this measurement, a single frequency "holding tone" is applied at the transmitting end of the channel to act as a signal. This tone operates compandors and other signal-dependent devices and simulates a data signal. At the receiving end, the tone is removed by a narrow band elimination filter (notch filter) and the noise is then measured through a C-message filter. The ratio of the received 1004-Hz test tone power to the C-notched noise power indicates the signal-to-noise ratio of the channel. The limit for the received 1004-Hz power to C-notched noise power ratio is a minimum of 21 dB. Since the 1004-Hz receiving power is -30 dBm (60 dBrn) at 2-wire remote stations and -16 dBm (74 dBrn) at 4-wire stations, the nominal C-notched noise limits at the receiver are 39 dBrnC and 53 dBrnC, respectively.

Impulse Noise

4.18 Impulse noise is characterized by large power peaks or spikes in the total noise waveform. It is measured with a 6F or 6H noise measuring set which counts impulses greater than a selected threshold value, using a counter having a maximum counting rate of approximately 7 counts per second. Measurements are made through a C-notched filter. A holding tone is transmitted and notched out at the receiver to activate any compandored facilities in the channel.

4.19 The usual impulse noise measurement involves counting the number of noise peaks exceeding a threshold numerically 6 dB below the received 1004-Hz test tone power. For a -30 dBm receive level the threshold is 54 dBrnC, and for a -16 dBm receive level the threshold is 68 dBrnC. The limit is 30 counts in 15 minutes (maximum).

4.20 In addition, there are limits of 18 counts in 15 minutes at a threshold 2 dB below the received 1004-Hz test tone power, and 10 counts in 15 minutes at a threshold 2 dB higher than the received 1004-Hz test tone power. These additional limits are designed to cover cases where impulses of relatively high power would interfere substantially with data transmission but the channel would pass the single threshold test.

Attenuation Distortion (Loss Versus Frequency)

4.21 One requirement for the end-to-end channel to provide distortionless transmission is that all signal frequencies experience the same loss over the channel. Typical channels, however, have variation in loss with frequency. To control the magnitude of this variation, attenuation distortion limits for each link are given in Table A.

4.22 Attenuation distortion is a difference in loss at one frequency with respect to the loss at another frequency. It is specified by placing a limit on the maximum loss at any frequency, in a specified band of frequencies, with respect to the loss at a reference frequency. The reference frequency established is 1004 Hz. The limit for attenuation distortion on the end-to-end channel is -4 to +14 dB in the 500- to 2800-Hz band. Note that "+" means more loss than the loss at 1004 Hz.

4.23 The preservice test made on a 2-wire local loop to a remote station consists of the 1004-Hz loss measurement. The loss of the loop is padded to 12 dB. The test is made when the CSU is installed and the loop is connected at the main distribution frame (MDF) to the DSS. The procedures for making this installation and adjustment are given in Section 590-101-000.

5. MAINTENANCE PLAN

5.01 This part describes the maintenance plan for the DATAPHONE Select-A-Station service. The plan is based on the use of a test center in each service area for centralized testing, test coordination, and maintenance administration. This part also includes maintenance objectives and test access arrangements. This maintenance plan is intended to provide the following objectives:

- Centralized maintenance administration
- Fault diagnosis from customer trouble reports
- Fault sectionalization by remote tests on common transmission links and system equipment prior to dispatch.

5.02 In order to achieve these objectives, the maintenance plan prescribes the operation of a test center in a given service area to oversee the maintenance administration of the DATAPHONE Select-A-Station service. The responsibilities of the test center are covered in Section 666-617-100.

5.03 Maintenance of this service differs from normal voiceband analog bridged multipoint circuits. An isolation capability is designed into the operation of the DSS which is used in place of a resistive bridge. The capability of setting up point-to-point connections under the control of the master station prevents trouble such as noise or interference on a facility from affecting communication between the master station and other remote stations or from affecting the master station control of the DSS. The DSS permits no interaction between remote stations or between any remote station to which the DSS is not connected and the master station. The problems of finding the troubled loop and isolating it before the customer can use the remainder of the multipoint circuit is eliminated.

5.04 Trouble on remote station loops can be handled without affecting overall system operation. Troubles on common facilities or in common portions of the DSS will affect many or all portions of the system. To clear this type of trouble, maintenance features are built into the DSS and SCU to facilitate remote testing. These features are to be used by a test center which can access the common portion of the system, perform appropriate tests, and dispatch repair forces as required.

A. Maintenance Requirements

5.05 Three forms of testing are required for this service:

(1) Dc testing on loops

(2) Ac transmission testing on primary and secondary links and remote office lines

(3) Digital and functional tests on the master station SCU and CO DSS equipment.

5.06 To aid the test center, other associated telephone company and Long Lines maintenance centers will be responsible for testing, fault locating, and repairing equipment and facilities used in this service.

5.07 Interstate transmission links may be maintained by Long Lines serving test centers (STCs). These STCs, located near each end of an interstate link, will be responsible for restoring service on those facilities if a trouble occurs. The STCs should respond to requests from the test center for assistance in testing and clearing troubles on interstate links.

5.08 The local loop facilities serving remote stations from each DSS will be tested by the appropriate Repair Service Bureau in the wire center where the DSS is located. If the service is maintained by Switched Access Remote Test System No. 1A (SARTS), testing on local loops can be performed via the Remote Test System No. 1A (RTS-1A) for trouble verification purposes.

B. Test Access Arrangements

5.09 Three arrangements are recommended for providing testing access. Any one of these three can provide the capability of sectionalization so that the trouble can be identified and appropriate repair forces dispatched. The trouble sectionalization will also be aided by information from the customer who is able to identify what remote station or stations cannot be reached satisfactorily and whether the problem is intermittent or permanent.

5.10 The first possible access arrangement is the Switched Access Remote Test System No. 1A (SARTS-1A). This is a standard Bell System maintenance system for special services. If SARTS-1A is available in a given serving area, it can access the transmission links via a Switched Maintenance Access System (SMAS) using SMAS maintenance connectors installed within the DSS equipment bay. Testing for trouble sectionalization can be performed by the Remote Test System No. 1A (RTS-1A) or, if not available, by a 24A testboard or equivalent. Figure 6 shows this arrangement. All links of the system to which an RTS-1A has access can be tested for trouble sectionalization purposes. This includes interoffice and loop facilities. Preservice testing of primary and secondary links which call for complete data parameter tests should be performed from the jack ended test port (JETP) in a 24A-type testboard located in the same office as the DSSs. These testboards should also be equipped for functional and digital testing of the SCU and DSSs.

5.11 The second access arrangement, shown in Fig. 7, uses a test center through which the primary link is routed. The test center should have jack access to permit breaking into the circuit and testing in either direction on the 4-wire primary link. All sectionalization tests on the primary and secondary links can be made from this test center. When testing secondary links, however, service must be interrupted on the primary link in order to gain access to the secondary link through the primary DSS. All testing of local loops with this approach should be carried out by referral to LTDs in the appropriate wire center where access is by means of a shoe on the main frame. The test center should be equipped for full data parameter transmission tests and for functional and digital tests of the SCU and DSSs.

5.12 A manual method for testing secondary links is available through the 4-wire port card jacks at the primary DSS. This will not disrupt the remaining services operating out of that primary DSS.

5.13 The third possible test access arrangement uses a test line from an appropriately equipped test center to the master station. This arrangement, shown in Fig. 8, permits access to the primary link at the SCU interface. A manually controlled access arrangement is provided in the SCU multiple mounting. This can be operated by customer master station personnel under telco direction. The test line is a C4 conditioned 4-wire private line channel terminated in a DAS 829-L1A which has means for inhibiting tone activated loopback by a lead on the DAS 829-L1A circuit pack. As shown in Fig. 8, additional amplification (16 dB) is provided in the DAS 833A for level compensation. The test line can be shared among all the circuits originating from the master station. This provides for economical use of the dedicated test line and access equipment. This arrangement will require customer assistance in trouble isolation of SCU problems by having customer personnel manually switch the primary link to the spare SCU in the circuit in place of the original SCU. Both primary and

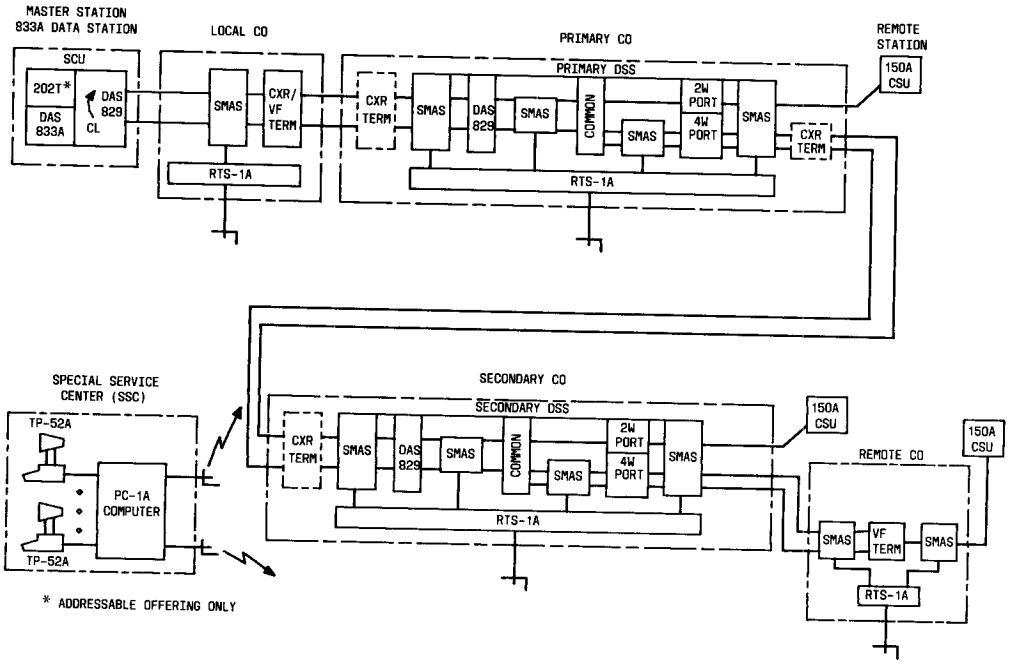

Fig. 6—Switched Access Remote Test System

secondary links can be tested with this arrangement. The testing of local loops will require LTD assistance. The test center should be equipped for data parameter transmission testing and digital and functional testing of SCU and DSS equipment.

Loop Maintenance

5.14 Two-wire metallic loops are maintained as they would be for regular telephone service. Locating a fault on a loop will be done by the local test desk via shoe access at the MDF or by the RTS-1A test system if SARTS is used. Troubles can be sectionalized to inside or outside the office.

6. TEST EQUIPMENT

6.01 DATAPHONE Select-A-Station Service will use several varieties of test equipment for installation and maintenance. These can be categorized as transmission test sets, a new special function test set, and data test sets. The types of equipment in each category are discussed in the following paragraphs.

Transmission Test Sets

6.02 Installation and maintenance tests on the primary and secondary links and on remote office lines will require a fairly extensive list of test equipment functions. For installation testing, this equipment will be used at the customer master station, at DSS office locations, at test center locations, and at remote offices when a remote office line is used. The test functions associated with standard installation and maintenance testing are listed below:

- 1004-Hz loss
- C-notched noise
- Impulse noise
- Attenuation distortion.

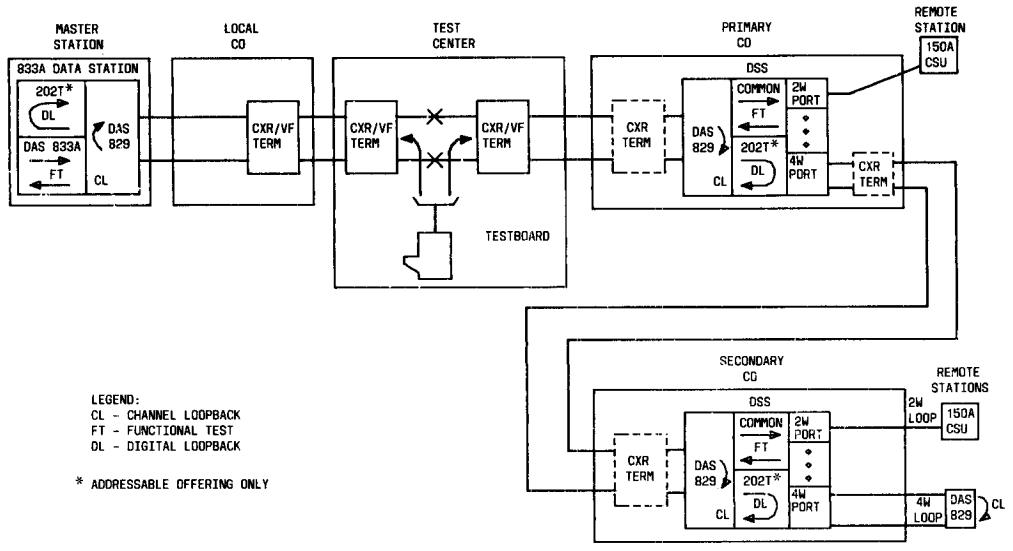

Fig. 7—Test Center on Primary Link

6.03 Test sets such as the WE 6F and Hewlett-Packard Model 3550B can be used for initial channel lineup. A list of typical equipment which can also be used is given in Section 314-410-500.

New Special Function Test Set

6.04 A new test set (the 178A) is required for test center use and for certain testing from a DSS location. It provides for:

(a) Functionally testing the SCU and DSS.

(b) Digitally testing data set 202T in the addressable SCU and DSS in conjunction with a data test set.

(c) Setting up connections through a primary DSS to test over secondary links to a secondary DSS.

(d) Testing through any type of DSS (except an automatic step optioned DSS) to a 4-wire DAS 829-type L1A terminating a remote station. The test set can send the 2713-Hz loopback tone for making loopback tests.

(e) Test access to the channel facilities so that transmission tests can be made.

6.05 To perform these functions, the 178A test set has the following capabilities and features:

(a) Generation of precise short duration tone bursts designed to control a sequential DSS or release addressable DSS connections.

(b) Detection of short duration tone bursts from sequential or addressable DSSs.

(c) Built-in data set 202T to:

- Send address to an addressable DSS to set up a connection
- Make a digital loop test with data set 202T in either the SCU or DSS.

(d) Test circuitry to verify proper functional operation of sequential DSS and SCU and make a connection to a specific port of a controlled step sequential DSS.

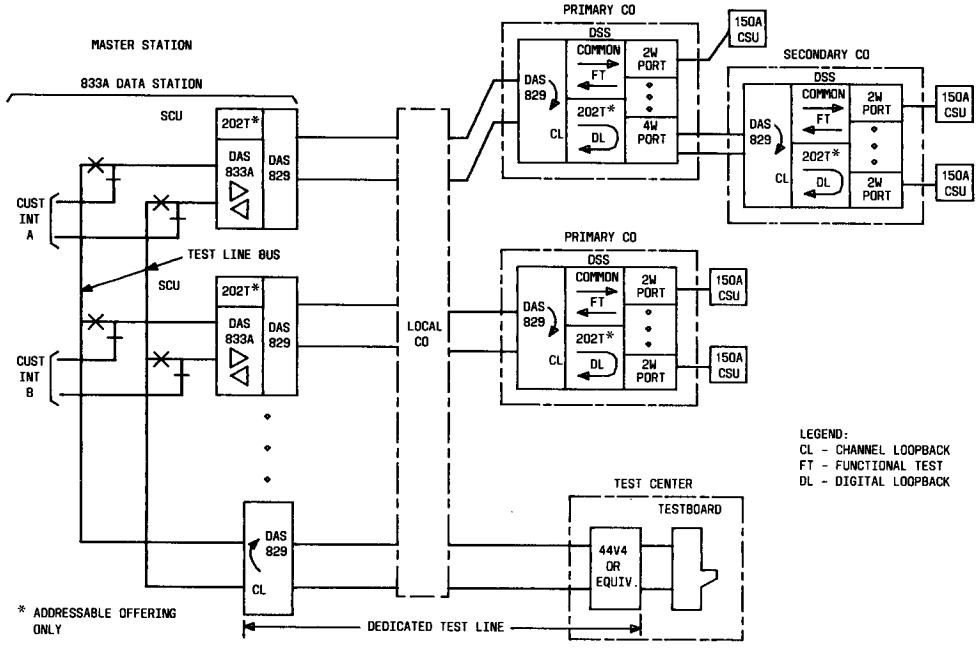

Fig. 8—Test Line to Master Station

(e) Test circuitry to verify proper functional operation of addressable DSS and SCU and make a connection to a specific port of an addressable DSS.

(f) Monitor and test jacks for transmission test sets providing access to the channel for transmission tests. The set also contains a loudspeaker for monitoring purposes.

(g) Controls and displays to permit signals to be sent and received at the normal DSS and SCU operating rate.

(h) Circuitry to display the results of the tests.

6.06 The 178A test set is designed primarily for use at the test center which has voiceband access to the circuit. The test set is portable, which allows it to be used at a DSS or at an SCU. The test set is designed to access the circuit or transmission equipment using standard jacks and test cords. It has transmission level adjustments to adjust to the appropriate signal power at the point in the circuit where it is expected to be used.

Data Test Sets

6.07 Several types of data test sets will be required for installation and maintenance tests. For installation and maintenance tests at the master station to verify proper system operation, a 921A data test set will be used. It will interface at the 25-pin customer connector on the DAS 833A in an SCU with the Electronic Industries Association (EIA) interface module of the test set. The initial version of the 921A is not programmed to perform the appropriate tests. Software control logic is being developed for this purpose. The 921A can also be used for start-stop distortion tests from the master station on the addressable version of the service.

6.08 For maintenance testing from the test center, the 178A test set is required to control the DSS plus a data test set for start-stop distortion

tests on the addressable SCU or DSS. Either the 921A or 914-type data test sets can provide this function. Either test set can provide a synchronous error rate test. While this type of test does not exercise data set 202T in the same way as it is used in the service, it is adequate to determine steady state performance of data set 202T. Information on peak distortion can be obtained by using the 50 percent sample window. For further information on testing data set 202T with a 914-type data test set, refer to Section 592-031-500.

7. CATEGORIES OF TRANSMISSION PARAMETERS

7.01 The circuit transmission parameters are divided into the following categories:

- Interface parameters
- Facility parameters.

The facility transmission parameters that must be tested to ensure that limits are met were given in Part 4 (Preservice Tests). Additional transmission parameters along with a brief description of those parameters and their characteristics are given in the following paragraphs.

A. Interface Parameters

7.02 The voiceband interface parameter specifications are influenced by two considerations: electrical protection of the telephone network and its operating personnel, and standardization of private line design arrangements. The various parameters of this category are as follows:

- Terminal impedance and balance
- In-band data signal power
- Transmitted test signal power
- Control signal power
- Out-of-band transmitted signal power.

A brief description of each of these parameters is given in 7.03 through 7.09.

Terminal Impedance and Balance

7.03 The recommended impedance of data terminal equipment is 600 ohms ±10 percent resistive over the voiceband. The impedance of test equipment used for installation tests and trouble tests is 600 ohms resistive. Channels lined up using 600-ohm terminations should be used with 600-ohm terminations to assure transmitted and received signal power meets required limits.

7.04 If the impedance of the customer data terminal equipment is substantially different from 600 ohms, echoes interfering with the data signal may result. The SCU at the central station and the CSU at the remote station provide balanced terminations to the facilities. The customer equipment may be balanced or unbalanced; however, balanced is usually preferred due to local (on premises) noise considerations.

In-Band Data Signal Power

7.05 The maximum allowable transmitted signal power for an end-to-end data signal, averaged over any 3-second interval, is 0 dBm (as measured across a 600-ohm resistor). In meeting the 3-second average power, it is permissible for the instantaneous signal power to exceed the average power by as much as 13 dB. Therefore, at the 0-dBm transmit point the instantaneous signal power must not exceed +13 dBm (3.46 volts peak across 600 ohms resistive). The total power requirement applies in the frequency band below 3995 Hz (other than dc). All signal energy, spurious or otherwise, must be included when determining whether the transmitted power specification is met. The dc requirement is that the user terminal should cause no more than one milliampere dc to flow through the voiceband channel termination.

7.06 At the master station, the 1004-Hz received data signal power is -16 dBm based on a transmitted power of 0 dBm at the remote station. At the remote station, the 1004-Hz received data signal power is -30 dBm for a 2-wire termination and -16 dBm for a 4-wire termination based on a transmitted power of 0 dBm at the master station.

Transmitted Test Signal Power

7.07 Test signals applied to the circuit must not exceed 0 dBm. A test signal greater than 0 dBm may give erroneous results because of nonlinear channel response with changes in signal power.

Control Signal Power

7.08 The control signaling for the service takes place in the band above 2600 Hz. The power of the customer signal in the band from 2600 to 3995 Hz must be at least 10 dB below the power in the band from 500 to 2600 Hz. Failure to observe this requirement could result in false operations. These control signals will appear at the terminations of the end-to-end channel at levels that may be comparable to the received data signal power. Therefore, if the terminal equipment may be adversely affected by energy above 2600 Hz, the customer should filter out this energy.

Out-of-Band Transmitted Signal Power

7.09 Out-of-band signals are defined to be in the frequency band of 3995 Hz and above. The limits on out-of-band signal power apply to the transmitted signal power at the interface with the end-to-end channel. The out-of-band signal power limits are required to prevent interference with other services carried on telephone company facilities.

The objectives for short duration rms powers are:

- The power in the band from 3995 to 4005 Hz should not exceed -18 dBm.
- The power in the band from 4 to 10 kHz should not exceed -16 dBm.
- The power in the band from 10 to 25 kHz should not exceed -24 dBm.
- The power in the band from 25 to 40 kHz should not exceed -36 dBm.
- The power in the band above 40 kHz should not exceed -50 dBm.

B. Facility Parameters

7.10 The facility parameters covered in this part represent potential impairments to a data signal that is transmitted over the end-to-end channel. These parameters are objectives only and are not to be measured in normal preservice and maintenance testing. In all cases, the facility parameters exhibit some variation over a period of time. The parameter objectives, unless otherwise stated, apply to measurements of steady-state phenomena and the measurements generally last less than one minute. The various parameters of this category are as follows:

- C-message noise
- Envelope delay distortion
- Single frequency interference
- Frequency shift
- Phase intercept distortion
- Phase jitter
- Nonlinear distortion
- Gain hits and phase hits
- Dropouts.

A brief description of each of these parameters is given in 7.12 through 7.21.

7.11 Transient phenomena (impulse noise, phase hits, gain hits, and dropouts) are measured over longer periods and events meeting certain criteria are counted. The results of either steady-state or transient measurements may vary by time of day, day of week, season of year, or according to some other time dependency.

C-Message Noise

7.12 C-message noise is a weighted measurement of the background noise on a channel in the absence of a signal. It is measured with a noise measuring set such as the 3C noise measuring set. The weighting used is provided by a C-message filter.

Envelope Delay Distortion

7.13 Another channel requirement for distortionless transmission is a linear phase versus frequency characeristic. The end-to-end channel will typically only approximate such linearity over the voiceband. Measuring the phase versus frequency channel characteristic directly is difficult because of problems in establishing a phase reference. However, a usable approximation of phase with respect to frequency, called envelope delay, can be measured. The maximum variation in envelope delay over a band of frequencies is called envelope delay distortion.

The quality of the channel with respect to its phase characteristic is controlled by limiting the amount of envelope delay distortion allowed. The objective for envelope delay distortion for the end-to-end channel is 1750 microseconds over the 800- to 2600-Hz band. It assumes the use of an 83-1/3 Hz modulating frequency for the measurement.

Single Frequency Interference

7.14 Spurious single frequency tones may interfere with narrowband data signals which are frequency-division multiplexed onto the channel. Message circuit noise will be distributed across the voiceband, so the noise power in each narrowband channel will be less that the total noise power, and the signal-to-noise ratio per channel may be quite adequate. If, however, a single-frequency tone of substantial power is present, it may interfere with one of the narrowband channels. The limit for single-frequency interference is that the noise contribution at any frequency should, when measured with C-message weighting, be at least 3 dB below the C-message noise power at the modem receiver.

Frequency Shift

7.15 Long haul carrier systems operate in a single sideband suppressed carrier mode. Since the carrier is not transmitted and must be reinserted, there may be a slight difference in frequency between the modulating and demodulating carriers. The resulting frequency shift contributes a constant change at all frequencies in the voiceband. Substantial frequency shift can degrade some data demodulation processes and can cause high distortion in narrowband frequency division multiplex systems. The overall requirement on frequency shift is ±5 Hz.

Phase Intercept Distortion

7.16 When single sideband suppressed carrier transmission systems are used, the phase of the reinserted carrier with respect to the phase of the modulating carrier is not controlled. The result is phase intercept distortion, which contributes a constant phase shift to all frequencies present in the end-to-end signal. It appears as the phase intercept at zero frequency on a graph of phase versus frequency for carrier-derived channels. Phase intercept distortion will affect any signal in which preservation of the phase relationships in the transmitted waveshape is important. A modem designed to operate over a channel having frequency shift should not experience difficulties due to phase intercept distortion. There is no requirement at this time for this parameter.

Phase Jitter

7.17 Various sources cause the instantaneous phase, or zero crossings, of a signal to "jitter" at rates normally less than 300 Hz. This phase jitter is typically caused by ripple in the dc power supply appearing in the master oscillator of long haul carriers and then passing through many stages of frequency multipliers. Some phase jitter occurs in short haul systems from incomplete filtering of image sidebands. Digital carrier systems also will exhibit phase jitter at certain input frequencies. The most common jitter frequencies are 20 Hz (ringing current) and 60 Hz (commercial power) and the second through fifth harmonics of each of these.

7.18 Measurement of phase jitter is made with an instrument sensitive to frequencies within 300 Hz of a 1004-Hz carrier. Noise may strongly influence this measurement; therefore, phase jitter should be measured with a test tone at data level. The objective for phase jitter is 15° peak-to-peak.

Nonlinear Distortion

7.19 Nonlinear distortion is that portion of the channel output which is a nonlinear function of the channel input. It is measured by transmitting four equal level tones, consisting of two pairs of tones, with a composite signal power at nominal data signal level. Two of these tones are closely spaced around a center frequency "A" (860 Hz) and the other two tones are centered around a center frequency "B" (1380 Hz). The second order distortion is determined from the B-A and B+A products while the third order distortion is determined from the 2B-A product. The signal to second order distortion ratio objective is 25 dB and the signal to third order distortion objective is 28 dB.

Gain Hits and Phase Hits

7.20 Gain hits and phase hits are defined to be sudden changes in the amplitude or phase of a signal lasting for at least 4 ms and returning to the original value within 220 ms. Changes in amplitude or phase which last for more than 220 ms are referred to as gain or phase changes. Changes that last for less than 4 ms are classified

as impulse noise. Limits for gain hits and phase hits are not specified; however, objectives for these parameters are:

Gain hits: no more than eight in 15 minutes $\geq$ 3 dB
Phase hits: no more than eight in 15 minutes $\geq$ 20 degrees.

Dropouts

7.21 A dropout is a decrease in level $\geq$ 12 dB which lasts for at least 10 ms. Deep fading of radio facilities and defective components can cause dropouts. Since dropouts tend to be long with more than 40 percent in excess of 200 ms, they frequently are responsible for serious performance degradations. Limits for dropouts are not specified; however, the objective is no more than two dropouts in 15 minutes.

8. MAINTENANCE TESTING

8.01 Two distinct categories of maintenance testing exists for DATAPHONE Select-A-Station service. These are as follows:

(a) Common facilities and equipment which affect communication to many or all remote stations.

(b) Individual facilities and equipment dedicated to a single remote station.

The SCU, primary link, secondary link, and DSSs are in the first category. The local loops, remote office lines, and the 150A CSUs are in the second category. This part describes the various maintenance features that exist in the common and individual facilities.

833A Data Station

8.02 The 833A data station contains one or more 56A1 data mountings each equipped with up to five SCUs. Each data mounting includes a power and oscillator supply to serve the individual SCUs. The maintenance features in the data mounting include:

(a) Light emitting diode (LED) indicators for monitoring the status of the power supply. The power is fed in a dual arrangement so that if one supply fails the other is there to take the complete load. Failure of either supply will be indicated by the LED indicator.

(b) LED indicators for status monitoring of the dual crystal controlled oscillators which generate the control tones. A switch is provided to select oscillator "A", oscillator "B", or automatic switching based on internal detectors.

8.03 LED indicators are also provided on the individual SCUs for the following purposes:

(a) When a circuit is in channel loopback (LB) or functional test (FT).

(b) When the transfer to spare (TTS) switch is operated to indicate that a working primary link has been transferred to a spare SCU in place of the original SCU. The spare SCU is discussed in 8.06.

(c) To indicate that the test line (TL) is connected to the particular SCU for test center testing. The customer equipment is disconnected from the transmission channel leads when this occurs.

(d) On data set 202T LEDs are used in the addressable offering to display interface lead status, test status, and power status.

8.04 Two SCU arrangements are available, one for the sequential offering and one for the addressable offering. The SCU provides for transmitting the control signals to the DSS and contains two tone detectors which monitor signals from the DSSs. The two control signals, generated from the common oscillator supply, are used to control the primary and secondary DSSs. The primary control signal is a 2975-Hz tone. The secondary control signal is a 2800-Hz tone. The control signals also serve as test frequencies to verify SCU operation. The output of the tone detectors indicates to the customer equipment the reception of a frame signal with sequential DSSs or an acknowledgment signal with addressable DSSs.

8.05 The tone detectors and control signal oscillators in the SCU will be tested using a manually activated functional test.

> ***Note:*** This test cannot be made if test access is made using a test line to the master station which connects through the SCU interface.

This test allows a test center with access on the primary link to send a burst of one of the two tone signals using a 178A test set. Its detection is verified by the SCU sending back the other tone signal. This test exercises the SCU with signals of duration that will be used under normal operation with a DSS. Receipt of the other tone signal indicates that the tone detection and tone generating circuitry as well as both sides of the 4-wire facilities at the upper part of the voiceband are operational. When used in conjunction with the channel loopback test, problems can be distinguished between the primary link and the SCU.

8.06 When at least one spare maintenance SCU is provided it will operate with an entire multiple arrangement. It can be placed in service by customer personnel by moving the customer interface connector to the spare unit and operating the TTS switch to cause the spare unit to be transferred to the proper channel. The spare SCU offers a simple way to sectionalize trouble to a faulty SCU prior to the customer calling the repair center.

Data Station Selector

8.07 The basic maintenance features provided in the DSS are as follows:

(1) Remote tone activated channel loopback at the DSS trunk input

(2) Test jacks for voiceband transmission test sets on the 4-wire input DAS 829-type L1A and each 4-wire output port (but not the 2-wire output ports)

(3) Remote test access to the 4-wire input trunk, each 4-wire output port, and the 2-wire output ports for testing by SMAS local test ports or RTS-1A for SARTS-1A arrangements

(4) Frame tone signals on the sequential DSS and acknowledgment tone signals on the addressable DSS which can be used for test monitoring purposes

(5) Addressable test and report functions on the addressable DSS to aid in testing DSS operation and obtaining DSS status

(6) Test access to the EIA interface associated with data set 202T in the addressable DSS

(7) A 1-kHz tone source with a fixed -8 dBm output power (into 600 ohms) which can be used for loss lineup and continuity tests on the primary and secondary links (on the optional verify circuit pack)

(8) An 8-dB amplifier to permit equal level loopback at the 4-wire output port of a DSS (on the optional verify circuit pack)

(9) A means to verify the address of a port card and the address that the DSS is acting on (on the optional verify circuit pack).

Trunk Input Channel Loopback

8.08 Equal level channel loopback is provided in the input trunk terminating equipment on primary and secondary DSSs. This loopback is tone activated to permit remote testing from a test center with access to the primary link. The loopback is accomplished in the DAS 829-type L1A. The standard 2713-Hz loopback tone is used to establish and disable the loopback. The loopback detector is controlled by the DSS, and it is activated only when the DSS is in certain states.

Jack Access

8.09 The DSS provides jack access to 4-wire input and output ports. The 4-wire channel terminating equipment includes both test and monitor jacks for access to the transmit and receive paths. The test jacks break the circuit path toward the DSS common circuitry and permit a terminating test set to test toward the line through the channel terminating circuitry. The monitor jacks do not break the circuit path, but only bridge across it so that high impedance measurements can be made. Location of the jacks is shown in Fig. 9. Test jacks on the channel terminating equipment for the 4-wire output ports permit testing of secondary links and the interoffice portion of 4-wire remote office lines for initial channel lineup and for verification of channel parameters after repairing channel troubles.

Switched Maintenance Access System (SMAS) Access

8.10 SMAS access may be provided to the transmit and receive paths on both sides of the DAS 829-type L1A of the 4-wire DSS input and 4-wire output ports. Access may also be provided to the output side of 2-wire ports. This permits a SMAS

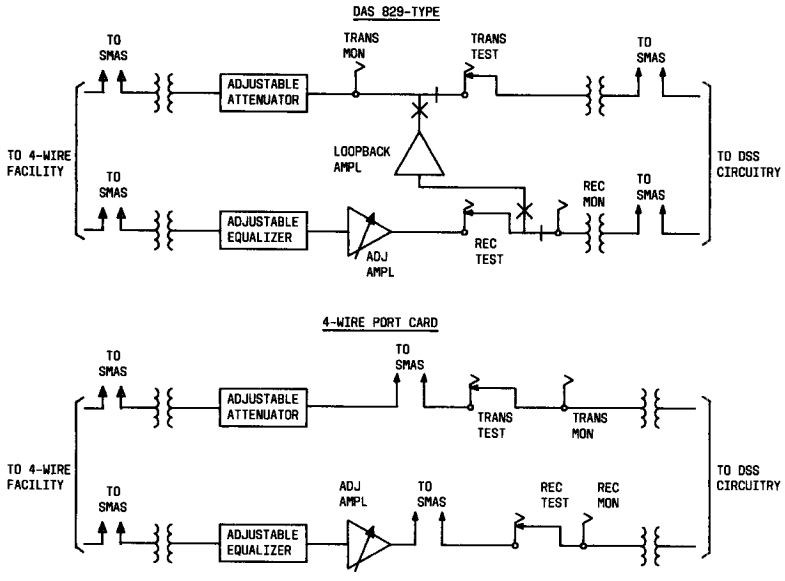

Fig. 9—Test Jack and SMAS Access Leads on DAS 829-Type and 4-Wire Ports

maintenance connector collocated with the DSS to access the circuit if SMAS access testing in the central office is required. The access points are located electrically at the same point in the terminating equipment as the test jacks so that remote measurements made from these points should follow those made from the test jacks.

8.11 SMAS access to the output terminals at the DSS bay eliminates the need for routing to an intermediate distribution frame (IDF). This saves circuit installation costs and reduces the exposure of these circuits at other IDFs. The internal access points on the 4-wire equipment allows testing at the appropriate end point of a 4-wire facility. Channel testing can be from a 24A testboard that is remote from the DSS bay but within the same central office building. The SMAS access leads do not have to be used if the CO is not equipped with SMAS. They can be bypassed by a shorting connector installed on the back of the DSS assembly.

Sequential DSS Features

8.12 The sequential offering of the DSS has a frame signal source which indicates the beginning of the cycle of ports. The number of ports through which the DSS steps (switches) is controlled by an option in the DSS. The frame signal, one for a primary and a second to a secondary, can be monitored by the test center for verification of DSS operation. In the automatic step and automatic step with reset DSS options, the test center can detect the frame signal using the new 178A test set. The DSS will transmit the frame signal for the duration of one and one-half port intervals. In the controlled step DSS option, the test center will be able to step the DSS from one port to the next until the frame signal is reached. The DSS will transmit the frame signal as long as no further control tones are received to command the DSS to step to the next port. The frame signal is the equivalent of two port intervals in the controlled step DSS option.

Testing Aids in Verify Circuit Pack (RL7)

8.13 The verify circuit pack provides three simple testing aids to assist in performing channel verification tests. The first provides a 1-kHz tone source at -8 dBm. It is used for lining up or verifying transmission levels in any of the DSS channel terminating equipment or other transmission equipment on the circuit. The 1-kHz tone is at the proper power to be placed on the outgoing side of the 4-wire trunk input and the 4-wire output ports. The tone is accessed by a standard patch cord and plugged into the appropriate test jack on one of the 4-wire port circuit packs.

8.14 The second testing aid is an 8-dB amplifier, accessible with two standard patch cords, which permits equal level loopback tests at the 4-wire input trunk or 4-wire output ports. It may be used at the input trunk if the far-end does not have a means to activate equal level loopback. In the case of the 4-wire output ports, there is no built-in equal level loopback.

8.15 The third testing aid provides for address verification of each port circuit pack plugged into the assembly. A three position switch on the verify circuit pack controls this feature. With the switch in its normal position, the port address of any port circuit pack can be determined by depressing a switch on the port circuit pack. The address(es) will appear on a numeric display on the verify circuit pack as long as the switch is depressed. To determine the address of the port being addressed while the system is in operation, the three position switch may be set up or down to obtain the addresses presented to the A and B (if dualized) common circuitry. This verification aid will be used when a craft employee operates either the control switches on the individual port circuit packs or the three position switch on the verify circuit pack. These operations do not affect customer operation of the DSS.

8.16 Port addresses are set by option(s) on each port circuit pack. These are then plugged in and their address is verified as indicated above. When the proper address(es) is indicated, the port(s) can be placed into service by operating the service switch on the port circuit pack.

Maintenance Kit

8.17 For repairs to the DSS, a maintenance kit of spare circuit packs will be available. This should be kept in a central location to be carried by maintenance personnel to a DSS when dispatched. These kits may be ordered separately and the number of maintenance kits needed will be determined on the basis of the number of DSSs in a given serving area. Before working on a DSS, the test center must have the customer release the affected portion of the circuit so that service interruptions, which will occur when circuit packs are removed from the DSS, are not interpreted as troubles or alarms by the customer.

9. REFERENCES

9.01 The following sections provide additional information on facilities and equipment that is associated with DATAPHONE Select-A-Station service.

SECTION	TITLE
107-104-010	178A Test Set—Description and Operation
314-410-100	Voice Bandwidth Private Line Data Circuits—Description
314-410-500	Voice Bandwidth Private Line Data Circuits—Tests and Requirements
590-101-000	150A Channel Service Unit—Description, Installation, Maintenance, and Tests
590-105-100	Data Station Selector—J70180AA—Description and Operation
590-105-101	Data Station Selector—J70180AA—TOP
592-031-100	Data Set 202T Transmitter—Receiver Description and Operation

SECTION	TITLE
598-082-100	Data Auxiliary Set 829-Type—Channel Interface Units—Voiceband Private Line Channels—Description
598-083-105	833A Data Station—Description
598-083-106	833A Data Station—TOP
598-083-180	833A Data Station—DATAPHONE® Select-A-Station—Service—Summarizing Specification—Data Systems
666-617-100	DATAPHONE® Select-A-Station Service—Test Centers—Administrative Procedures
666-617-101	Test Center Procedures—TOP
807-702-150	Data Station Selector-DATAPHONE® Select-A-Station System—Equipment Design Requirements—Data Systems
880-480-010	DATAPHONE® Select-A-Station Service—Description and Engineering Considerations
999-100-147	833A Data Station—How to Operate Manual

10. GLOSSARY

10.01 A list of unique terms and their definitions used in this section are as follows:

Acknowledgement Signal—Signal transmitted from the DSS in the addressable service offering to indicate that the DSS is in an unconnected state.

Address—A bit sequence that activates digital control circuitry. Used generally, address refers to port addresses, instructions, and control words.

Addressable—A service offering in which the customer has in-service control of both the duration and order of connections to a number of remote stations.

Automatic Step—A DSS option of the sequential offering in which the duration and order of connections are fixed.

Automatic Step with Reset—A DSS option of the sequential offering in which the duration and order of connections are fixed, but the DSS will reset to the beginning of the connection cycle upon command from the master station.

Benchmark Measurement—These are measurements made on a looped-back or one-way basis when the circuit is known to meet all requirements. They are performed in conjunction with the installation and circuit order tests and results are recorded for later reference purposes.

Channel Service Unit (CSU)—A prepackaged, 2-wire unit that provides an interface between voiceband data station equipment and a 2-wire private line service or polled network service.

Control Signal—A signal transmitted from the master station (SCU) to reset the DSS, step the DSS to the next port, or implement a DSS control function.

Controlled Step—A DSS option of the sequential offering which allows the customer to have in-service control over the duration of the connection. However, the connection sequence is fixed.

Customer-Provided Equipment (CPE)—Customer equipment located on the customer side of the telephone company interface and provided by the customer. Examples are digital computers, communication controllers, and magnetic tape readers and recorders.

Data Auxiliary Set 829-Type—Circuit packs used to provide 4-wire terminations for 4-wire facilities.

Data Auxiliary Set 833A—A circuit pack that provides control signaling functions in the SCU at the master station.

Data Level—The data signal power level in dBm averaged over a 3-second period at a point in the transmission path. This level always corresponds to -13 dBm0 which means that the data level is always 13 dB lower than the corresponding TLP.

dBm—The signal power at a point relative to one milliwatt, expressed on a logarithmic basis.

dBrnC—The noise power at a point relative to 10^{-12} watt (-90 dBm) and measured after passing

through a C-message filter. This term is also expressed on a logarithmic basis.

Data Station Selector (DSS)—A switching device located in central offices and having the capability of making connections between a 4-wire input and up to 128 outputs (sequential service) or 125 outputs (addressable service) any of which may be 2-wire or 4-wire or mixed.

Data Test Center—An office responsible for remote testing of data service. Access to this office may be gained through a dedicated line or switched maintenance access system (SMAS) facilities.

Duplex Operation—The transmission of signals in both directions simultaneously.

Equal-Level Loopback—A circuit arrangement interconnecting the receive and transmit paths and correcting for any difference in the transmission level at the point of connection. This ensures that signals on the line are maintained at standard data level during loopback tests when a test signal at data level is applied toward a DSS or a 4-wire customer station.

Frame Signal—A signal from the DSS in the central office to the SCU at the master station to indicate the beginning of a connection cycle.

Half-Duplex Operation—The transmission of signals alternately in either direction, or for communication in one direction only, including bidirectional simultaneous transmission of tones required solely for control purposes or quick turnaround or synchronization.

Master Station—The station (containing CPE and SCUs) which controls the DSS operation and communicates with remote stations.

Polled Link—The transmission channel between a remote station channel termination and a DSS.

Polling Link—An end-to-end transmit-receive connection between the master station and a remote station.

Primary Link—The 4-wire transmission facility between the master station SCU and a primary DSS.

Remote Office Link—A polled link from a DSS to a remote station using interoffice facilities.

Remote Station—One of many remotely located stations on a multistation circuit that is connected to the master station by DSSs over a polling link.

Remote Test System (RTS)—A system that provides the remotely controlled equipment required to perform the testing functions of the switched access remote test system (SARTS).

SARTS—A standard remote one-person testing system developed for use during installation, trouble, and routine testing of special service circuits from a centralized test location.

Secondary Link—The 4-wire transmission facility between a primary DSS and a secondary DSS.

Selector Control Unit (SCU)—The equipment associated with one circuit located at the master station and used by the customer to transmit control signals to DSSs and receive supervisory signals from DSSs.

Sequential—A service offering to a customer in which the order of connections from the master station to the remote stations is fixed by assignment to the DSS output ports.

Serving Test Center (STC)—A designated office responsible for testing transmission facilities, station equipment, and central office equipment.

Special Service Center (SSC)—This is a test center with responsibility for coordination and control of customer service within a specific serving territory.

Switched Maintenance Access System (SMAS)—A relay switched access system for 2- or 4-wire circuits capable of being tested remotely. Tests can also be made locally using jack ports.

Transmission Level Point (TLP)—A reference level point on a circuit numerically equal to the algebraic sum of 1004-Hz gains and losses from an arbitrarily defined reference point (0-TLP) to the point of measurement.

TELEMETRY/ALARM BRIDGING SERVICE

DESCRIPTION

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1. GENERAL

1.01 This section provides the description of Telemetry/Alarm Bridging Service. Three types of bridging arrangements are described along with end-to-end transmission requirements and channel transmission requirements.

1.02 Whenever this section is reissued, the reason(s) for reissue will be given in this paragraph.

1.03 Telemetry/Alarm Bridging Service is designed to provide intercommunications between a master and up to 128 remote premises customer provided equipment (CPE) stations at low speed (400 b/s or less) data. Telemetry and alarm bridging can be provided in any one of three bridging arrangements, that is, passive bridging; split-band, active bridging; and summation, active bridging.

2. BRIDGING ARRANGEMENTS

2.01 Telemetry/Alarm Bridging Service requires the interconnection of various legs at common bridging points. A bridging point is a central office (CO) containing one or more bridges. A hub or primary bridging point may feed any number of secondary bridging points. A secondary bridging point may not feed another secondary bridging point. See Fig. 1. In order to achieve transmission stability, all circuit appearances or ports on a bridge (except split-band, active bridging) must be properly terminated when not in use.

2.02 Two types of bridges are used in telemetry and alarm services. The first, ***passive,*** is a bridging network without amplification. The second, ***active,*** is a bridging network with amplification.

2.03 Three bridging arrangements are used in telemetry and alarm services. The end-to-end transmission requirements are given in Table A. The three bridging arrangements are described as:

- ***Passive Bridging:*** A bridging system employing 2-wire, 10-port bridges with no amplification, resulting in a channel having relatively high loss, 2-wire, multipoint circuits between the customer master station and the remote premises.

- ***Split-Band, Active Bridging:*** A bridging system which divides the voiceband into two separate portions, one portion for each direction of transmission. Split-band, active bridging employs a 4-wire trunk between the master station and the bridge and employs 2-wire facilities between the bridge and the remote premises.

- ***Summation, Active Bridging:*** A unidirectional bridging system in which separate narrowband tones are transmitted from the remote premises and summed at a 2-wire bridge for introduction onto a 2-wire trunk between the bridge and the master station.

A. Passive Bridging

2.04 A typical system using passive bridging (Fig. 2) consists of a 2-wire voice frequency

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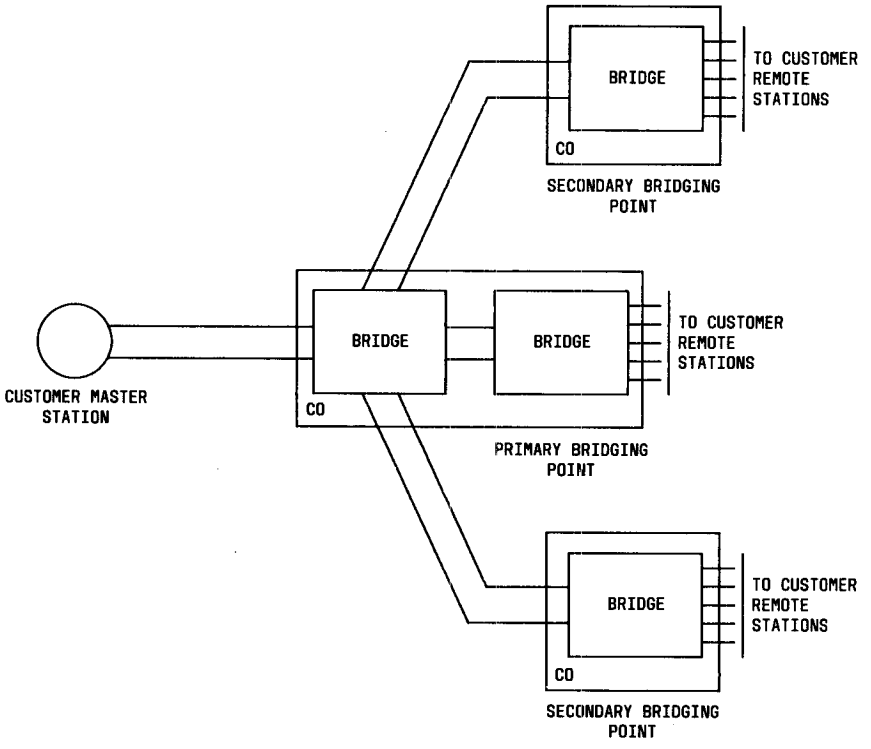


Fig. 1—Primary and Secondary Bridging Arrangement

(VF) facility from a customer master station to a 2-wire, 10-port passive bridge located in a telephone company (TELCO) CO. From the bridge, 2-wire VF facilities are distributed to nine remote customer locations. The system is referred to as passive bridging since the customer equipment is capable of receiving a signal at a very low level (less than -37 dBm) and, as a result, amplification by the TELCO is rarely required. Each of the remote customer locations will have a customer provided transponder capable of receiving and/or transmitting signals through the bridge to the master station. Each of these remote transponder locations may also house a customer provided regenerator which is capable of extending the bridging network (Fig. 3) to another 2-wire, 10-port bridge by regenerating and retransmitting the signals between the master station and the remote stations. In this way, 2-wire, 10-port bridges may be cascaded to support large customer bridged networks of 100 or more locations. (See Note.) In a passive bridging system, signals transmitted from any customer location (master station or remote premises) will be received at all other locations.

> ***Note:*** In a passive bridging network, although bridges may be cascaded, the Bell System does not assure transmission between bridges.

2.05 A typical master station transmits a remote station address code using the presence or absence of a 2740-Hz tone. Each remote transponder, upon receiving its address code responds with a code using one of four discrete frequencies. The transmit level of the signals from the master station or remote stations will be 0 dBm into 600 ohms, and the customer equipment is designed to operate with a receive level as low as -53 dBm into 600

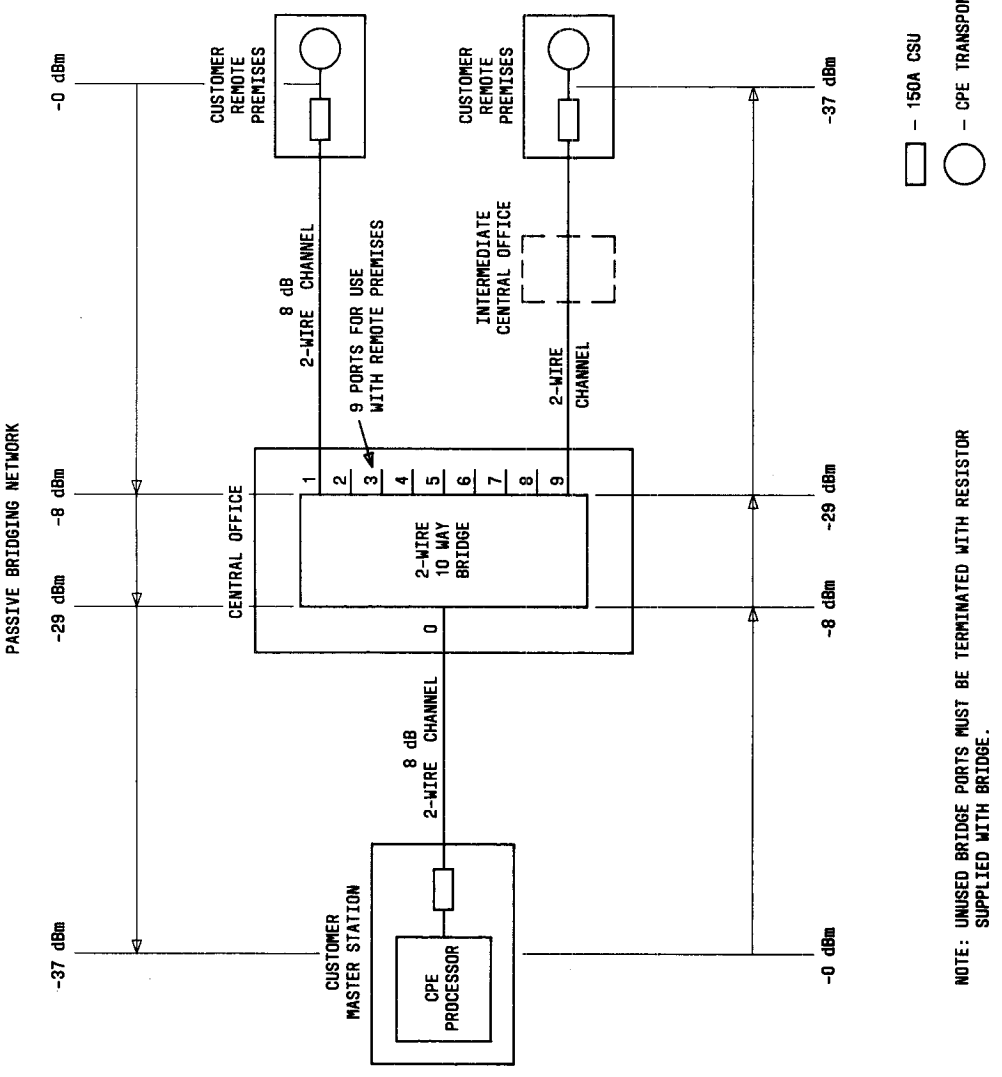
TABLE A

END-TO-END TRANSMISSION REQUIREMENTS

TYPE BRIDGING	CIRCUIT LOSS (NOTE 1)	LONG TERM VARIATION (NOTE 1)	LOSS VERSUS FREQUENCY (500 to 2800 HZ)	ENVELOPE DELAY DISTORTION	IMPULSE NOISE (NOTE 2)
Passive	37 dB ± 0.5 dB	±4 dB	−4 to +16 dB	Not Required	15 Hits
Active, Split Band	16 dB ± 0.5 dB	±5 dB	−4 to +14 dB	Not Required	15 Hits
Active, Summation	16 dB ± 0.5 dB	±5 dB	−4 to +16 dB	Not Required	15 Hits

Note 1: Total fixed 1-KHz end-to -end loss between the master station and any remote station.

Note 2: Measurement made with a threshold of 64 dBrn at each station for a 15 minute period.



NOTE: UNUSED BRIDGE PORTS MUST BE TERMINATED WITH RESISTOR SUPPLIED WITH BRIDGE.

Fig. 2—Passive Bridging Network

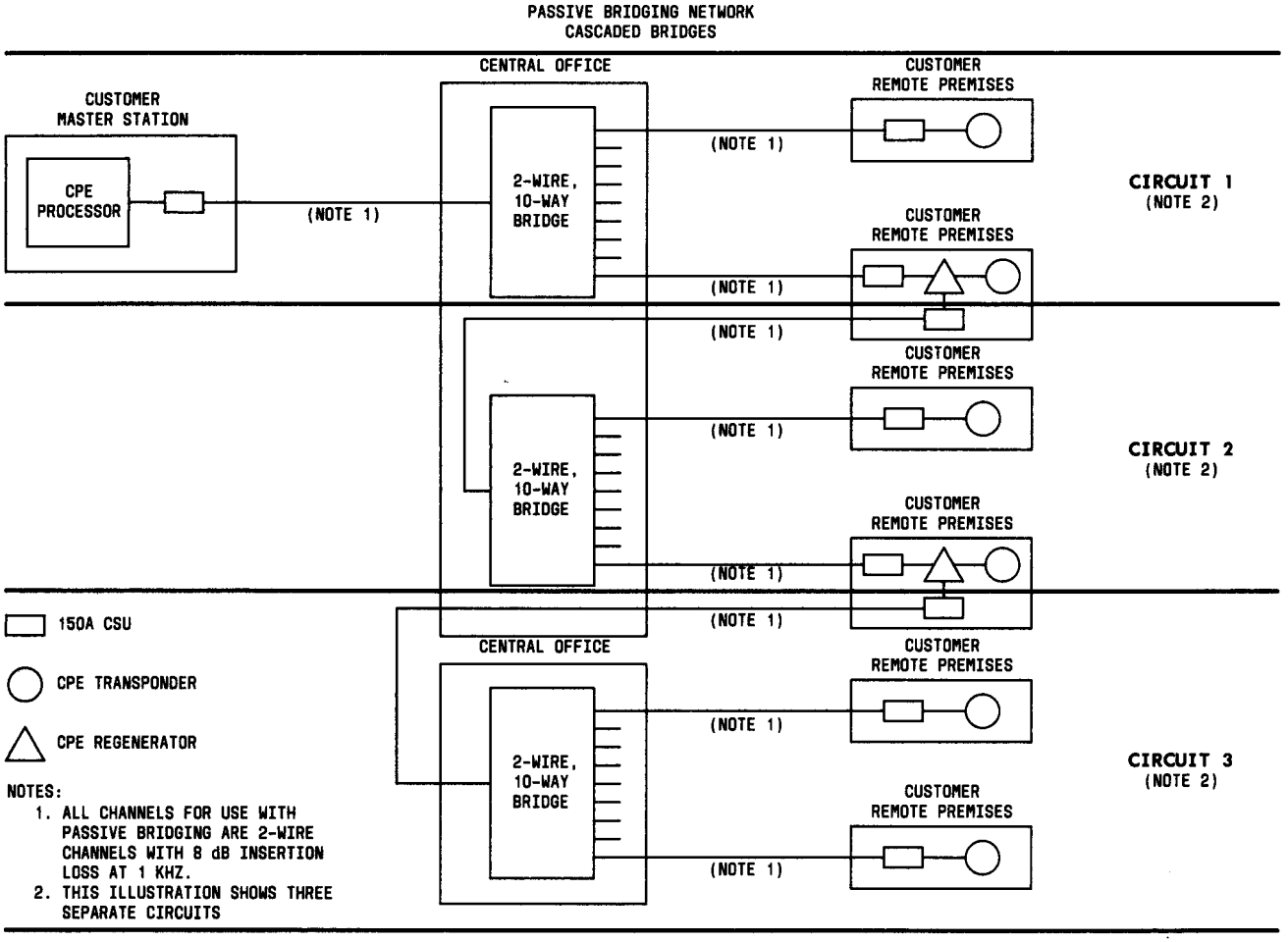


Fig. 3—Passive Bridging Network, Cascaded Bridges

ohms at 2740 Hz. In those cases where the remote signals are being regenerated, the total transmit signal power of the regenerated signals shall not exceed 0 dBm. In the case of four tones being regenerated simultaneously, each tone shall not exceed -6 dBm; the composite power of four -6 dBm tones equals 0 dBm. Where the terminal equipment is capable of transmitting a maximum of 25 different interrogation codes (with four transponder frequencies available), the system is limited to a maximum of 100 remote locations per multipoint network.

2.06 The passive bridge is a frame mounted 2-wire, 10-way resistive bridge available from various outside suppliers as defined in the Bell System's Product Evaluation Report (PER) No. 10. Copies of the PER are maintained at the headquarters of AT&T, Long Lines, and each Bell Operating Company. The passive bridge is typically a 600- or 900-ohm device consisting of ten transformer isolated ports with an insertion loss of approximately 21 dB at 1 kHz between any two ports with all ports properly terminated.

B. Split-Band, Active Bridging

2.07 A typical system using split-band, active bridging (Fig. 4) will consist of a 4-wire VF facility from the customer master station to a split-band, active bridge located in a TELCO CO. Using interchangeable filters located in the bridge, the transmission path through the bridge is divided into two portions, and these two portions are applied to the 2-wire facility from the bridge to the remote premises. Typically the band is divided around 1600 to 1800 Hz. One portion of the voiceband is used for signaling from the master station toward the remote premises transponders, and the other portion of the voiceband is used for responses from the remote premises transponders toward the master station. With the split-band, active bridge, a signal from the master station is broadcast to all remote stations; however, signals transmitted from the remote premises are received only by the master stations.

2.08 In addition to serving remote premises over 2-wire facilities, it is also possible, at the primary bridge location, to extend the 4-wire facility to other central offices where additional bridges may be added (secondary bridges).

2.09 A typical master station designed to work with the split-band, active bridging arrangement transmits a remote station address code using a frequency shifted tone of perhaps 1350 Hz. Each customer provided remote transponder, upon receiving its address code, responds with a frequency shift keying (FSK) signal in the upper half of the voiceband. The transmit level from the master station or the remote premises transponder is designed to be 0 dBm into 600 ohms, and the customer equipment is designed to operate with a receive level of -16 dBm into 600 ohms.

2.10 The split-band, active bridge is typified by a bay mounted, modular bridge wired with appropriate cable to the main distributing frame. These bridges are available from various outside suppliers as defined in PER No. 397. A typical split-band, active bridge mounting shelf is capable of supporting a distribution card, a summation card, and a variable number of 2-wire port termination cards. The distribution card will terminate the receive side of the 4-wire facility from the customer master station, will provide level adjustment and equalization, and will include one band-splitting filter. The summation network terminates the transmit side of the 4-wire facility to the customer master station, provides level adjustment and equalization, and includes the second band-spliting filter. The 2-wire port termination cards will provide 2-wire, transformer coupled terminations for a number of 2-wire facilities and will interface 2-wire facilities to the 4-wire trunk via a resistive network.

C. Summation, Active Bridging

2.11 Summation, active bridging (Fig. 5, 6, and 7) is a system which uses 1-way transmission from the remote customer premises through the bridge or bridges to the customer master station.

2.12 In a typical system using summation, active bridging, the customer master station and remote premises will all be connected to a CO located bridge via 2-wire VF facilities. In summation, active bridging, each remote customer premises continuously transmits a single narrowband tone through the bridge to the master station. The individual tone transmitted by each remote premises is not transmitted by any other remote premises on the bridge network. Absence of the tone at the master station would normally indicate a problem at the remote premises. With summation,

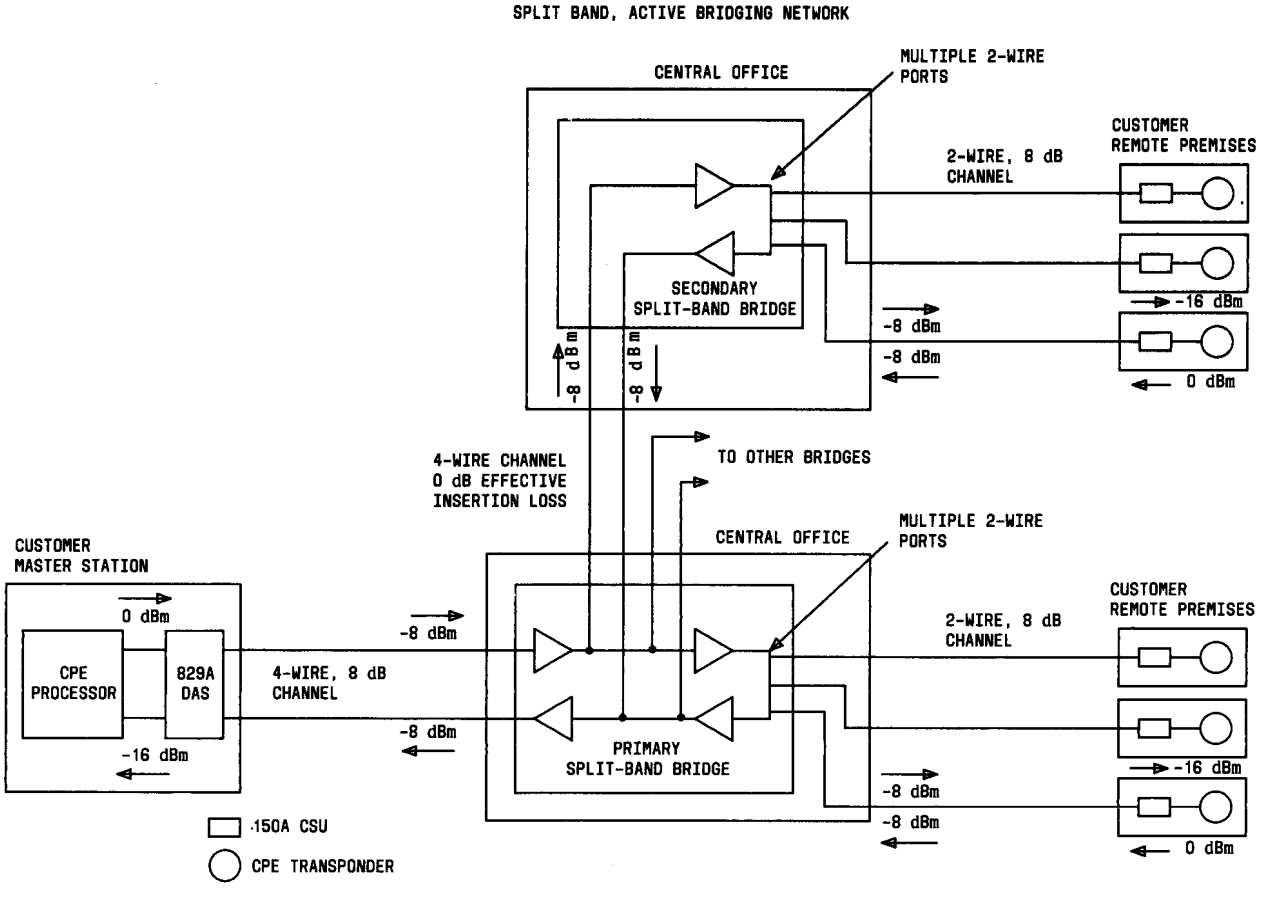


Fig. 4—Split-Band, Active Bridging Network

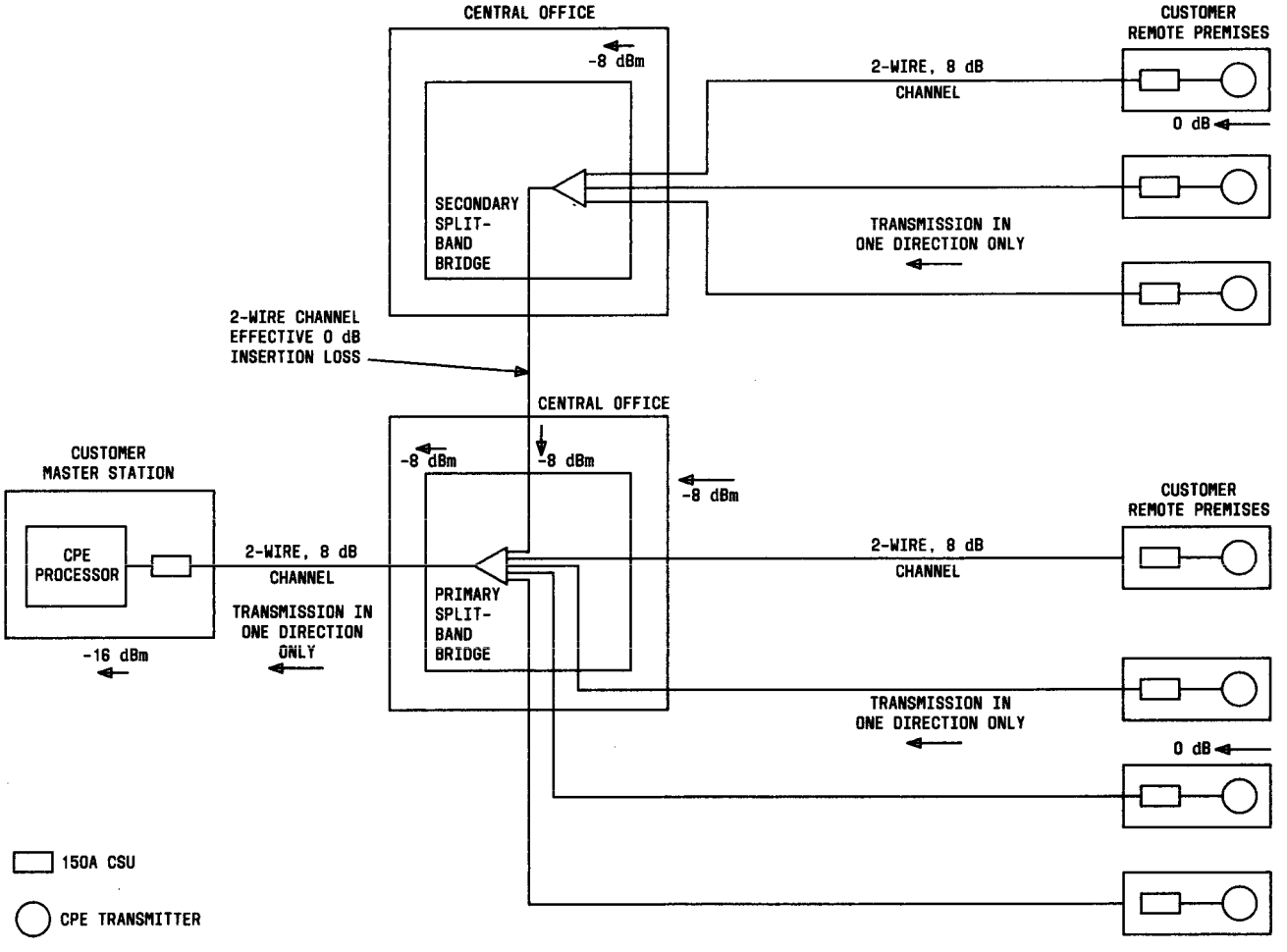


Fig. 5—Summation, Active Bridging Using Split-Band Bridging Equipment

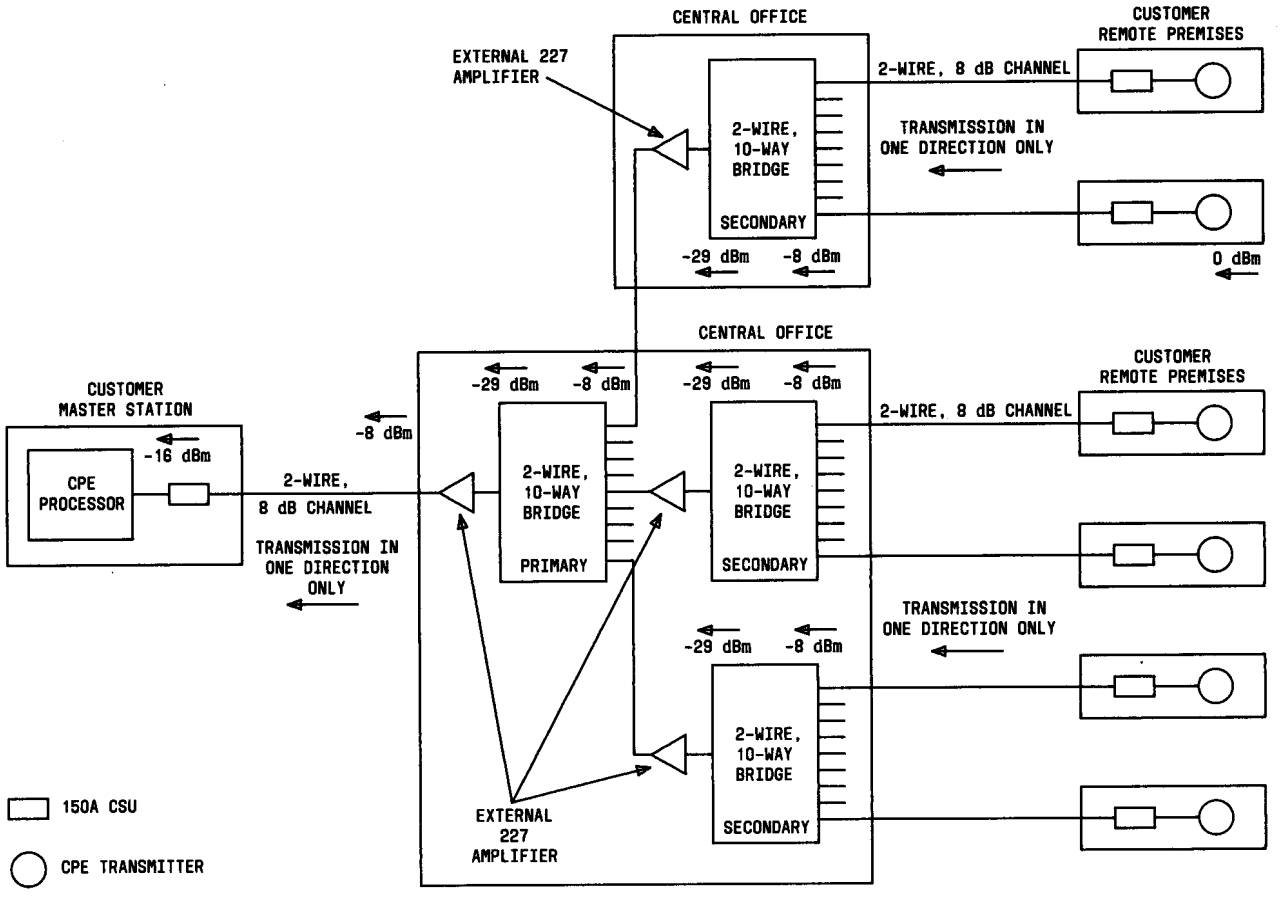


Fig. 6—Summation, Active Bridging Using Passive Bridging Equipment

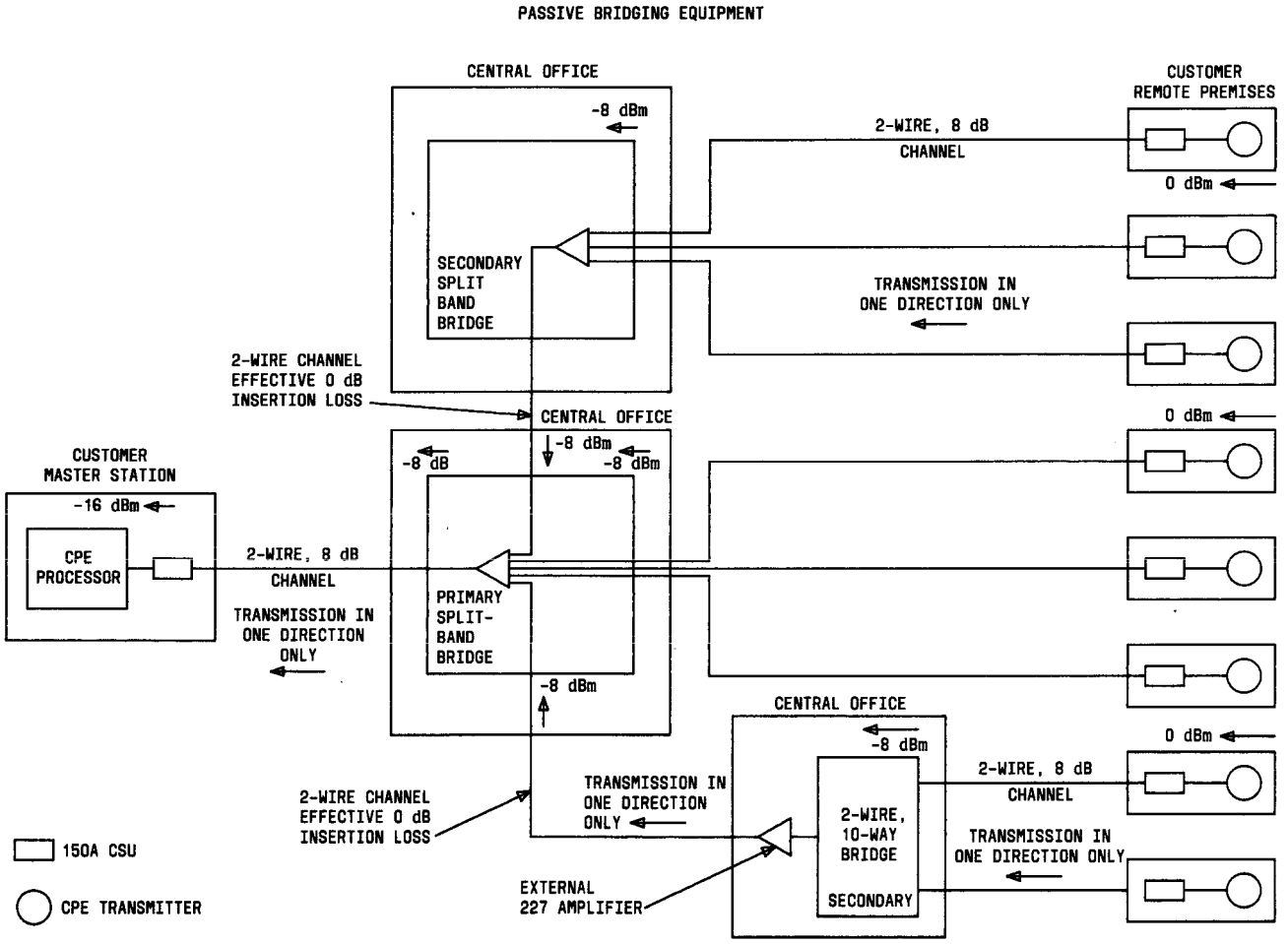


Fig. 7—Summation, Active Bridging Using A Combination of Split-Band and Passive Bridging Equipment

active bridging, the bridge may be tandemed, ie, the signal from a remote premises may be fed through the bridge on which that premises is terminated to another bridge on which the master station is terminated. In this manner a signal from a remote premises may pass through more than one bridge.

2.13 A typical master station designed for use with summation, active bridging may have 60 individual tone sources (and thus a maximum of 60 customer remote premises) connected to a single multipoint network. The transmit level of each of the 60 tones at the remote location would be -18 dBm into 600 ohms. (The CPE is designed to meet this requirement.) Therefore, when the 60 tones are composited at the bridge, the total power will not exceed 0 dBm. The overall network is designed for 16-dB loss at 1000 Hz end-to-end; therefore, each individual tone is received at the master station at approximately -34 dBm. At the master station, the customer provided receiver continuously monitors for presence of each individual tone. Absence of an assigned tone would normally indicate a problem at the remote premises.

2.14 Summation, active bridging is a special application of the equipment used to provide either passive or split-band, active bridging. When using split-band bridging equipment for summation bridging, the mounting, the summation card (without band splitting filters), and the 2-wire port cards would be required. The distribution card would not be required since transmission is in one direction only. Using the passive bridging equipment for summation bridging, an external 227 or metallic facility terminal (MFT) type amplifier would be required on the master station side of the 2-wire, 10-way bridge. This amplifier would be required to compensate for the loss through the bridge. The passive equipment would otherwise be the same as that used to provide passive bridging.

3. CHANNEL ARRANGEMENTS

3.01 After the initial bridge has been installed, end-to-end measurements need not be made again except in trouble conditions. When adding bridges and/or remote stations, only those additional segments need be tested. There are four channels used in telemetry and alarm services. They are:

- Two-wire, 8-dB channel — The only channel type used to provide passive bridging. In split-band, active bridging, this channel is used between the bridge and the remote premises. In summation, active bridging, this channel is used between the bridge and the master station or remote premises.

- Four-wire, 8-dB channel — Used in split-band, active bridging between the master station and the bridge.

- Two-wire, 0-dB (effective) channel — Used between bridges in summation, active bridging.

- Four-wire, 0-dB (effective) channel — Used between tandemed split-band, active bridges.

The transmission requirements of each channel are given in Table B.

3.02 The 2-wire, 8-dB channel from a design standpoint is very similar to the type 40 channel used in DATAPHONE® Select-A-Station Service (DSAS). The major difference is that the type 40 channel is a 12-dB channel instead of 8 dB; however, more than 90 percent of the loops will be less than 6.8 dB [8.0 dB minus the minimum insertion loss of a 150A channel service unit (CSU)]. Therefore, the only difference between the type 40 channel and this channel would be, in the majority of cases, the loss adjustment in the 150A CSU.

3.03 The 4-wire, 8-dB channel from a design standpoint is exactly the same as the type 41 channel used in DSAS. The channel will terminate at the customer premises in an 829A data auxiliary set (DAS), will receive a 0-dBm transmit level from the customer, and will present a -16 dBm receive level to the customer.

3.04 The 2-wire, 0-dB channel is used between summation bridges. The amplifier associated with the secondary bridge is an integral part of this channel. This amplifier is set to compensate for the loss through the secondary bridge and the channel. The level at the input of the primary bridge must be the same as the receive level at the secondary bridge. This level will be the same level as that of a remote premises channel terminating directly on the primary bridge (-8 dBm).

3.05 The 4-wire, 0-dB channel is for use between split-band bridges. Here again, the amplifiers associated with the bridge are an integral part of the channel, compensating for the insertion loss of the channel and providing compatible levels at the bridge.

TABLE B

CHANNEL TRANSMISSION REQUIREMENTS

TYPE CHANNEL	1-KHZ LOSS	1-KHZ LOSS LONG TERM VARIATION	LOSS VERSUS FREQUENCY	NOISE	
				C-NOTCHED	IMPULSE (NOTE 1)
2-Wire, 8 dB	8.0 dB ± 0.5 dB	±2.0 dB	500 to 2800 Hz −2.0 dB to +8.0 dB*	31 dBrnc	5 Counts†
4-Wire, 8 dB	8.0 dB ± 0.5 dB	±2.0 dB	500 to 2800 Hz −1.0 dB to +3.0 dB 300 to 3000 Hz −2.0 dB to +6.0 dB	31 dBrnc	5 Counts†
2-Wire, 0 dB	0 dB (effective)‡	±1.0 dB	500 to 2800 Hz −1.0 dB to +3.0 dB 300 to 3000 Hz −2.0 dB to +6.0 dB	31 dBrnc	5 Counts §
4-Wire, 0 dB	0 dB (effective)¶	±1.0 dB	500 to 2800 Hz −1.0 dB to +3.0 dB 300 to 3000 dB −2.0 dB to +6.0 dB	31 dBrnc	5 Counts §

Note 1: Measurement made for 5 minutes.

* When used for summation master station channel, 500 to 2800 Hz limits are −1.0 dB to +3.0 dB.

† Measurement made with a threshold of 64 dBrn.

‡ The gain of the amplifier associated with the secondary bridge should be adjusted to compensate for the insertion loss of the interbridge facility and any losses in the secondary bridge. Therefore, the signal level at the input to the primary bridge will be the same as the input at the secondary bridge (−8.0 dBm).

§ Measurement made with a threshold of 72 dBrn.

¶ The gain of the amplifier associated with the secondary bridge should be adjusted to compensate for the insertion loss of the interbridge facility and any losses in the secondary bridge. The transmit and receive levels between the bridges should be compatible with the interoffice facility requirements.

PROTECTIVE RELAYING CHANNEL

DESCRIPTION

CONTENTS PAGE

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2. TYPES OF ARRANGEMENTS 3
3. TRANSMISSION PARAMETERS 4
4. INITIAL LINEUP 10
5. REFERENCES 11

1. GENERAL

1.01 ▶This section provides information on the protective relaying (PR) channel, which is a voice grade private line channel specifically designed for power industry audio tone protective relaying applications. ***If this channel is not to be used for audio tone PR applications, do not use the channel design specified in this section; instead, use the design specified in Section 880-420-100.***◀

1.02 This section is reissued to include a discussion of:

(a) The optional 8 dB PR channel

(b) SARTS and SMAS test access points

(c) Impulse noise as a transmission parameter in the PR channel.

1.03 PR is the art of protecting a power system during a fault condition. The power system fault may be due to any number of causes, such as lightning striking a high-voltage transmission line, or insulation problems in a piece of power system equipment, such as a generator or transformer. The term "protective relaying" is derived simply from the name of the major items in a PR system, namely the various fault sensing relays (protective relays), which detect abnormal conditions for parameters such as voltage, current, or temperature. The relays can be simple or complex devices, but all operate to provide a relay contact closure that acts as a control. This control is used to operate circuit breakers remotely and thus protect the power system by fault isolation.

1.04 In general, the term "protective relaying" implies the total arrangement of all relaying devices needed to protect the total customer-owned power system. However, in this section, the term "protective relaying" will refer to the protection of high-voltage transmission line sections. For all practical applications, this is the only area of protective relaying in which telephone company communication channels are used. The PR channel as used in this section is the voice-frequency channel used to transmit tone signals from one point to another.

1.05 Below are terms and definitions that may help clarify the explanation of the PR channel. Figure 1 gives an example of the terms below:

(a) ***Guard tone:*** A single-frequency tone applied at one PR terminal, transmitted over the PR channel, and received at the distant PR terminal to indicate circuit continuity, to inhibit false operation of the protective relaying equipment at the receiving end, or both.

(b) ***Enhanced trip signal:*** A trip signal of short duration (about 70 ms) may be transmitted at a much higher level than the guard signal. This signal operates relay circuitry in the receiver to activate circuit breakers to remove the high-voltage line from service. By transmitting at a higher power level, the signal-to-noise (S/N) ratio is improved.

(c) ***Trip hold signal:*** A trip signal that is transmitted after the enhanced trip signal.

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The trip hold signal will be transmitted as long as the fault condition exists or until the terminal is reset.

1.06 When power transmission lines experience a fault, regardless of the cause, a PR terminal will receive an alerting signal (Fig. 1) from the power company fault-detecting equipment. It is the function of the PR channel (which is terminated at both ends by a PR terminal such as the Western Electric 1A PR terminal) to transmit this trip signal to a distant location. At the distant location the trip signal may be employed by the power company to de-energize the defective power transmission line(s).

1.07 This channel is intended to provide improved ***reliability*** for PR systems during the power fault interval, exceeding that which can be obtained from other voice bandwidth private line channels. "Reliability," as used in this section, means both dependability and security. Dependability is the degree of assurance of delivering valid trip signals, and security is the degree of assurance of avoiding delivery of false trip signals.

1.08 One of the unique problems inherent in providing communication service to power stations is the severe noise signals that are frequently introduced into cable facilities during power faults. This noise is often responsible for inhibiting the reception of valid trip signals during the most critical interval. Thus the degree of dependability can be reduced by noise generated during fault intervals. This noise is also responsible for causing undesired trip signals when the fault involves other power facilities, thereby reducing the security of the channel.

1.09 The improved dependability of this channel is the result of a basic improvement in the S/N ratio of the received trip signal. This improvement is accomplished by the following means:

- Selective placement of gain and loss devices

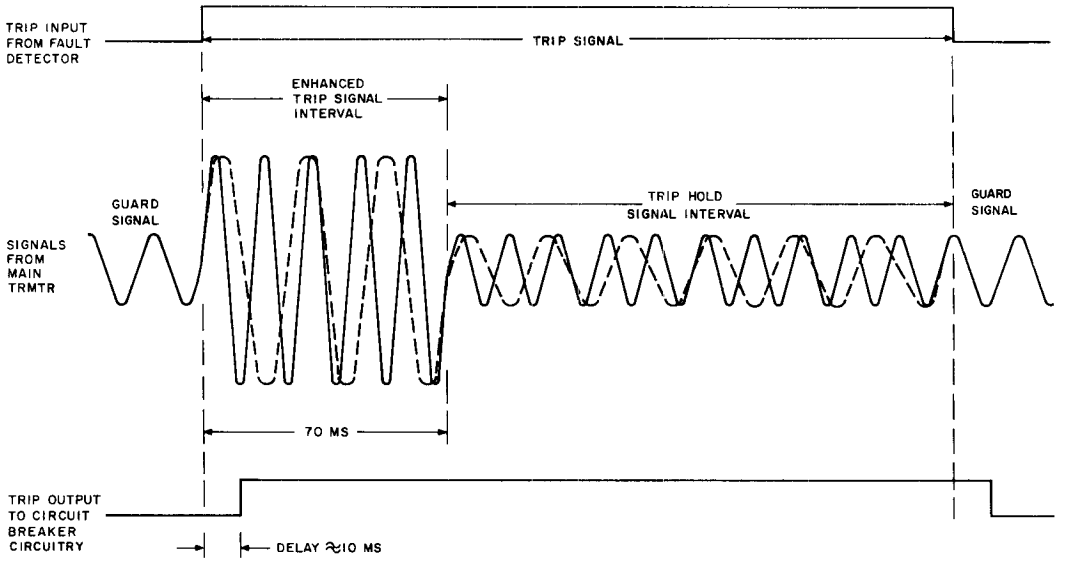


Fig. 1—Example of Signal Format for PR Channel

- Selection of cable facilities with improved resistance balance
- ▶Transmission of an enhanced trip signal.

1.10 The standard net loss of the PR channel is 16.0 dB. An optional channel with 8.0 dB net loss will be provided upon customer request subject to the conditions described in 3.02. For channels having either the standard or optional net loss, any necessary gain or loss devices are installed at locations that insure a true improvement in the S/N ratio.◀ For example, receiving amplifiers are not located at power stations since they would amplify undesirable noise generated in the cable from the central office to the power station as well as the incoming signal. This would degrade the S/N ratio and therefore should be avoided.

1.11 ▶***It is essential that the PR channel be terminated in power station locations using arrangements of 44V4 or equivalent equipment (see Fig. 2 and 3). Channel terminating arrangements with such devices as Data Auxiliary Sets (828-type or 829-type), 150A Channel Service Units, 31B Voice Couplers, or Metallic Facility Terminal (MFT) equipment must not be employed.***◀

1.12 The conversion of longitudinal noise voltage to metallic noise voltage is directly dependent on the resistance balance of the cable pairs serving the power stations. Therefore, to minimize metallic noise voltage, cable facilities with better than average resistance balance will be employed. The resistance unbalance of the local portion of a PR channel must be 1 percent or less.

1.13 The employment of enhanced trip signals to improve the S/N ratio may result in adjacent channel interference. To minimize this interference, restrictions on signal levels, duration of signals, and frequency of occurrence are placed on the use of enhanced trip signals. The transmitted inband signal power, averaged over any 3-second interval, must not exceed 0 dBm. The short-term power limitation sets the maximum power at +16 dBm (rms), but it should be noted that signal peaks that exceed a +12 dBm sine wave may experience clipping. Because of the possible interference to adjacent lines, the number of enhanced trip signals that may be transmitted for testing is limited to seven occurrences per week. An occurrence is defined as an enhanced signal transmission within a 3-second interval. The number of actual trip signal transmissions over the PR channel will depend on the number of power fault occurrences and hence cannot be defined.

1.14 On the other hand, the use of enhanced trip signals increases dependability, which results in the prompt de-energization of the power line that has the fault condition. This minimizes the period during which interfering noise from power line faults can be introduced into the telephone cable plant. Therefore, the net effect on adjacent channels from the employment of enhanced trip signals is beneficial.

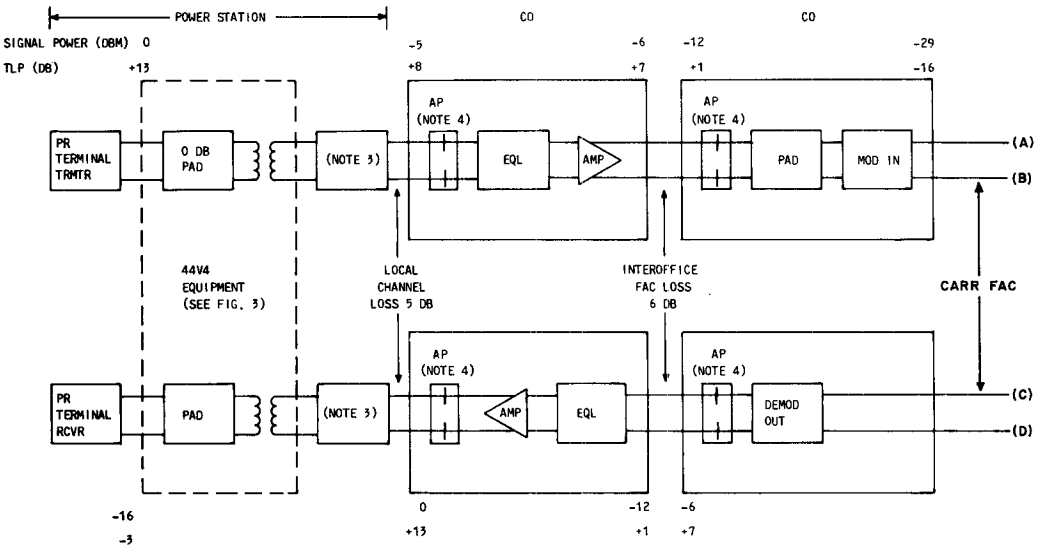
2. TYPES OF ARRANGEMENTS

2.01 The PR channel can be used in several different system arrangements, depending on application requirements. Basically, there are two circuits: either one-way, using two wires; or 2-way, using four wires. The one-way, 2-wire system can only transmit in one direction. This system would be similar to one-half of the 4-wire PR system shown in Fig. 2.

2.02 Each circuit can be used in 2-point or multipoint configurations. The 2-point circuit shown in Fig. 2 and 3 consists of two direct transmission paths, whereas the multipoint circuit in Fig. 4 is slightly more complex. (Figure 3 shows the equalization employed at the terminal location on a 2-point circuit. Similar equalization arrangements may be provided for multipoint circuits). The local portion of the PR channel is not limited to 4-wire in multipoint operation. At each location, a pair exists for each transmitter and each receiver. The number of receivers depends on the number of distant locations—one receiver for each distant location. For example, each location in a 3-point symmetrical system would have two receivers and three pairs of wires. An example of this multipoint system is shown in Fig. 4.

2.03 Variations and combinations of the 2-point and multipoint circuits may be arranged where necessary to satisfy requirements. The channel may be nonsymmetrical where transmission is in only one direction between certain points.

2.04 ▶Switched Maintenance Access Systems (SMAS) provide access for testing PR channels at central office locations either locally or by the Switched Access Remote Testing System (SARTS). Fig. 2 and 4 show the central office locations for



NOTES:
1. 2-POINT, 2-WIRE LAYOUT IS SAME AS ONE HALF OF THIS LAYOUT.
2. THE 16-DB LOSS FROM PR TERMINAL TRANSMITTER TO PR TERMINAL RECEIVER IS MADE UP OF FACILITY LOSS, TRANSFORMER LOSS, EQUALIZATION LOSS IN 44V4 EQUIPMENT, AND PAD LOSS.
3. TWO TYPES OF INTERFACES ARE POSSIBLE AT THIS POINT. THEY ARE: AN ISOLATION TRANSFORMER OR A NEUTRALIZING TRANSFORMER. THEY MAY BE MOUNTED IN A HIGH VOLTAGE INTERFACE UNIT WHICH IS PART OF THE INTERGRATED PROTECTION SYSTEM. BOTH INTERFACES ARE OPTIONAL; THEREFORE IN SOME CASES ONLY A DIRECT PATH MAY EXIST.
4. SMAS ACCESS POINTS - REFER TO SECTION 667-302-102, 667-302-103, 667-302-200 AND 667-303-102 FOR ACCESS CODES, ORIENTATION CODES AND OTHER INFORMATION. THESE ACCESS POINTS MUST BE FLAGGED AS SPECIAL AT TIME OF INSTALLATION. REFER TO BSPS FOR FLAGGING TECHNIQUE. SEE 2.04.

Fig. 2—Typical 2-Point, 4-Wire Layout for Standard 16 dB PR Channel (Sheet 1 of 2)

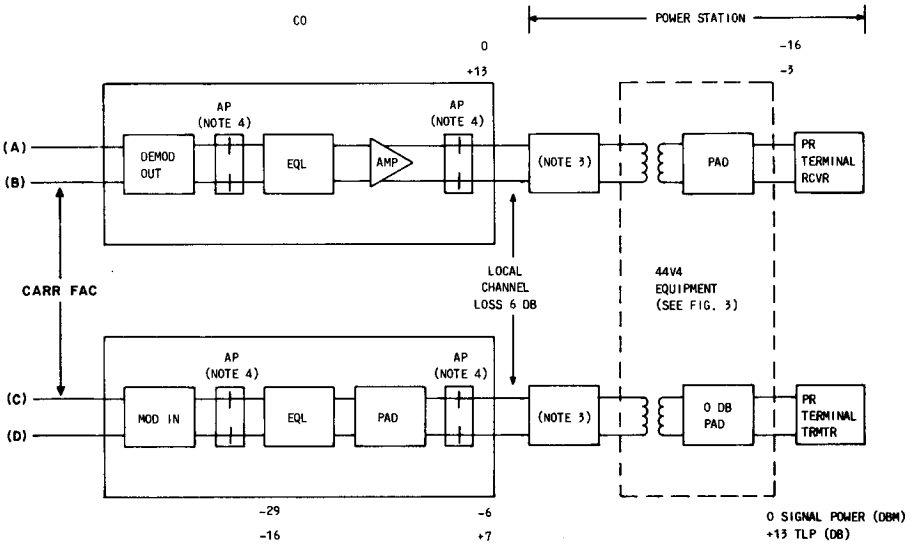


Fig. 2—Typical 2-Point, 4-Wire Layout for Standard 16 dB PR Channel (Sheet 2 of 2)

the minimum number of access points required to take full advantage of the trouble sectionalization capability of SARTS. SMAS access is not applicable to customer premises—see following information. Additional SMAS information is available in Sections 667-302-102, 667-302-103, 667-302-200, and 667-303-102.

CAUTION: All tests on this channel must be performed on an out-of-service basis; no test shall be performed on this channel unless prior coordinated approval for circuit turn-down has been given by the authorized power utility personnel.

3. TRANSMISSION PARAMETERS

3.01 The facility parameters covered in this part represent the minimum limits to which the PR channel must be maintained. The limits specified are somewhat different in certain areas from the usual voice grade private line transmission specifications. The differences are due to the particular requirements for the PR systems. Table A provides a summary of the transmission parameters that are covered in more detail in the following paragraphs.

3.02 The engineered standard net loss of the PR channel is 16.0 dB at 1000 Hz. As an option, however, a PR channel having an engineered net loss of 8.0 dB at 1000 Hz will be provided upon customer request subject to the availability of suitable local facilities. Accordingly, the 8.0 dB channel will be provided only if the loss of the normally available local loop in the receive leg (including loop loss from the serving central office, high voltage protection transformer loss, circuit terminating transformer loss) does not exceed 8.0 dB. For either the standard or optional net loss channel, a loss variation of ±1 dB is permitted at the time of initial installation. Short-term (meaning a few seconds or less) loss variations may be caused by dynamic regulation of carrier system amplifiers and some maintenance activities. This variation in the channel loss should not exceed ±3 dB. Long-term (meaning periods of days, weeks, or even longer) loss variations are primarily caused by temperature changes affecting local plant, component aging, and amplifier drift. Long-term loss variations should not exceed ±4 dB.

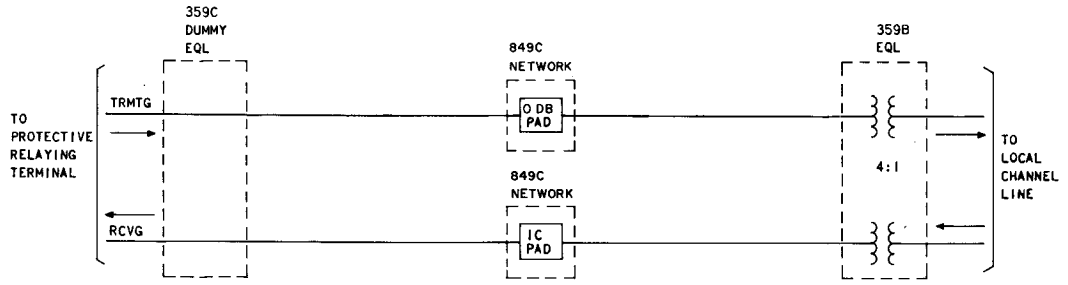
3.03 Attenuation distortion is the difference in the response of a channel at any two frequencies. It is specified by placing a limit on the maximum loss at any frequency in a specified band of frequencies with respect to the loss of a 1000-Hz reference frequency. The loss may vary from -2 to +6 dB compared with the loss at 1000 Hz in the frequency band between 300 and 3000 Hz. For the frequency band between 500 and 2800 Hz, the loss may vary from -1 to +3 dB compared with the loss at 1000 Hz.

3.04 Envelope delay distortion is an indirect measure of nonlinearity of the phase characteristics of a circuit. An indirect measure is used because of the difficulty of measuring phase directly. The measured envelope delay distortion for a circuit is the maximum envelope delay minus the minimum envelope delay within the frequency band of interest. For this channel, the envelope delay distortion must be less than 2000 μs over the frequency band between 800 and 2600 Hz.

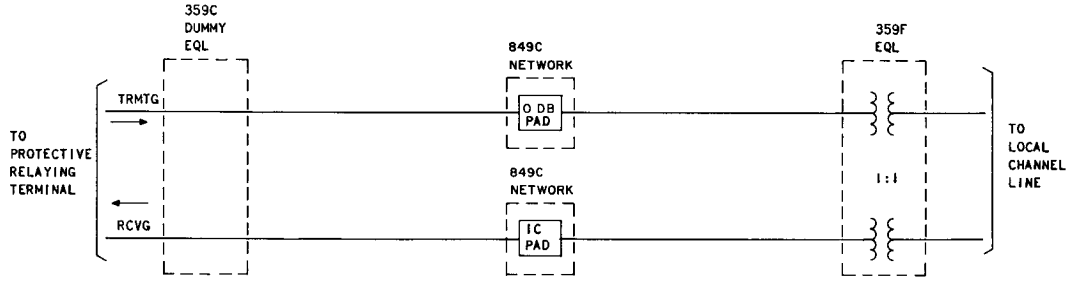
3.05 Message circuit noise is the noise on a channel in the absence of a signal. The measurement of this noise is called C-message noise because it is passed through a C-message weighting network before being measured at the receiving end. Limits for C-message noise at the receiving end are given in Table A.

3.06 The C-message noise described above is not necessarily the noise experienced when a signal is present. Quantizing noise in digital carrier systems and the effect of compandors in both analog and digital systems result in signal-dependent noise. Because this noise depends on the presence of a signal, it is impossible to approximate the S/N ratio from the received level and C-message noise measurements alone. For long-haul analog systems that are noncompandored, the received level and C-message noise measurement give a good approximation of the S/N ratio.

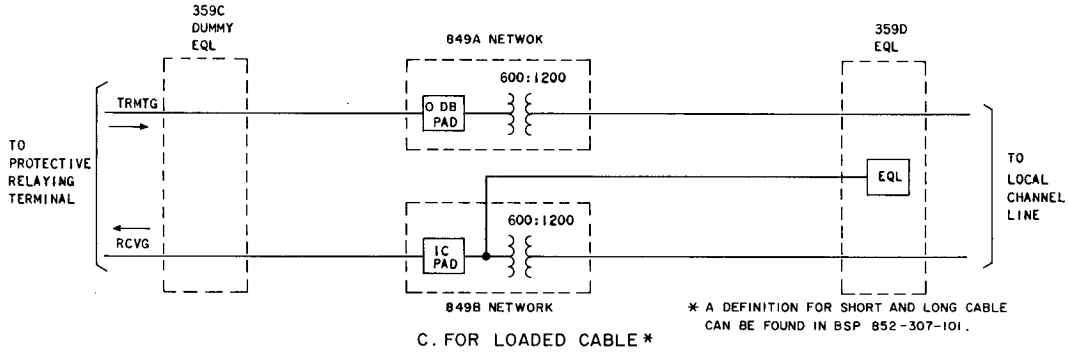
3.07 C-notched noise is a measurement of the amount of noise on a channel when a signal is present. In making this measurement, a single-frequency holding tone is applied at 0 dBm at the transmitting end of the PR channel to simulate a signal. This tone operates compandors and other signal-dependent devices. At the receiving end, the tone is removed by a narrow band elimination filter (notch filter), and the noise is then measured through a C-message filter. The ratio of the received 1000-Hz power to the C-notched noise is a good approximation of the S/N ratio.



A. FOR LONG NONLOADED CABLE*



B. FOR SHORT NONLOADED CABLE*



* A DEFINITION FOR SHORT AND LONG CABLE CAN BE FOUND IN BSP 852-307-101.

C. FOR LOADED CABLE*

Fig. 3—44V4 Equipment Arrangement

The limit of S/N ratio is 24 dB. ▶For a standard 16 dB channel, assuming the transmitted signal power of a 1000-Hz test signal is 0 dBm and the received signal power is -16 dBm (74 dBrnC), the C-notched noise will be at least 24 dB less (50 dBrnC or less) at the receiver. For an 8.0 dB channel, if the transmitted signal power of a 1000 Hz test signal is 0 dBm and the received signal power is -8 dBm (82 dBrnC), the C-notched noise will be at least 24 dB less (58 dBrnC or less) at the receiver.

3.08 Impulse noise is characterized by large peaks or impulses in the total noise waveform. It is measured with an instrument which responds to noise waveform excursions above a selectable power threshold using a counter having a maximum counting rate of 7 counts per second. Measurements are made through a C-message filter. A holding tone which is transmitted to activate any compandored facilities in the channel is notched out at the receiver. The impulse noise measurement for the PR channel involves counting the number of noise peaks exceeding a threshold numerically 6 dB below the received test tone power. In addition, counts are made of the number of noise peaks exceeding thresholds which are 2 dB below and 2 dB above the received test tone power. Limits for impulse noise at the receiver are given in Table A.◀

3.09 Single-frequency (SF) interference is defined as the presence of spurious or interfering tones with a received signal. It can usually be detected by a simple listening test. The human ear can detect an interfering tone if its level is within 3 dB of the desired signal. A listening test in the presence of the desired signal is required to detect spurious tones generated as a result of the signal. For such interfering tone, an alternate method may be used employing the C-notched noise measurement technique. A listening test made after the suppression of the holding tone will reveal the presence of any tones. In either case, a signal should be applied to the circuit to condition compandors to their normal operating point. If the presence of SF interference is detected by the listening test, further tests using a frequency selective voltmeter, or equivalent, are usually necessary to determine the frequency and level of the interfering tone. SF interfering tone appearing on the PR channel should be less than the limits given in Table A.

3.10 Most long-haul carrier systems operate in a single sideband suppressed carrier mode. Because the carrier is not transmitted and must be reinserted at the receiving end, there may be a slight difference in frequency between the modulating and demodulating carriers. The resulting frequency shift contributes a constant change at all frequencies in the voiceband. The frequency shift limit for the overall channel is ±5 Hz, although it is very unusual for this limit to be approached.

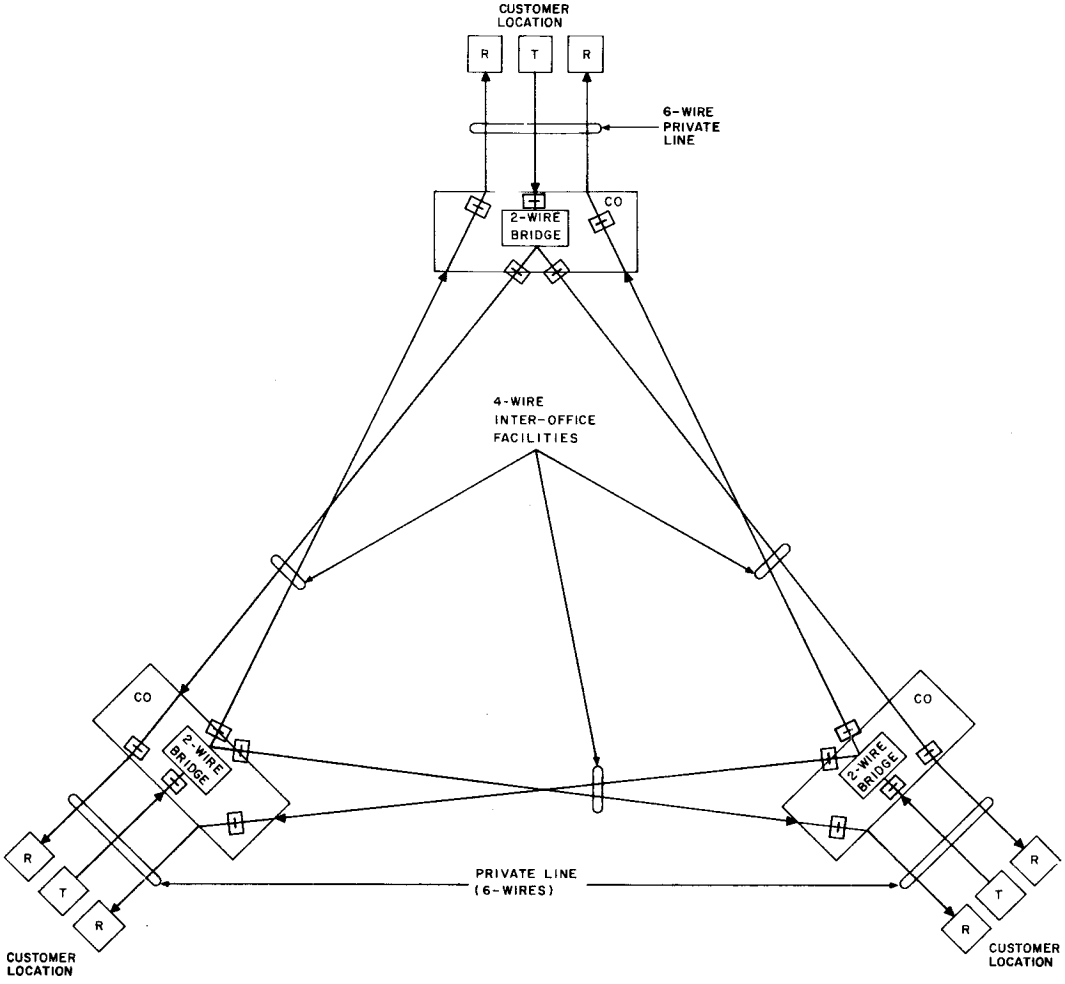
3.11 During power fault conditions, longitudinal voltages of large magnitude may be induced in the local channels serving power stations. When terminated by a well-balanced, protected repeat coil, the conversion from longitudinal to metallic voltage depends primarily on the resistance of the cable facility serving the power station. The resistance unbalance of the local channel cable pairs provided for PR channels must be 1 percent or less.

4. INITIAL LINEUP

4.01 The parameters of the PR channel described above are actually requirements that must be met for the PR channel to provide communication for protection of the customer's high-voltage lines. Some of these requirements are engineered into the channel at the time of design and layout of the circuits. Other requirements must be met by adjustments that are made by the operating personnel at the time the circuit is to be turned up for service.

4.02 For initial lineup, the measurement of certain channel parameters is necessary to assure that the channel meets the established requirements. The parameters that must be measured on initial lineup are:

- Loss (end-to-end)
- Attenuation distortion
- C-message noise
- C-notched noise
- ▶Impulse noise◀
- Resistance balance.



NOTES:

1. EACH [T] REPRESENTS TRANSMITTER.
2. EACH [R] REPRESENTS RECEIVER.
3. EACH ⊣⊢ REPRESENTS A SMAS ACCESS POINTS. REFER TO SECTIONS 667-302-102, 667-302-103, 667-302-200 AND 667-303-102 FOR ACCESS CODES, ORIENTATION CODES AND OTHER INFORMATION. THESE ACCESS POINTS MUST BE FLAGGED AS SPECIAL AT THE TIME OF INSTALLATION. REFER TO BSPs LISTED ABOVE FOR FLAGGING TECHNIQUE. SEE 2.04.

Fig. 4—3-Point Symmetrical System

TABLE A

PROTECTIVE RELAYING CHANNEL

1. Engineered Loss: Standard Channel — 16.0 dB @ 1000 Hz
   Optional Channel (subject to the stipulation that the total loss in local loop of receive leg does not exceed 8.0 dB) — 8.0 dB @ 1000 Hz

2. Initial Loss at Installation: Standard Channel — 16.0 dB ±1 dB @ 1000 Hz
   Optional Channel — 8.0 dB ±1 dB @ 1000 Hz

3. Short Term Loss Variations: Less than ±3 dB

4. Long Term Loss Variations: Less than ±4 dB

5. Attenuation Distortion (Reference 1000 Hz)

FREQUENCY RANGE	VARIATION (dB)
300 — 3000 Hz	−2 to +6
500 — 2800 Hz	−1 to +3

6. Envelope Delay Distortion: Less than 2000 microseconds over band from 800 to 2600 Hz

7. C-Notched Noise: Standard 16.0 dB Channel — Less than 50 dBrnC at receiver
   Optional 8.0 dB Channel — Less than 58 dBrnC at receiver

8. C-Message Noise:

	NOISE AT RECEIVER	
CIRCUIT LENGTH (MILES)	16dB CHANNEL (dBrnC)	8 dB CHANNEL (dBrnC)
0 — 50	28	36
51 — 100	31	39
101 — 400	34	42
401 — 1000	38	46

9. Impulse Noise:

THRESHOLD WITH RESPECT TO RECEIVED 1004 Hz TEST TONE POWER SENT AT 0 dBm	MAXIMUM COUNTS ABOVE THRESHOLD ALLOWED IN 15 MINUTES
−6 dB	15
−2 dB	9
+2 dB	5

TABLE A (Contd)

PROTECTIVE RELAYING CHANNEL

10. Single Frequency Interference:

CIRCUIT LENGTH (MILES)	SINGLE FREQUENCY LIMIT 16 dB CHANNEL (dBrnC)	8 dB CHANNEL (dBrnC)
0 — 50	25	33
51 — 100	28	36
101 — 400	31	39
401 — 1000	35	43

11. Frequency Shift: Less than ±5 Hz

12. Local Channel Resistive Unbalance Limit: 1% or less unbalance between conductors

▶Limits◀ for these parameters are given in Table A. Detailed test procedures are given in Section 310-540-500.

4.03 Initial lineup of the PR channel will require the coordination of operating personnel at both the customer locations and the COs. A communication path between these locations should be established to facilitate lineup and test procedures.

4.04 When transmission problems are suspected or when one or more of the parameter requirements listed for initial lineup is not met, further measurements may be necessary. Here again, Section 310-540-500 provides more detailed information on the measurements that need to be made. In general these measurements include the remaining parameters and requirements listed in Table A.

5. REFERENCES

5.01 The following is a list of BSPs that are related to the PR channel and may be useful reference material:

201-211-101	▶CO Terminating Unit for Integrated Protection System—Description, Installation, and Maintenance◀
310-540-500	Protective Relaying Channel—Initial Lineup and Maintenance Test Requirements
638-600-100	▶Integrated Protection System for Power Station Communications–Description and Placing
638-600-101	Integrated Protection System for Power Station Communications–Installation
638-600-102	Integrated Protection System for Power Station Communications–High Potential and Resistance Unbalance Testing
638-600-103	Integrated Protection System for Power Station Communications–Assignment Charts and Circuit Establishment
638-600-104	Integrated Protection System for Power Station Communications–Installation Inspection, Test and Maintenance Requirements
667-302-102	SMAS-4A Access Point Locations
667-302-103	SMAS-4A Access Point Assignment
667-302-200	SMAS-4A Access Point Cross Connections
667-303-102	SMAS-5A Access Point Rules◀
851-201-101	Protective Relaying Channel—Transmission Specifications and Considerations

NOTES

PROTECTIVE RELAYING CHANNEL

INITIAL LINEUP AND MAINTENANCE TEST REQUIREMENTS

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1. GENERAL

1.01 ▶This section describes the initial, routine, and maintenance test requirements for the protective relaying (PR) channel, which is a voice grade private line channel specifically used in power industry audio tone PR applications. The PR channel provides improved reliability for PR systems during power fault intervals over that obtainable from other voice bandwidth channels. ***If this channel will not be used for audio tone protective relaying applications, do not use the channel design specified in this section; instead, use the design specified in Section 880-420-100.***◀

1.02 This section is reissued to include a discussion of:

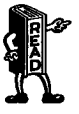
(a) The optional 8 dB PR channel

(b) SARTS and SMAS test access points

(c) Impulse noise as a transmission parameter.

1.03 This section affects Equipment Test Lists.

1.04 Fault conditions of high-voltage transmission lines may be caused in various ways, but whatever the cause, the result can be severely damaging to critical power company equipment. To prevent this, the PR terminal, which terminates each end of the channel, transmits a trip signal from one power station to another. This signal activates power company circuit breakers, which de-energize the faulted transmission line. A more complete description of the PR channel and its operation is covered in Section 310-540-100.



▶***CAUTION: All tests in this section must be performed on an out-of-service basis: no test shall be performed on this channel unless prior coordinated approval for circuit turndown has been given by the authorized***

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Bell System except under written agreement

power utility personnel.◀ Since the tests in this section pertain only to the PR channel, tests should be made from the standpoint that the terminal equipment is functioning properly.

1.05 The following definitions should be helpful:

(a) ***Customer—provided equipment (CPE):*** This includes any customer-provided equipment that is connected to the telephone company equipment or line. In some cases this may be the PR terminal.

(b) ***End link:*** The facility between a central office bridging location and the transmission interface at the customer location. This definition holds regardless of whether the end link consists of only a local channel or of intercity facilities and a local channel (see Fig. 1).

(c) ***Local loop (Local channel):*** The transmission facility between the customer premises and the serving test center (STC).

(d) ***Middle link:*** The facility between the central office and/or bridging locations. The connection between two bridges in the same central office is not considered to be a middle link (see Fig. 1).

(e) ***Plant Control Office (PCO):*** The designated office responsible for all maintenance activities on a circuit or circuit link. The PCO should be informed of all trouble reports and will maintain office records for each circuit or circuit link.

(f) ***Serving Test Center (STC):*** A designated office responsible for testing transmission facilities and apparatus under direction of the PCO. If a PCO has not been designated, the STC is responsible for coordinating maintenance activities and maintaining circuit records.

(g) ***Transmission level point (TLP):*** A reference level point on a circuit numerically equal to the algebraic sum of 1000-Hz gains (+) and losses (-) from an arbitrarily defined reference point (0 TLP) to the point of measurement. Further discussion of transmission level point is given in 3.03 through 3.08.

2. TESTING APPARATUS

2.01 Accurate measurements require accurate test equipment. All equipment should be checked prior to use to ensure that it is calibrated and functioning properly. Ample warm-up time is also important for stable operation of the test equipment.

2.02 ▶Table A provides a partial listing of test sets which may be used. A detailed listing of test equipment is provided in the booklet ***Bell System Transmission Test Equipment—Performance Evaluation.*** Copies of this booklet are furnished to the General Trade Products representative for each operating company.◀

2.03 All transmission measurements, unless otherwise stated, are to be made between balanced 600-ohm resistive terminations. If other than

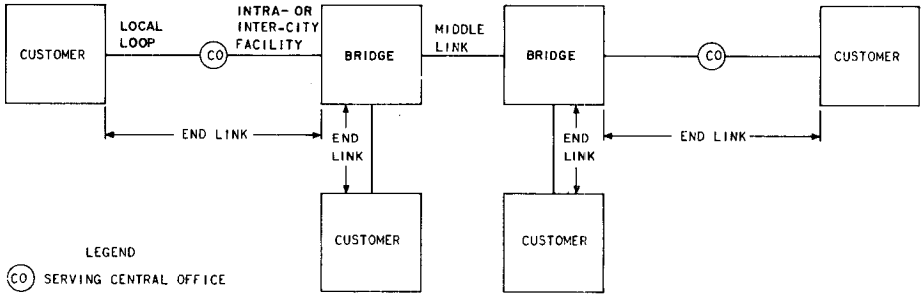


Fig. 1—End Link and Middle Link Definition

♦ TABLE A ♦

TEST EQUIPMENT LIST

FUNCTION	TEST SETS
1000-Hz Loss and Attenuation Distortion*	• Halcyon 515A Data Line Test Set • Hewlett-Packard 3550B Portable Test Set • Hewlett-Packard 4940A Transmission Impairment Measuring Set • KS-20805 Transmission and Noise Measuring Set† • Northeast Electronics Transmission Test Set 4B-NH, or 48-NH-N, or 15B, or 35B • Telecommunication Technology, Inc. 1103A or 1103B Digital Transmission Test Set • Telecommunication Technology, Inc. 1105 Level/Noise Digital Test Set† • WECo 21A Transmission Measuring Set
Sine Wave Oscillators	• Halcyon 515A Data Line Test Set • Hewlett-Packard 3550B Portable Test Set • Hewlett-Packard 4940A Transmission Impairment Measuring Set • KS-19260-L1, KS-19353-L1, or KS-19353-L4 Oscillator • Northeast Electronics Transmission Test Set 4B-NH, or 4B-NH-N, or 15B‡, or 35B • Telecommunication Technology, Inc. 1103A‡ or 1103B Digital Transmission Test Set • WECo 21A-L2 Transmission Measuring Set‡ • WECo 25B Voiceband Gain and Delay Set‡
Envelope Delay*	• Halcyon 515A Data Line Test Set • Hewlett-Packard 4940A Transmission Impairment Measuring Set • WECo 25B Voiceband Gain and Delay Set
C-Message Noise*	• Hewlett-Packard 3555B Transmission and Noise Measuring Set • Hewlett-Packard 4940A Transmission Impairment Measuring Set • KS-20805 Transmission and Noise Measuring Set • Northeast Electronics TTS 4B-NH-N • Telecommunications Technology, Inc. 1105 Level/Noise Digital Test Set • WECo 3A, 3B, or 3C Noise Measuring Set
C-Notched Noise*	• Hewlett-Packard 4940A Transmission Impairment Measuring Set • Telecommunications Technology, Inc. 1105 Level/Noise Digital Test Set • WECo 6F or 6FR Voiceband Noise Measuring Set§
Impulse Noise*	• Hewlett-Packard 4940A Transmission Impairment Measuring Set • WECo 6F or 6FR Voiceband Noise Measuring Set • WECo 6H or 6HR Impulse Counter
Single Frequency Int.**	• General Radio 1568-A Wave Analyzer • Hewlett-Packard 302A Wave Analyzer • WECo 4A Frequency Analyzer

♦ TABLE A (Cont) ♦

TEST EQUIPMENT LIST

FUNCTION	TEST SETS
Frequency Shift*	• Halcyon 515A Data Line Test Set • Hewlett-Packard 4940 A Transmission Impairment Measuring Set • KS-20805 Transmission and Noise Measuring Set • Wandel-Goltermann FVM-1 Frequency Shift Meter • WECo 72A Frequency Meter
Local Channel Resistance Unbalance	• KS-14959 Test Set (Portable Wheatstone Bridge)

* These tests may also be performed by the Collins CLA-101A System and Test Signal Generator (TSG).

† Requires a separate sine wave oscillator.

‡ Measure harmonic content of oscillator **before** using this oscillator as a tone source for harmonic distortion measurements.

§ This set is intended primarily for impulse noise measurements and does not meet certain recent Bell System measurement standards for C-notched noise measurements. It may be used for C-notched noise measurements if other test sets are not available.

** A listening test is normally sufficient for the detection of single tone interference and specialized test equipment is seldom required. The test set listed here may be used for those few cases where specialized test equipment may be required.

standard Bell System test equipment is used, it may be necessary to use an isolation transformer with the proper impedance between the line being tested and the test equipment.

3. TRANSMISSION REQUIREMENTS AND TESTING METHODS

GENERAL

3.01 Accurate measurements of the transmission characteristics of voiceband private line circuits, such as the PR channel, depend upon knowledge of the correct test levels to be transmitted and received. The power of the test signal with respect to the TLP at which it is applied will have a major influence on the test results obtained. The definition of TLP in 1.05 should be read before making the measurements described in this part. In addition, an expanded definition of TLP is given in 3.03 through 3.08.

A. Transmission Level Point (TLP)

3.02 The following is intended to clarify the term "transmission level point" (TLP). An understanding of TLP is neccessary before measurements on private line circuits are made.

3.03 In discussing a channel, it is necessary to describe the power (of the signal, noise, or test tones) present at a particular point in the channel and to compare this power (of the same signal, noise, or test tones) present at other points in the channel. Figure 2 illustrates the relationship between TLPs and signal power in dBm for a simple 2-point PR circuit. The power present at a particular point in a channel is dependent upon the power at the source, where the source is applied, and the loss or gain in the channel between the points in question. Since this information is not always available, it is convenient to describe the power present in a channel by comparing it to some standard reference point in the channel.

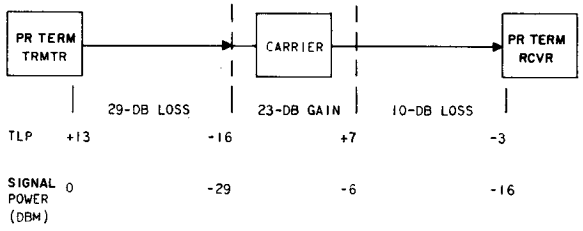


Fig. 2—Relationship Between TLP and Signal Power

3.04 Describing this power is similar to the problem of trying to describe the height of a mountain. To measure the height of a mountain, it is necessary to pick a reference height from which to measure. If the reference height is standardized, then comparison of two mountains can be made even though they are thousands of miles apart. The widely accepted standard reference height for measuring mountains is sea level.

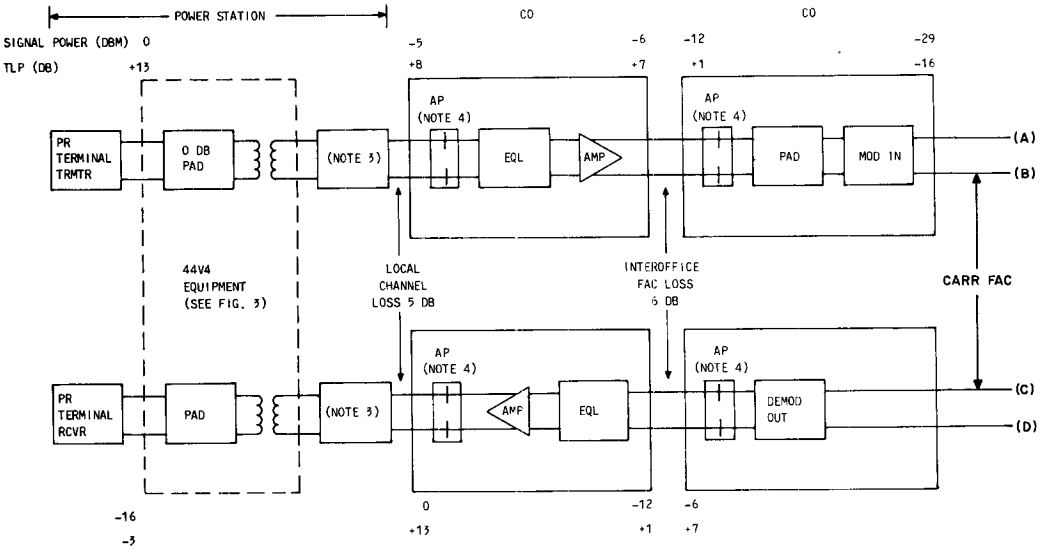
3.05 The standard reference point for measuring power in the Bell System channels is called the zero transmission level point, or 0 TLP. This reference point makes it possible to compare the signal power at two points in the channel even though the points are many miles apart.

3.06 With the establishing of the 0 TLP concept, the power present in a channel is described by stating what this power would be if it were accurately measured at the 0 TLP. The standard notation used to describe the power in this case is dBm0. For example, the term "-13 dBm0" means that the power at the 0 TLP is -13 dBm; if a -13 dBm0 signal were measured at the 0 TLP, the meter would indicate -13 dBm.

3.07 After the power at the 0 TLP is described, the power (from the same source) at any other point in the channel can be determined. For example, if the signal power is -13 dBm when measured at the 0 TLP, it will be 13 dB below the numeric value of any TLP on the channel when measured at that TLP. If the signal is -13 dBm at the 0 TLP, then the power at the -3 TLP would be -16 dBm (-3 - 13 = -16). If this -13 dBm0 signal were measured with a transmission measuring set (TMS) at the -3 TLP, the meter would indicate -16 dBm. Similarly, if a -13 dBm0 signal were measured at the -16 TLP, the meter would indicate -29 dBm (-16 - 13 = -29).

> ***Note:*** The numeric value of the TLP does not describe the power present at that point any more than the elevation of a mountain top above sea level describes how high the mountain rises above the plains that surround it. To know how high the mountain rises above the plains, it is necessary to know the elevation of the plains above sea level as well as the elevation above sea level of the mountain itself. To know the power present at any given TLP, it is necessary to know the power present at some other TLP in the channel. As mentioned previously, the standard way to describe the signal is in terms of its power in dBm at the 0 TLP (dBm0). The signal can be described in dBm0 if the power is known at any TLP. For example, if a -29 dBm signal is applied to the channel at the -16 TLP, the signal is -13 dBm0 [-29 - (-16) = -13]. The power at the -16 TLP is 16 dB lower than the power at the 0 TLP. Therefore, to find the power at the 0 TLP, -16 dB must be subtracted from the power at the -16 TLP.

3.08 Use of the 0-TLP reference also permits transmission objectives and measured results to be stated independently of any specific TLP. For example, the C-notched noise objective is 53 dBrnc0. With this information, the appropriate value at any other TLP can be determined. For measurements at the -3 TLP receive terminal, 3 dB should be subtracted from the objective to determine the absolute value, which is 50 dBrnC. For measurements at the +7 TLP DEMOD OUT jack, 7 dB should be added to the objective to determine the absolute value, which is 60 dBrnC.



NOTES:

1. 2-POINT, 2-WIRE LAYOUT IS SAME AS ONE HALF OF THIS LAYOUT.
2. THE 16-DB LOSS FROM PR TERMINAL TRANSMITTER TO PR TERMINAL RECEIVER IS MADE UP OF FACILITY LOSS, TRANSFORMER LOSS, EQUALIZATION LOSS IN 44V4 EQUIPMENT, AND PAD LOSS.
3. TWO TYPES OF INTERFACES ARE POSSIBLE AT THIS POINT. THEY ARE: AN ISOLATION TRANSFORMER OR A NEUTRALIZING TRANSFORMER. THEY MAY BE MOUNTED IN A HIGH VOLTAGE INTERFACE UNIT WHICH IS PART OF THE INTERGRATED PROTECTION SYSTEM. BOTH INTERFACES ARE OPTIONAL; THEREFORE IN SOME CASES ONLY A DIRECT PATH MAY EXIST.
4. SMAS ACCESS POINTS - REFER TO SECTION 667-302-102, 667-302-103, 667-302-200 AND 667-303-102 FOR ACCESS CODES, ORIENTATION CODES AND OTHER INFORMATION. THESE ACCESS POINTS MUST BE FLAGGED AS SPECIAL AT TIME OF INSTALLATION. REFER TO BSPS FOR FLAGGING TECHNIQUE. SEE 3 11.

Fig. 3—Typical 2-Point, 4-Wire Layout for Standard 16 dB PR Channel (Sheet 1 of 2)

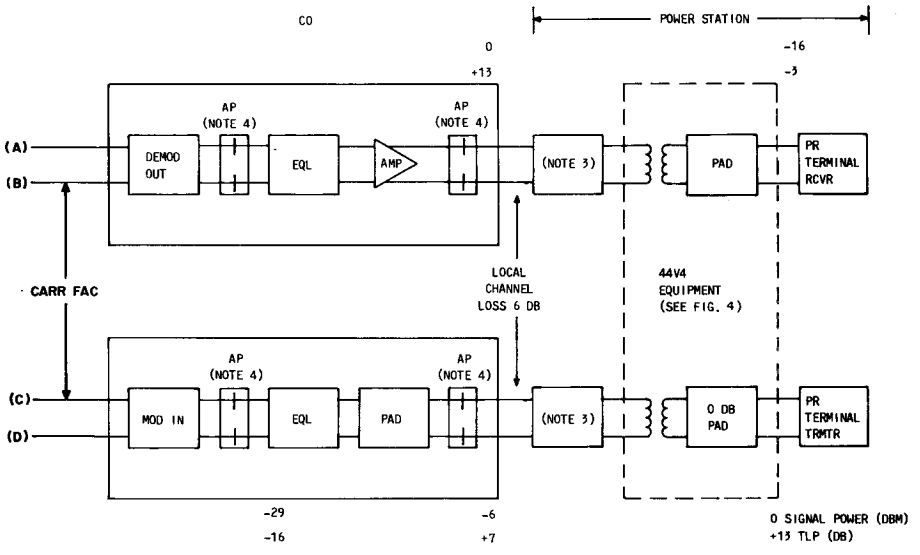


Fig. 3—Typical 2-Point, 4-Wire Layout for Standard 16 dB PR Channel (Sheet 2 of 2)

B. Test Level

3.09 The circuit layout record (CLR) issued by the companies may indicate the expected 1000-Hz loss of a circuit between various test access points in either or both of two ways:

(a) By the designation of the TLP

(b) By the designation of the signal power (dBm).

It will be necessary to know which method is used before making measurements. Generally the CLR will indicate whether TLP or signal power (dBm) is being specified. If not, the level specified at either the PR terminal transmitter or the MOD IN jack of a 4-wire carrier facility should be noted. If the level at the PR terminal transmitter is given as +12 dB or +13 dB, the CLR is probably written in terms of TLP. If the level at the PR terminal transmitter is given as 0 dBm, it is likely that the CLR is written in terms of signal power (dBm). In this case, or if other than the above values are given, note the level at the MOD IN jacks of a 4-wire carrier facility as follows:

- If the level is given as -16 dB, the CLR is written in terms of TLP.
- If the level is given as -28 dBm or -29 dBm, the CLR is written in terms of signal power (dBm).

3.10 If it is still not possible to determine whether the CLR is written in terms of TLP or signal power (dBm), the engineer responsible for the CLR should be contacted for clarification.

All transmission measurements are to be made at levels of signal power that are in accordance with the following: The signal power for the PR channel is a power 13 dBm below the TLP at which the tests are being made. For example at a -16 dB TLP, the signal power would be -29 dBm. A test power of -29 dBm would be applied here.

C. Test Access

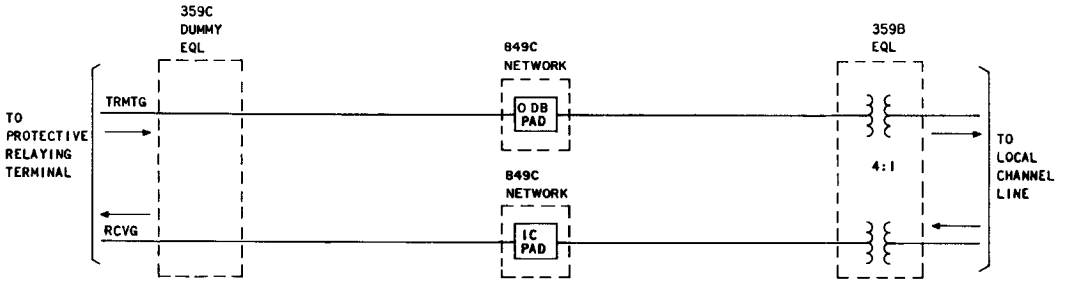
3.11 Switched Maintenance Access Systems (SMAS) provide access for testing PR channels at central office locations either locally or by the Switched Access Remote Testing System (SARTS). Fig. 3 shows the central office locations for the minimum number of access points required to take full advantage of the trouble sectionalization capability of SARTS. SMAS access is not applicable to customer premises (see following information). Additional SMAS information is available in Sections 667-302-102, 667-302-103, 667-302-200, and 667-303-102.

Warning: All tests in this section must be performed on an out-of-service basis; no test shall be performed on this channel unless prior coordinated approval for circuit turn-down has been given by the authorized power utility personnel.

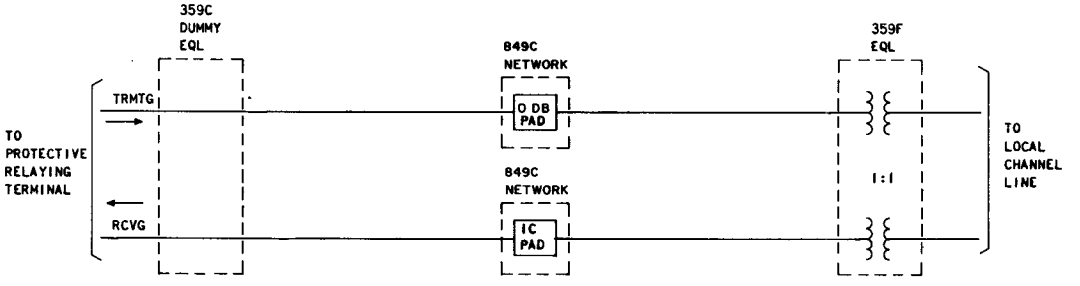
3.12 In the absence of SMAS or SARTS, it is best to limit the choice of test access points to a few locations to be certain of measuring at a known impedance and TLP. Figures 3 and 4 illustrate a typical 4-wire circuit. In this case the best test access points would be at the point where the PR terminal is connected to the channel. This point has been chosen because it is a fixed 600-ohm termination point, and measurements can be made (with the PR terminal disconnected from the circuit) that include all the pads and repeat coils located at the customer location.

3.13 The test equipment should ***not*** be connected directly to the local cable pairs when transmission components (such as pads or repeat coils) are used at the customer location, as this will result in incorrect attenuation distortion and envelope delay distortion as well as other test results. The test equipment should be set to make measurements in a 600-ohm terminated mode unless the CLR specifies a different impedance at this point. Although the cable pair will seldom have a 600-ohm impedance, the transmission measuring equipment will be indicating the characteristics of the circuit with which the terminal (which should also be 600 ohms) is designed to work.

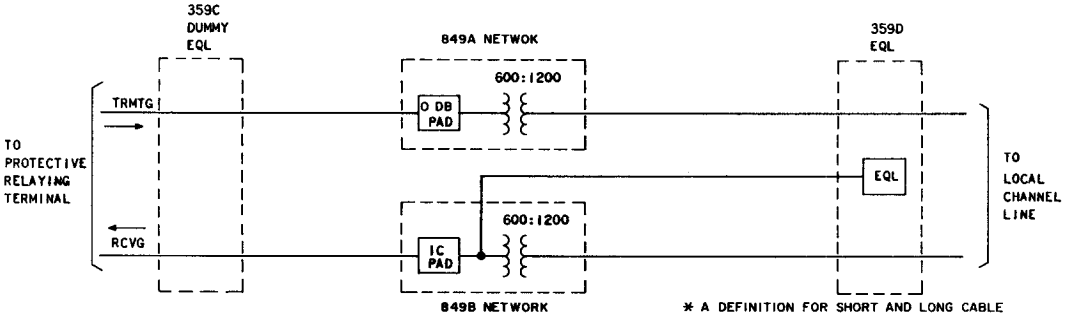
3.14 Figure 5 illustrates a 4-wire multipoint circuit at a central office bridge location. Measurements should be made at the closest test access point to the bridge to measure the effect of all equipment used to make up the end link or middle link. When testing a link off a bridge, that appearance must



A. FOR LONG NONLOADED CABLE*



B. FOR SHORT NONLOADED CABLE*



* A DEFINITION FOR SHORT AND LONG CABLE CAN BE FOUND IN BSP 852-307-101.

C. FOR LOADED CABLE*

Fig. 4—44V4 Equipment Arrangement

first be terminated in 600 ohms to avoid unbalancing the bridge.

TRANSMISSION PARAMETERS

3.15 The transmission parameters covered in this part pertain to the PR channel only. Some parameters should be measured routinely to insure channel performance; however, others need to be measured only when transmission difficulties are observed on initial lineup or after repeated trouble reports (see Section 310-540-100). Table B lists the transmission parameters and gives intervals for their required testing, which insures proper channel performance.

3.16 ▶Following the discussion of requirements for each of the transmission parameters beginning in 3.17, an example is given using the test points defined above for standard 16 dB 4-wire PR channel at the customer location and the STC.◀ The results given in the example are recorded on a sample form as shown in Fig. 6. The use of the form is described in Part 4.

A. 1000-Hz Loss

3.17 ▶The 1000-Hz loss of the standard PR channel is 16 dB measured end-to-end. The 1000 Hz loss of the optional PR channel is 8 dB measured end-to-end (see Sections 310-540-100 and 851-201-101 for local channel requirements for the optional channel). The required end-to-end loss is listed on the CLR as the expected measured loss (EML).◀

3.18 Table C indicates the maximum loss deviation requirements for the PR channel, ie, maximum deviation from the EML. All loss measurements should be made and adjusted within requirements before any other transmission parameters are measured. This is necessary because many of the other transmission parameters are level sensitive. Loss measurements must be made at the level of signal power.

3.19 If adjustments must be made to an end link for the 1000-Hz loss requirement, they ***must*** be made at certain locations. In the transmitting end link, adjustments should be made at the CO; in the receiving end link, adjustments should be made at the power station end.

3.20 ***Example of test:*** An oscillator is connected at an interface point in place of the PR terminal transmitter (+13 TLP). A transmission measuring set is placed at the distant terminal in place of the receiver (-3 TLP). The meter reads -16.4 dBm. Since the correct signal level at the -3 TLP should be -16 dBm, the loss deviation is +0.4 dB [-16 - (-16.4) = +0.4] and is within the requirement in Table C. This loss deviation value should be entered on the form shown in Fig. 6.

B. Attenuation Distortion (Frequency Response)

3.21 The attenuation distortion requirements for the PR channel are given in Table D. Measurements are made at the interface (customer terminal) location using the measurement frequencies given in Table E.

3.22 As indicated in Fig. 3 and 4 a 44V4 equipment package is usually installed at the power station for level adjustment and equalization. This equipment also serves as a coupling arrangement for connecting customer-owned PR equipment to telephone company facilities. ▶***It is essential that the PR channel be terminated in power station locations using arrangements of 44V4 or equivalent equipment. Channel terminating arrangements with such devices as Data Auxiliary Sets (828-type or 829-type), 150A Channel Service Units, 31B Voice Couplers, or Metallic Facility Terminal (MFT) equipment must not be employed.***◀ An additional high-voltage isolating transformer is provided at those locations where a high ground potential rise occurs during fault conditions.

3.23 Figure 7 illustrates the attenuation distortion requirements for the PR channel. Measurements falling within the outlined area are considered to be meeting requirements, whereas measurements falling outside the outlined area are out of limits. The attenuation distortion of a circuit may be measured and adjusted at the same time that the 1000-Hz loss measurements are made. The distortion is stated in terms of the loss at a particular frequency referenced to the loss at 1000 Hz. The convention used is (+) for more loss and (-) for less loss.

3.24 Attenuation distortion is usually corrected by means of 359-type equalizers. A number of codes are available for use with various types of cable plant. The 359A, D, G, H, K, L, and P equalizers are adjustable and may be used to correct for slope or for excessive gain at the low end of the band or for excessive loss at the high end of

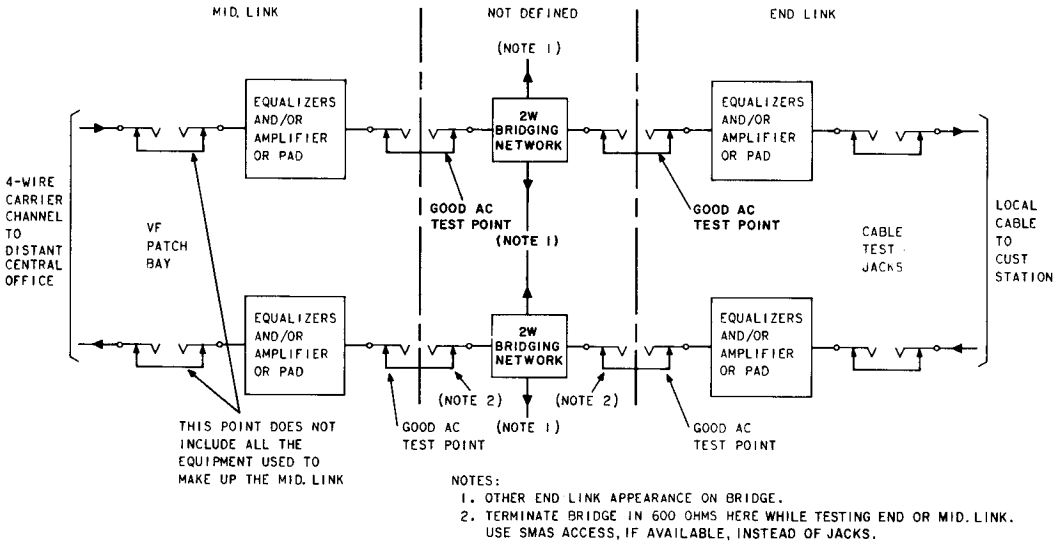


Fig. 5—Test Access Points on 4-Wire Multipoint Circuit at Bridge Location

NOTES

TABLE B

PARAMETERS AND INTERVALS FOR TEST

TEST PARAMETERS	INITIAL	ROUTINE	ROUTINE INTERVAL	INITIAL TROUBLE REPORT	CHRONIC TROUBLE REPORT
1000-Hz Loss	Yes	Yes	12 Mon	(1)	(3)
Attenuation Distortion	Yes	Yes	12 Mon	(1)	(3)
Envelope Delay Distortion	No	No	None	(1)	Yes
C-Message Noise	Yes	Yes	12 Mon	(1)	(3)
C-Notched Noise	(1)	No	None	(1)	Yes
Single-Frequency Interference	(2)	No	None	(2)	Yes
Frequency Shift	(1)	No	None	(1)	Yes
Local Channel Resistance Unbalance	Yes	Yes	12 Mon	(1)	(3)
Impulse Noise	Yes	No	None	(1)	Yes

Numbers in parentheses refer to the following notes:
(1) If suspicion exists that this may be a problem.
(2) A listening test will normally be sufficient.
(3) This test is required after repeated trouble reports have been received and the source of the problem can not be determined.

the band. Other types of equalizers may be necessary to compensate for excessive ripple in the middle of the band.

3.25 Information on the attenuation distortion characteristics of the 359-type equalizers is given in the 332-116-ZZZ series of Bell System Practices. Some information on the adjustment of these equalizers is given in Part 8 of Section 332-104-500 and in Section 314-016-125.

3.26 The attenuation distortion equalizers on multipoint circuits should be adjusted to give the best frequency response on the overall circuit within limits. This is necessary because it is possible on multipoint circuits to meet the attenuation distortion limits on any individual link, but not meet the end-to-end limits. Since the control office is responsible to the customer for end-to-end limits, adjustments of the equalizers to obtain the best frequency response initially may eliminate the need to re-equalize multipoint circuits later.

3.27 In some instances it may not be possible to meet the attenuation distortion requirements with the specified equalizers. Two possible sources of poor high-frequency response are bridge taps on the local channel cable pairs or the use of older N2 carrier channel service units with LC channel bandpass filters. The gain of N2 carrier channels at 3 kHz should not be more than 3 dB below the gain at 1 kHz. If the channel does not meet these limits, a channel service unit with ***crystal*** filters may be needed.

3.28 If a D1 channel bank (used on T-carrier) is used, 4079 BD transmitting gates and filters must be used. The older filters have a poorer high-frequency response and should not be used for the PR channel.

3.29 If attenuation distortion requirements cannot be met and the problem cannot be isolated, engineering assistance should be requested. A record of measurements made should be kept to aid engineering in arriving at a solution.

3.30 ***Example of test:*** A 25B voiceband gain and delay set is connected in place of the PR terminal transmitter and set for an output level of 0 dBm at the +13 TLP. Another 25B set is connected in place of the terminal receiver (-3 TLP) at the distant location. The received level in the transmit direction is measured and recorded as shown in Table F. Calculation of attenuation distortion is made by using the information in Note 2 of Table F. Figure 8 illustrates the determination of the attenuation distortion shown in Table F. From the measurements it can be determined that the attenuation distortion for this example is:

300—3000 Hz -0.4 to +2.1 dB

500—2800 Hz -0.4 to +1.1 dB

These values are well within the requirements stated and therefore should be recorded on the form as shown in Fig. 6.

C. Envelope Delay Distortion

3.31 Envelope delay distortion for the PR channel must be less than 2000 μs over a frequency band of 800 to 2600 Hz. Delay equalizers, if provided, should be specified on the CLR. They are usually of the nonadjustable variety with two major exceptions, the 385A and 385B. The specified equalizers will normally be adequate to meet delay distortion requirements.

> ***Note:*** If changes are required in the equalizers, it will be necessary to recheck the 1000-Hz loss and the attenuation distortion since changes in the delay equalizers will have some effect on these parameters. Changes may be made in the step settings of the 385A and 385B equalizers without rechecking the attenuation distortion.

Measurements of envelope delay are generally only made in the event of chronic trouble reports (see Table B). If these measurements are required, Table F and the accompanying Note 1 may be used. These measurements are made at the PR terminal location using the measurement frequencies given in Table E.

3.32 Information on the 384- and 385-type delay equalizers may be found in Section 314-820-104. Information on the 200-type delay equalizer may be found in Section 314-820-100.

D. Message Circuit Noise (C-Message Noise)

3.33 Message circuit noise is the background noise on a channel in the absence of a signal. The usual measurement is frequency weighted by a C-message filter, and the result is called C-message noise. A more detailed discussion of this noise is covered in Section 310-540-100. The C-message noise limits for this channel are given in Table G.

3.34 ***Monitor the circuit with the noise set receiver while making the noise measurement.*** If intelligible crosstalk of identifiable signals at the noise measurement level is heard, it is an indication of crosstalk, which should be corrected. If a single-frequency tone or tones of long duration are heard, single-frequency interference may be present and should be measured (refer to 3.53). If compandored facilities are employed in the circuit being measured, a C-notched noise measurement will be required (refer to 3.39).

3.35 A standard reference of noise used throughout the Bell System is -90 dBm. The measurement of noise is expressed in dB above this reference, ie, dBrn. A 1000-Hz tone at a level of -90 dBm will be equal to a 0-dBrn reading on an NMS. From this we have the relationship of 0 dBm = 90 dBrn at 1000 Hz. This relationship applies to any frequency in a flat weighted passband, but only at, or very near to, 1000 Hz in the C-message weighted band. To get the reference level for other specific frequencies, the effect of the C-message weighting curve must be subtracted. The notation "dBrnC" is commonly used to express noise measured through a C-message weighting network.

CIRCUIT NUMBER (1)		TRANSMISSION HISTORY RECORD								LINK NUMBER (2)			
TEST DATE		(3)		(3)		(3)		(3)		(3)		(3)	
CIRCUIT ORDER NUMBER: (4)		TRMT		RCV		TRMT		RCV		TRMT		RCV	
		ENV DELAY	ATTEN DIST	ENV DELAY	ATTEN DIST	ENV DELAY	ATTEN DIST	ENV DELAY	ATTEN DIST	ENV DELAY	ATTEN DIST	ENV DELAY	ATTEN DIST
300		X	(5)	X	(5)	X	(5)	X	(5)	X	(5)	X	(5)
500		X		X		X		X		X		X	
600		X		X		X		X		X		X	
800		(6)		(6)		(6)		(6)		(6)		(6)	
1000													
1200													
1400													
1600													
1800													
2000													
2200													
2400													
2500													
2600													
2700		X		X		X		X		X		X	
2800		X		X		X		X		X		X	
3000		X		X		X		X		X		X	
Frequency Shift	Hz	(7)		(7)		(7)		(7)		(7)		(7)	
Single Frequency Interference	dBrnc0	(8)		(8)		(8)		(8)		(8)		(8)	
C-Notched Noise	dBrnc0	(9)		(9)		(9)		(9)		(9)		(9)	
Local Channel Resistance Unbalance	%	(10)		(10)		(10)		(10)		(10)		(10)	
C-Message Noise	dBrnc0	(11)		(11)		(11)		(11)		(11)		(11)	
1000-Hz Loss	dB	(12)		(12)		(12)		(12)		(12)		(12)	
IMPULSE NOISE Ref. __ dBrnc0 Counts in 15 minutes	COUNTER 1 COUNT	(13)		(13)		(13)		(13)		(13)		(13)	
	2 COUNT	(13)		(13)		(13)		(13)		(13)		(13)	
	3 COUNT	(13)		(13)		(13)		(13)		(13)		(13)	
Special Notes or Instructions													

Fig. 6—Transmission History Record

NOTES

TABLE C

1000-Hz LOSS DEVIATION
MAXIMUM DEVIATION FROM EML STATED ON CIRCUIT LAYOUT RECORD

	INITIAL	ROUTINE OR TROUBLE ISOLATION
End Link	±0.5 dB	±2.0 dB
Middle Link	±0.5 dB	±1.0 dB
Overall (STA—STA)	±1.0 dB	±4.0 dB

TABLE D

ATTENUATION DISTORTION REQUIREMENTS*

FREQUENCY RANGE (Hz)	VARIATION (dB)
300 — 3000	—2 to +6
500 — 2800	—1 to +3

*Referenced to 1000 Hz.

TABLE E

MEASUREMENT FREQUENCIES

FREQUENCY (Hz)	FREQ RESP	ENV DELAY
300	X	
500	X	
600	X	
800	X	X
1000	X	X
1200	X	X
1400	X	X
1600	X	X
1800	X	X
2000	X	X
2200	X	X
2400	X	X
2500	X	X
2600	X	X
2700	X	
2800	X	
3000	X	

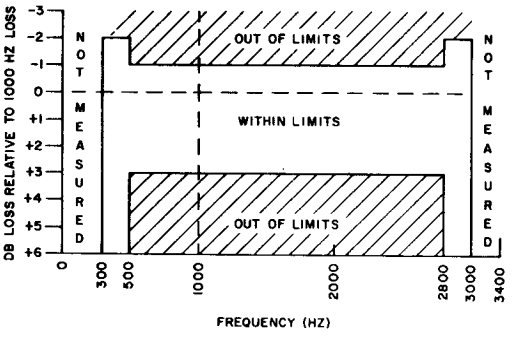


Fig. 7—Graphical Representation of Attenuation Distortion Requirements

3.36 The measured noise must be corrected to the 0-TLP reference point to determine whether requirements are being met, ie, for comparison to the requirements stated in dBrnc0.

Example: When measuring at a +7 TLP, subtract 7 dB from the reading; when measuring at a -16 TLP, subtract -16 dB from the reading.

3.37 If the CLR specified the signal level, the signal power should be converted to TLP by adding 13 dB to the signal level. At the -29 dBm signal power point, 13 dB must be added to convert to a -16 TLP.

3.38 ***Example of Test:*** A 600-ohm termination or a 3C noise measuring set (NMS) is connected across the input to the circuit in place of the PR terminal transmitter. At the distant customer location, a 3C NMS is connected to the circuit in place of the PR terminal receiver. A reading of 31 dBrnC is taken from the 3C NMS at the receive end. So that this reading may be adjusted to dBrnc0, the TLP (-3 dB) is subtracted from the reading; the result is 34 dBrnc0. The circuit has a length of 60 miles of both N and T carrier facilities. According to the information in Table G, the requirement is met. The corrected measured value is entered on the Form XXXX as shown in Fig. 6.

TABLE F

SAMPLE MEASUREMENT RESULTS

MEASURED FREQUENCY	ENVELOPE DELAY	RECEIVED LEVEL	LOSS WITH RESPECT TO 1000 Hz
300		−16.9	+1.1
500		−16.0	+0.2
600		−15.7	−0.1
800	180	−15.7	−0.1
1000	150	−15.8	0
1200	85	−15.4	−0.4
1400	25	−15.6	−0.2
1600	10	−15.7	−0.1
1800	0	−15.8	0
2000	−15	−15.8	0
2200	−35	−15.9	+0.1
2400	−10	−16.0	+0.2
2600	15	−16.2	+0.4
2800		−16.9	+1.1
3000		−17.9	+2.1

Note 1: To calculate the envelope delay distortion between 800 Hz and 2600 Hz, determine the maximum envelope delay (180 μsec) and the minimum envelope delay (−35 μsec) between those frequencies. The envelope delay distortion is the difference between those values 180 − (−35) = 215 μsec.

Note 2: To calculate the attenuation distortion, reference all loss measurements with respect to 1000 Hz. The attenuation distortion between 500 Hz and 2800 Hz would be the minimum loss(−) and maximum loss (+) between those frequencies (−0.4 to +1.1 dB). The attenuation distortion between 300 Hz and 3000 Hz is −04. to +2.1 dB.

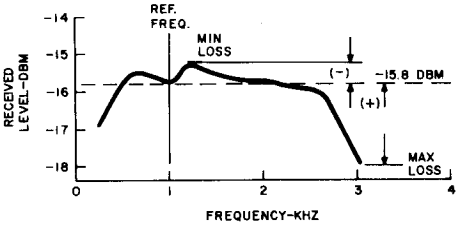


Fig. 8—Attenuation Distortion for 300- to 3000-Hz Band

E. C-Notched Noise

3.39 The C-message noise discussed in the above paragraphs is not necessarily the noise experienced when a signal is present. Quantizing noise in digital carrier systems and the effect of compandors in both analog and digital systems results in signal-dependent noise. Because this noise is signal dependent, it is impossible to approximate the signal to noise (S/N) ratio, which is important in PR channels, from received level and C-message noise measurements alone.

3.40 C-notched noise is a measure of the amount of noise on a channel when a signal is present. In making this measurement, a

▶ TABLE G ◀

C-MESSAGE NOISE LIMITS

	STANDARD 16 dB CHANNEL		OPTIONAL 8 dB CHANNEL	
FACILITY LENGTH (MILES)	NOISE (dBrnC0)	NOISE AT RECEIVER (–3 TLP)	NOISE (dBrnC0)	NOISE AT RECEIVER (+5 TLP)
0 – 50	31	28	31	36
51 – 100	34	31	34	39
101 – 400	37	34	37	42
401 – 1000	41	38	41	46

single-frequency holding tone is applied at the transmitting end of the channel to act as a signal. This tone operates compandors and other signal-dependent devices. At the receiving end, the tone is removed by a narrowband elimination filter (notch filter) and the noise is then measured through a C-message filter. The ratio of the received 1000-Hz power to the C-notched noise is a good approximation to the S/N ratio. However, the S/N ratio could be better than indicated by the approximation.

3.41 The S/N ratio limit as defined in 3.40 is 24 dB for the PR channel. Since the standard receiving power is -16 dBm (or 74 dBrnC), the C-notched noise must be at least 24 dB less at the receiver. This establishes a C-notched limit of 50 dBrnC (74 - 24). (Note that 50 dBrnC at a -3 TLP is equivalent to 53 dBrnC0.) ▶For the optional channel the receiving power is -8 dBm (82 dBrnC). Again, the C-notched noise must be at least 24 dB less at the receiver. So the C-notched noise for the option 8 dB channel is 58 dBrnC (82-24).◀

3.42 To sectionalize C-notched noise troubles, the C-message noise should be measured on each N, O, or ON channel used to make up the overall circuit. This will prevent the higher apparent noise from masking the noise on the compandored channels. The limits in Table G should be used.

3.43 A conventional noise measurement on a channel in a D1 channel bank used on T1 carrier will not reveal a possible C-notched noise problem on that channel. If a channel in a D1 channel bank is suspected of causing the problem because of high quantizing noise, it will be necessary to request a distortion test on that channel. More information on this measurement can be found in 3.20 through 3.33.

3.44 ***Example of test:*** At the customer location, an oscillator is connected to the channel in place of the PR terminal transmitter and is adjusted to send a single-frequency holding tone at a level of 0 dBm (+13 TLP). At the distant customer location, an NMS is connected to the channel in place of the PR terminal receiver (-3 TLP). A reading of 41 dBrnC is taken. Correcting the figure to the value for a 0 TLP, a final figure of 44 dBrnC0 is obtained. ▶This value is better than the stated requirement of 53 dBrnC0 at the receiver and is entered on the form as shown in Fig. 6.

F. Impulse Noise

3.45 The threshold settings for impulse noise are as follows:

End Link	67 dBrnC0
Middle Link	Use mileage limits from Table H
Overall	71 dBrnC0

3.46 Impulse noise is characterized by large peaks or impulses in the total noise waveform. It is measured with an instrument such as the 6F or 6H impulse noise counter which counts impulses greater than a threshold value, using an electromechanical counter having a maximum counting rate of 7 counts per second. Measurements are made through a C-message filter. A holding tone is transmitted and notched out at the receiver.

3.47 Impulse noise should be measured with a holding tone of 1004-1020 Hz, 2804 Hz, or 2750 Hz. A holding tone frequency of 1004-1020 Hz is the new Bell System standard. If the WECo 6F or 6H impulse counters are used, a holding tone frequency of 2750 Hz is used with the 497E network, and 2804 Hz with the 497G network inserted in the impulse noise counter. The threshold setting on the impulse noise counter should be set to a level corresponding to the threshold requirement in dBrnC0 plus the TLP at the point of measurement. For example, at a +7 TLP when measuring a midlink consisting of a 100-mile LMX carrier channel, adjust the threshold setting of the impulse counter to 58 (from Table H) + 7 = 65. If the same channel were measured at a -16 TLP, the threshold would be set at 58 - 16 = 42. If the CLRC specified data level (-13 dBm 0), add 13 dB to the data level to obtain the TLP. Then determine the threshold setting using the same procedure. The same channel measured at a data level point of -16 would correspond to a TLP of -16 + 13 = -3. The threshold setting would be 58 - 3 = 55. This procedure is merely correcting from dBrnC0 to dBrnC.

3.48 When impulse noise is measured overall from one customer station to another, a threshold setting of 71 dBrnc0 should be used regardless of facility type or mileage. The overall 1000-Hz loss must be adjusted to within 1 dB in order to obtain an accurate impulse noise count. Table H may be used to isolate troubles to a facility section. In the event of a trouble report involving an excessive error rate between two specific data stations, an overall impulse noise test must be made between the reported stations since the end link/midlink impulse noise thresholds given in 3.45 do not offer complete assurance that the overall impulse noise requirements will be met. If the overall impulse noise requirements are met between stations it will not be necessary to meet end link/midlink or facility impulse noise requirements.

3.49 ***Example of Test:*** An overall impulse noise measurement is to be made between station A and station B. At station A, an oscillator is connected in place of the PR terminal transmitter (+13 TLP) and adjusted for an output of 0 dBm at 2804 Hz. The 2804-Hz loss deviation was previously measured between stations A and B and was determined to be within ±2 dB of the 1004-Hz loss of the example given in 3.20. At station B, a 6H impulse noise counter is connected in place of the data set receiver (-3 TLP). The reference level for the threshold control is set at 71 - 3 = 68 dBrnC. In a 15-minute period, 7 counts are recorded on the counter. This figure is within limits and is recorded on the form as shown in Fig. 6.

3.50 The distribution of impulse noise voltage levels on typical telephone facilities is such that for each 7-dB increase in the threshold, the expected number of counts decreases by an average factor of 10. A channel just meeting the limit of 15 counts in 15 minutes at 71 dBrnC0 would have an estimated 1.5 counts in 15 minutes at 78 dBrnC0.

3.51 In some cases it may be necessary to measure the impulse noise distribution in order to verify that the number of very high level impulses is within reasonable limits. In such a case a multiple level 6F impulse noise counter or equivalent should be used. The first counter circuit in the 6F set should be set to the same threshold level that would be chosen from 3.45 if normal impulse noise measurements were made. This will be referred to as the reference threshold level. For example, for overall measurements, the reference threshold level would be 71 dBrnC0. The COUNTER SEPARATION switch should be set to 4 dB. This will place the second counter circuit 4 dB above the reference threshold level and the third counter circuit 8 dB above the reference threshold limit. The fourth counter circuit is not used.

◆ TABLE H ◆

IMPULSE NOISE
THRESHOLD SETTINGS IN dBrnc0

LENGTH (MILES)	TYPE FACILITY		
	(1)	(2)	(3)
0-59	54	67	58
60-124	54	67	58
125-249	54	67	59
250-499	—	—	59
500-999	—	—	59

(1) Voice frequency cable facilities only.

(2) N, O, ON, N3L junction facilities or T carrier facilities.

(3) C, K, L, or R carrier facilities.

Note 1: These thresholds assume the use of a —13 dBm0 holding tone. Do not use other holding tone levels as the above thresholds for type 2 (compandored) facilities would be incorrect.

3.52 The maximum number of counts that may be recorded in 15 minutes is as follows:◆

COUNTER CIRCUIT		MAXIMUM COUNTS
1	Reference Level	15
2	Reference Level + 4 dB	9
3	Reference Level + 8 dB	5

G. Single-Frequency Interference

3.53 The overall facility requirements for single-frequency interference are given in Table I.

3.54 Spurious single-frequency tones may interfere with the narrowband signals that are normally used on a PR channel. Since the output of the PR channel must meet the voiceband channel signal power requirements, the signal power in a narrowband channel may be close to the voiceband channel noise power. The narrowband channel noise will be less than the voiceband noise, but if a single-frequency tone is in the narrowband channel, it may interfere with the desired signal. (Unlike the noise, the power of the tone is not decreased when passed through the narrowband channel filter.) The limit for single-frequency interference is that any spurious single-frequency tone will be at least 3 dB below the C-message noise power limit.

3.55 A listening test is required to check for single-frequency interference while the C-message noise measurement is being made as discussed above. A C-message weighting network must be used when making this test. If message noise can be heard, but noticeable tones are not heard, the circuit is probably good. If tones are heard, a measurement of the interference should be made as described in 3.57.

3.56 A level measurement of the interference may be made using a frequency selective voltmeter. The voltmeter should be tuned to the interfering tones between the frequency range of 300 to 3200 Hz and the level in dBm should be measured. This value may be converted to dBrnC0 by using the following procedure.

◗ TABLE I ◖

SINGLE-FREQUENCY INTERFERENCE LIMITS

	STANDARD 16 dB CHANNEL		OPTIONAL 8 dB CHANNEL	
FACILITY LENGTH (MILES)	SF LIMIT (dBrnc0)	SF LIMIT AT RECEIVER (–3 TLP)	SF LIMIT (dBrnc0)	SF LIMIT AT RECEIVER (+5 TLP)
0 — 50	28	25	28	33
51 — 100	31	28	31	36
101 — 400	34	31	34	39
401 — 1000	38	35	38	43

STEP	PROCEDURE
1	Convert the level measurement to dBm0 by algebraically subtracting the TLP at the point of measurement from the reading obtained on the meter. If the CLR specifies signal power (dBm) instead of TLP, add 13 to the signal power (dBm) shown on the CLR to obtain the TLP.
2	Convert from dBm0 to dBrn0 by adding 90 dB to the dBm0 value.
3	Calculate the C-message weighting factor by using the curve in Fig. 9. Determine the frequency of the interference from the dial setting on the frequency selective voltmeter. Determine the C-message loss at this frequency from Fig. 9. Subtract this loss from the value in dBrn0 (Step 2) to obtain the value in dBrnc0 and compare this value against the requirement table.

3.57 ***Example of test:*** ◗Single-frequency interference is heard when a listening test is made at the PR terminal receiver which with the standard 16 dB channel is a -16 dBm signal power or -3 TLP.◖ A frequency selective voltmeter is connected at this point (after the C-message filter is removed), and a reading of -60 dBm at a frequency of 600 Hz is obtained. A termination is applied to the distant end of the circuit, which is approximately 90 miles long. To convert the level measurement from dBm to dBm0, the TLP is subtracted from the level measurement: -60 dBm - (-3 TLP) = -57 dBm0. Convert the dBm0 value to dBrn0 by adding 90: -57 dBm0 + 90 = 33 dBrn0. By referring to Fig. 9, it is apparent that the loss at 600 Hz as compared with 1000 Hz is 4.7 dB. Convert the dBrn0 value to dBrnc0 by subtracting the loss at 600 Hz: 33 dBrn0 - 4.7 dBm = 28.3 dBrnc0. Although the interference can be heard, it falls within the requirement of 31 dBrnc0 for a 90-mile circuit and therefore need not be corrected. This value should be entered on Form XXXX as shown in Fig. 6. If the listening test has revealed no single-frequency interference, the notation "OK" may be made on the form, and a level measurement will not be required.

H. Frequency Shift

3.58 The overall circuit requirement for frequency shift is ±5 Hz end-to-end. Frequency shift measurements are only required on the carrier channel portion of the circuit and do not normally include the metallic facility to the customer location. Frequency shift measurements are only required in the event of repeated customer trouble reports.

3.59 Frequency shift of carrier facilities will seldom be a serious problem for most PR applications. It cannot appear on physical plant

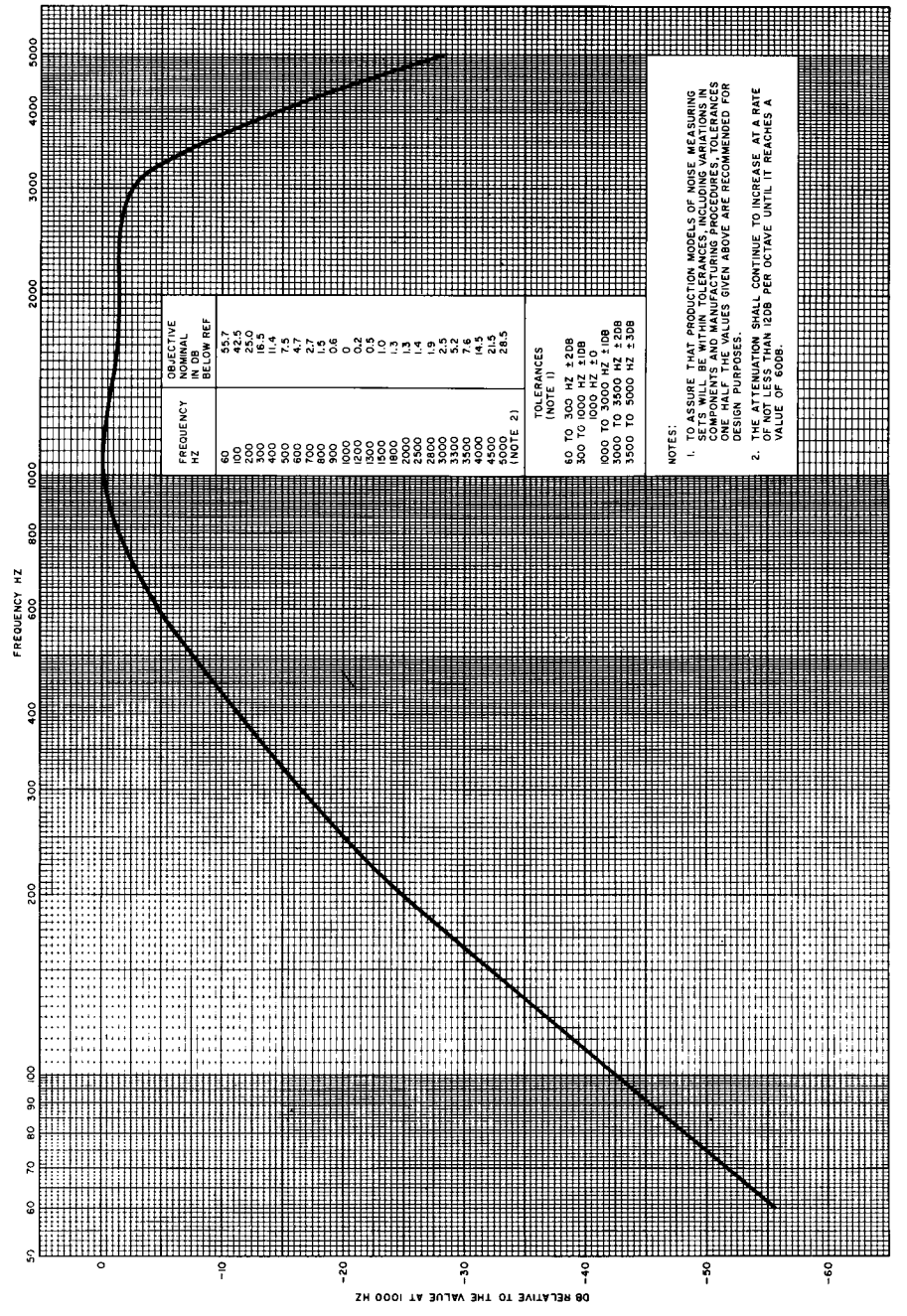


Fig. 9—C-Message Weighting Curve

NOTES

and will be insignificant on carrier systems that have a transmitted carrier modulation scheme, such as N- or O-type. Frequency shift may appear on every other channel of an N3. In this case, a different channel on the N3 should be chosen. Frequency shift will not be found on D1 or D2 channel banks of T Carrier Systems. The LMX channels of L-type carrier should normally hold frequency shift well within the ±5 Hz end-to-end limit. An exception to this may be the result of improperly performed maintenance on the primary frequency supplies, especially when deviations in excess of 10 Hz for a number of hours have been observed. If such trouble is suspected, an inquiry regarding maintenance associated with primary frequency supplies on the route should be made and supervisory assistance requested to ensure that the work is carefully done to avoid interfering with transmission. The C or H carrier channel may exhibit large amounts of frequency shift and should be avoided.

3.60 To measure the frequency shift parameter, a frequency counter is used at both ends of the circuit to compare the frequency of a tone, which is sent from one end to the other. The 72A frequency meter may also be used to observe the frequency shift.

3.61 ***Example of test:*** When frequency shift is suspected on a circuit, an oscillator is connected at signal power (dBm) at the STC serving the customer location. A frequency counter is then bridged across the output. Another frequency counter is bridged across the circuit at the STC serving the distant customer location. A frequency of 958 Hz is read at both STCs at the same time. The frequency shift is therefore 0 Hz. This value should be recorded on the form as shown in Fig. 6.

I. Local Channel Resistance Balance

3.62 The local channel portion (end link) of the PR channel must have a resistance unbalance of 1 percent or less.

3.63 Since the conversion of longitudinal noise to metallic noise depends directly on the resistance balance of the cable pairs, the above requirement must be met.

3.64 Various procedures for making resistance balance measurements may be used; however, the ones given below are recommended for the PR channel. Since the channel may be provided with different types of interface facilities (see Fig. 3, Note 3), a somewhat different test procedure is provided for each case.

Neutralizing Transformer

3.65 When a neutralizing transformer is used for protection and reduction of noise at the power station location, the resistance unbalance should be measured as in the following procedure.

> ***Warning: Any talk circuit used for testing should be established from the station side of the neutralizing transformer.***

STEP	PROCEDURE
1	On the station side of the neutralizing transformer, short together all four conductors of the pair to be measured and a spare pair.
2	At the CO, short together the tip and ring conductors of the spare pair. This will be designated as "common" in the following steps.
3	With a wheatstone bridge at the CO, measure the resistance between the tip conductor of the desired pair and the common.
4	Now measure the resistance between the ring conductor of the desired pair and the common.

STEP	PROCEDURE
5	Finally, measure the resistance between the tip and ring conductors of the desired pair. See 3.69 for procedure of calculating percent of resistance unbalance.

Isolation Transformer

3.66 When an isolation transformer is used, the procedure is the same as above except that the four conductors should be shorted together on the CO side of the isolation transformer.

Integrated Protection System

3.67 Where the integrated protection system arrangement is employed on the PR channel, the following procedure should be used.

STEP	PROCEDURE
1	Ensure that black, personnel-protector plugs are in the proper position at both the high-voltage interface unit (HVIU) and the remote drainage unit (RDU).
2	At the HVIU, insert "red high potential" test plugs into the REM DRNG CA jack that corresponds both to the pair to be tested and to the spare pair.
3	At the RDU and the CO terminating unit (COTU), remove the shorting protection blocks for both pairs.
4	At the CO, short together the tip and ring conductors of the spare pair. This will be used as a common in the following steps.
5	Using a wheatstone bridge at the CO, measure the resistance between the tip conductor of the desired pair and the common.
6	Now measure the resistance between the ring conductor of the desired pair and the common.
7	Finally measure the resistance between the tip and ring conductors of the desired pair. See 3.69 for procedure of calculating the percentage of unbalance.

No Interface Unit or Transformer

3.68 When there is no interface unit or transformer used either for safety or noise reduction, there should be a direct path between power station and CO. The procedure for testing resistance unbalance will be the same as in 3.65 except that there is no neutralizing transformer, and the shorting of conductors at the power station location should be done as close to the terminating unit as possible. Again, 3.69 should be consulted for a procedure of calculating resistance unbalance percentage.

3.69 In each of the above procedures, three resistance values are obtained. Use the formula below and these values to determine the percentage of resistance unbalance.

(a) Tip and Common = (T + C)

(b) Ring and Common = (R + C)

(c) Tip and Ring = (T + R)

$$\frac{(T + C) - (R + C)}{(T + R)} \times 200\% = \text{Percent Unbalance}$$

3.70 ***Example of test:*** A spare pair of conductors is selected, and the pair to be tested is chosen. The appropriate procedure above is completed to obtain the following measurement results:

Tip plus Common	750 ohms
Ring plus Common	746 ohms
Tip plus Ring	1000 ohms

Following the procedure in 3.69.

$$\frac{750 - 746}{1000} \times 200\% = 0.8\%$$

The resulting percentage of unbalance for the measured pair is within the limit, and the value shown should be recorded on Form XXXX as shown in Fig. 6.

4. USE OF CIRCUIT TRANSMISSION HISTORY RECORD

4.01 The tests to be performed to insure proper operation of the PR channel are given in Table B. These measurements should be made and the results recorded for future reference. A form is provided for this purpose, and since its use is optional, a reproducible copy (Fig. 10) is provided with this section.

4.02 The following is an explanation of entries for the Circuit Transmission History Record (Fig. 6). The number beside each item corresponds to the line number on the form:

1. Circuit number
2. Link or section of circuit if straightaway measurements are recorded.
3. Date of test
4. Circuit order number
5. Results of attenuation-distortion measurements (loss with respect to 1000 Hz)
6. Results of envelope delay distortion measurements (if needed)
7. Results of frequency shift measurements
8. Results of single-frequency interference measurements
9. Results of C-notched noise measurements
10. Results of local channel resistance unbalance
11. Results of C-message noise measurements
12. Results of 1000-Hz loss measurements
13. ▶Results of impulse noise measurement.◀

5. REFERENCES

5.01 The list below contains BSPs that are related to the PR channel and that may contain helpful information:

201-211-101	CO Terminating Unit For Integrated Protection System (IPS)—▶Description, Installation and Maintenance◀
310-540-100	Protective Relaying Channel—Description
638-600-100	▶Integrated Protection System for Power Station Communications–Description and Placing

638-600-101	Integrated Protection System for Power Station Communications–Installation
638-600-102	Integrated Protection System for Power Station Communications–High Potential and Resistance Unbalance Testing
638-600-103	Integrated Protection System for Power Station Communications–Assignment Charts and Circuit Establishment
638-600-104	Integrated Protection System for Power Station Communications–Installation Inspection, Test and Maintenance Requirements
667-302-102	SMAS-4A Access Point Locations
667-302-103	SMAS-4A Access Point Assignment
667-302-200	SMAS-4A Access Point Cross Connections
667-303-102	SMAS-5A Access Point Rules

CIRCUIT NUMBER		TRANSMISSION HISTORY RECORD								LINK NUMBER			
TEST DATE		TRMT		RCV		TRMT		RCV		TRMT		RCV	
CIRCUIT ORDER NUMBER:		ENV DELAY	ATTEN DIST	ENV DELAY	ATTEN DIST	ENV DELAY	ATTEN DIST	ENV DELAY	ATTEN DIST	ENV DELAY	ATTEN DIST	ENV DELAY	ATTEN DIST
300		X		X		X		X		X		X	
500		X		X		X		X		X		X	
600		X		X		X		X		X		X	
800													
1000													
1200													
1400													
1600													
1800													
2000													
2200													
2400													
2500													
2600													
2700		X		X		X		X		X		X	
2800		X		X		X		X		X		X	
3000		X		X		X		X		X		X	
Frequency Shift	Hz												
Single-Frequency Interference	dBrnc0												
C-Notched Noise	dBrnc0												
Local Channel Resistance Unbalance	%												
C-Message Noise	dBrnc0												
1000-Hz Loss	dB												
IMPULSE NOISE Ref – dBrnc0 Counts in 15 minutes	COUNTER 1 COUNT												
	2 COUNT												
	3 COUNT												
Special Notes or Instructions:													

Fig. 10—Reproducible Copy of Transmission History Record

NOTES

PART VII

DATA TECHNICAL (DATEC) SUPPORT PLAN

DATA TECHNICAL (DATEC) SUPPORT

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1. GENERAL

1.01 This section describes the objectives and operation of Data Technical Support (DATEC Support). In addition, it outlines the background, the coordinating procedures, and the test equipment DATEC personnel need to perform effectively.

1.02 The growth in number and complexity of data services has shown the necessity of establishing teams of data technical experts. These DATEC Support personnel must have the knowledge and equipment to go beyond the normal capabilities of the installation and repair forces in solving data communications problems. The existence and effective functioning of Data Technical Support is absolutely essential to maintaining high quality data service and in ensuring customer satisfaction.

Objectives of DATEC Support

1.03 The foremost objective of DATEC Support is to improve our data communications services by bringing data service problems to the attention of technical personnel through the use of mandatory escalation procedures. The use of these procedures in conjunction with existing Bell System Practices can be an effective aid in reducing long service delays which cause acute customer

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dissatisfaction. An initial step toward the objective of improving data service is to ensure that the installation and maintenance forces are properly trained and equipped to carry out their basic data assignments.

1.04 A second objective of DATEC Support is aiding the coordination of intercompany and interarea data service problems by establishing definite procedures for obtaining technical assistance from distant locations. Following these procedures should help in promoting a teamwork approach to mutual problems and aid in providing a uniform grade of service.

1.05 A third objective of DATEC Support is to provide business machine representatives a contact for those technical questions regarding Bell System data services that are not routinely referrable to Data Specialists or Data Service Advisors. These types of contacts can be cultivated in both directions and could become invaluable when interfacing problems arise.

1.06 The data services of concern to DATEC Support will include the following:

- DATA-PHONE® service
- DATASPEED® service
- Data access arrangements
- Acoustic and inductive coupled data services
- Private line data service (switched and nonswitched)
- Wideband data service
- Data line concentrator service
- Teletypewriter service.

DATEC Support personnel may also be concerned with transmission problems associated with Telegraph and Telephoto Services.

1.07 For the purposes of this section, the term "field forces" refers to the installation, maintenance, and testing personnel and their supervision who are involved with the normal provision of data services. These persons may be located at central offices, test centers, high frequency equipment, customer premises, or intermediate locations. Also, the term "Associated Company" refers to any Bell System Operating Company with the exception of Long Lines.

2. DATEC SUPPORT PERSONNEL

2.01 This part describes the typical qualifications, organization, responsibilities, and activities of DATEC Support personnel.

A. Qualifications

2.02 In order to perform effectively, DATEC Support personnel must be experienced or trained in the following items:

- Transmission and circuit design
- Bell System data apparatus and terminals
- Interface circuits and arrangements
- Switching equipment and network structures
- Tariffed service offerings.

2.03 In addition to the telecommunication disciplines, DATEC Support personnel should have a good appreciation for the following:

- Computer technology and teleprocessing
- Software operations
- Modulation and coding schemes
- Customer-provided equipment (CPE).

2.04 DATEC Support personnel will often be communicating with individuals and organizations both inside and outside the Bell System. Therefore, they must have a sufficient technical background to be effective in these situations. Support personnel should also have a working knowledge of the Intercompany Services Coordination (ISC) plan, Data Specialist, and other administrative procedures and functions.

B. Organization

2.05 The specific manner in which DATEC Support is organized may vary in different locations. However, technical designees from both Plant

Operations and Engineering departments are essential ingredients. Local preference may place primary responsibilities in either organization.

2.06 The number of DATEC Support personnel needed for proper coverage is strongly influenced by the quantity, geographical dispersion, and complexity of data services in the operating area. These should be a minimum of two management level technical designees for each operating area and two second echelon DATEC Support designees at the Company Headquarters. These teams may be one and the same in single area companies. They must be able to travel to outlying points whenever necessary to carry out DATEC responsibilities.

C. Responsibilities

2.07 The responsibilities of DATEC Support personnel fall into two general categories: ***Fundamental Responsibilities*** and ***Continuing Responsibilities.*** The ***Fundamental Responsibilities*** apply directly to the main objective of DATEC Support which is the technical backup of the data field forces. Items that fall into this first category will demand immediate attention when they arise. The ***Continuing Responsibilities*** apply indirectly to the main objectives of DATEC Support and should be performed between Fundamental case occurrences or during a particular case when they apply.

Fundamental Responsibilities

2.08 ***On-Site Technical Field Assistance:*** DATEC Support personnel will be required to go to customer locations, central offices, and intermediate locations when necessary to identify and resolve technical data service problems. The Support personnel should coordinate their efforts in these locations with local work groups according to normal administrative procedures. When assistance is needed at locations outside their assigned territories, Support personnel should coordinate their activities with the DATEC Support personnel at the distant locations.

2.09 ***Technical Counsel:*** DATEC Support personnel will advise on questions of a technical nature relating to data communications. These questions may originate from inside or outside the Bell System and may concern any of the following:

- Advice on specific types of data problems, ie, what to do first, second, third, etc
- Specific data set options
- Compatibility between CPE and Bell System equipment in accordance with current interconnection guidelines
- Tariff compliance of channels for customer-provided modems
- Suitability of switching machines for certain data services
- Advice on the technical feasibility of a customer service.

2.10 ***Policy Counsel:*** The DATEC Support personnel will assist the field forces in interpreting the Bell System's technical responsibilities in data communications. · Some of the major items of concern may be the following:

- Technical responsibilities outlined in the Tariffs
- Technical Reference requirements
- Maintenance philosophy of Data Transmission Systems as opposed to Data Transmission Assemblies
- Activities at the interface of data access arrangements
- Performance expectations of Bell System-provided equipment, facilities, and services
- Limits of responsibility on channel-only data services using customer-provided data modems.

2.11 ***Supplemental Training of Field Forces:*** DATEC Support personnel will supplement the formal training of the field forces through on-site contacts on difficult data service problems. The use of sophisticated test equipment and methods should be demonstrated and explained where practical. This training can be of great benefit to both the field forces and Support personnel by sharing knowledge gained during problem

investigations. Informal training, such as this, will take place automatically but should be carefully cultivated and can be augmented by verbal and written communication from the DATEC Support personnel.

Continuing Responsibilities

2.12 ***Quality Control:*** Quality control is a major Continuing Responsibility of DATEC Support personnel. In their position, the technical designees are able to observe the whole data service effort. They should identify areas where improvement is needed and refer them to the responsible organizations. Items of concern may include the following:

- Test equipment shortages, updating, and maintenance
- Poor service order documentation or flow
- Recommendation of improvements in administrative procedures
- Feedback on initial service planning and installation deficiencies to the groups originally responsible
- Technical recommendations for data service improvements
- Recommendations to AT&T on Bell System equipment design or BSP improvements.

2.13 ***Monitor Training Requirements and Effectiveness:*** DATEC Support personnel's frequent contact with the interdepartmental activities involved with data services offers an excellent opportunity to monitor training needs and effects. Some items of interest under this topic may include the following:

- Repeated field force difficulty with similar problems
- Excessive time to complete BSP tests before escalating data service problems
- Misunderstandings by sales forces or customers of a data service's operation, capabilities, or limitations.

The Support personnel should document any training deficiencies and recommend improvements to the appropriate administrative organization.

Availability

2.14 DATEC Support personnel must always ensure that someone is accessible to assist on data service problems during normal working hours. After-hours assistance requests should be handled through normal off-hour administrative channels. The Support personnel must not be so encumbered by non-DATEC duties that they are unavailable to the field for technical support activities. Apart from safety, no other job function shall have a higher priority over their time.

Relationship to Data Specialists

2.15 There are wide differences in the functions of Data Specialists in the various companies. Because of this, no clear and consistent relationship can be formulated between Data Specialists and DATEC Support personnel. The DATEC Support responsibility is primarily technical while a Data Specialist may have both technical and administrative responsibilities. However, the DATEC Support function might logically be included as a responsibility of the Engineering and Plant Data Specialists in some cases.

D. Recording DATEC Support Activities

2.16 All case activities of DATEC Support personnel should be recorded on the DATEC Case Report form shown in Fig. 1. This report is available as AT&T Form E-6236 from stationary stock. The standard maintenance sections in the 314, 59X, 660, and 668 Divisions, as they are reissued, will include an outline of the information DATEC Support personnel require when called from the field for assistance.

2.17 Documentation, such as the DATEC Case Report with an outline of the problem and its solution, is an invaluable aid in appraising data service efforts and DATEC Support effectiveness. Nonescalated cases of advising on field force questions over the telephone and assisting on other DATEC Support team's data service problems might also deserve recording since a good deal of operational time may be involved.

DATEC CASE REPORT

TO AREA: Date _____ Time _____

TO CO. HQ: Date _____ Time _____

TO AT&T HQ: Date _____ Time _____

☐ Installation/Pre-service
☐ Maintenance/In-service

Circuit No. _____ Customer _____

Location _____ Contact & Tel. # _____

Assistance Requested By _____ Location _____ Tel. # _____

Request Received By _____ DATEC Location _____ Tel. # _____

1. First Customer Report: Date _____ Time _____
2. Problem Resolution: Date _____ Time _____
3. Type of Service:

☐ DATA-PHONE ☐ Intrastate P. L. ☐ Voiceband
☐ DAA ☐ Interstate P. L. ☐ Wideband
☐ Other _____

4. Method of Operation: Data Set Rate _____

☐ Point-to-Point ☐ Automatic Calling ☐ HDX ☐ Polling
☐ Multipoint ☐ Automatic Answer ☐ FDX
☐ Other _____

5. Station Equipment:

Bell System: DAA/Data Set _____ Aux. Set(s) _____
Options _____ ; _____
CPE: Modem _____ Mfr. _____ Model _____
Terminal: Type _____ Mfr. _____ Model _____
Far End Eqpt: ☐ Same. ☐ Other _____

6. Summary of Problem and Symptoms: _____

Fig. 1—DATEC Case Report (Sheet 1 of 2)

DATEC CASE REPORT (Cont.)

7. Problem solution including methods and tests which isolated the problem:

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

8. Special Test Equipment Used (commercial or black boxes): ☐ None
   Function _____ Mfr. _____ Model _____
   Function _____ Mfr. _____ Model _____

9. Attach additional information, such as sketches, circuit layout, test data, pictures, recordings, or other items, which further illustrate the problem and/or its solution. ☐ Attachments

10. Problem resolution reached by: ☐ Telephone; ☐ On-site visit

11. Was involvement of DATEC Support due to deficiencies in field force training, customer training, test equipment or techniques, circuit design, BSP s, etc?

    ☐ No ☐ Yes (State what and explain) _____
    _____
    _____
    _____

12. Remarks (commendations, suggestions, conclusions, reasons for DATEC assistance delays, other DATEC teams involved, etc): _____
    _____
    _____
    _____
    _____
    _____

Completed By _____

Tel. # _____

Fig. 1—DATEC Case Report (Sheet 2 of 2)

2.18 A copy of each closed DATEC Case Report must be forwarded to the Company's Headquarters DATEC Support designee. These closed case reports are compiled monthly into the DATEC Support Cases—Summary shown in Fig. 2. The Summary Report must be forwarded to AT&T Headquarters by the 15th of the following month.

2.19 Particular data service problem solutions may be of interest to DATEC Support personnel in other areas. These cases, when received by Headquarters DATEC Support, should be distributed to others within the company and forwarded to AT&T with the Summary Report if they are of systemwide interest.

E. Job Aids

Intercompany Communications

2.20 There is frequent need for intracompany and intercompany communications among DATEC Support personnel. To encourage this communication, Section 010-521-101 contains the names, telephone numbers, and addresses of the Support personnel throughout the Bell System.

2.21 There are frequent requests from customers and business machine representatives for contacts within the Bell System to discuss data service problems at a technical level. This communication should be encouraged at both company headquarters and area levels within the Operating Companies as the alternative to outside escalation of problems to high company officials. A new Technical Reference on maintenance and troubleshooting will be published including the names and the telephone numbers of Company Headquarters DATEC Support personnel.

Supportive Documentation

2.22 In order to keep adequately informed, DATEC Support personnel will require an up-to-date file of reference information. This information falls into two general categories: information from Bell System sources and information from non-Bell System sources.

2.23 ***Information From Bell System Sources:*** Some useful Bell System documents that cover data-related material are as follows:

- Bell System Practices on data apparatus and equipment, private line channels, etc
- "Bell System Data Communications Technical References"—available from WECo, Indianapolis
- "Data & Teletypewriter Advance News"—available from AT&T Headquarters
- "AT&T Executive Summary"—available from AT&T Headquarters
- "Data Bits" and "Data Reference List"—available from AT&T Long Lines
- "Transmission Systems for Communications," Fourth Edition—available from WECo, Indianapolis.

In addition to the above items, DATEC Support personnel must have ready access to Engineering Letters, AT&T General Letters, SDs, CDs, etc.

2.24 ***Information From Non-Bell System Sources:*** Some worthwhile references available from outside the Bell System include the following:

- Electronic Industries Association, Interface Standards RS-232-B, RS-232-C, and RS-334
- "Data Transmission" by W. R. Bennett & J. R. Davey, McGraw-Hill, 1965
- "Principles of Data Communications" by R.W. Lucky, J. Salz, & E. J. Weldon, Jr., McGraw-Hill, 1968

NOTES

DATEC CASE SUMMARY

Company _____ Reporting Month _____

Area _____ Prepared by _____ Date _____

Categories	Installation		Maintenance		Total
	Telephone	On Site	Telephone	On Site	
1. Customer Related Troubles					
A. Customer System Design					
B. Training					
C. CPE Trouble					
1. Modem					
2. Terminal					
D. Other					
II Bell System Station Equipment					
A. Data Sets, DAS and DAA					
1. 100 Series					
2. 201 A/B					
3. 201C					
4. 202 C/D/E/R					
5. 202 S/T					
6. 208 A/B					
7. 209A					
8. Other Type					
B. Teletype Equipment					
1. TTY Set					
2. DATASPEED® Term					
3. DATASPEED® 40 Term					
4. Other					
C. PBX					
D. Other					
III Procedure or Design					
A. Data Equipment Option					
1. Engineering Error					
2. Installation Error					
3. Mktg/Cust Error					
B. EL-EM Fix					
C. Installation Error					
D. Testing Procedure					
E. Incorrect Design					
F. Other					
IV Documentation and Training					
A. BSP in Error					
B. BSP not Available					
C. BSP not Followed					
D. BSP/Tech Ref. not clear					
E. Training Required					
F. Other					
V Facility or Office Trouble					
A. Loop/Local Channel (Cable)					
B. Carrier Trouble					
1. N/ON Type					
2. T Type					
3. LMX Type					
4. Other					
C. C.O. or STC Equipment					
D. Other					
Total					

Mail To: American Tel. & Tel. Co. 195 Broadway
DATEC Control Center C-2937
New York. N.Y. 10007

- Certain relevant papers listed in the bibliographies of various Technical References, such as the Technical Reference entitled "Data Communications Using the Switched Telecommunications Network"

- A frequently updated source of information on data communications equipment, such as "Auerbach," "Office Automation," etc

- Publications by various vendors on their equipment and its operation

- Military Standard—MIL. STD 188-type.

A good working relationship should be established between DATEC Support personnel and data services vendors and contacts should be made periodically to discuss mutual technical problems and to exchange information related to current data services and hardware.

3. CASE ESCALATION

3.01 Formal and uniform escalation procedures are necessary to bring the proper resources to bear on data service problems. Complex problems encountered by the field forces, such as incompatibility between the data apparatus and the customer's method of operation, programming difficulties in the business machine, or poor performance due to an unusual transmission impairment, often require expert assistance for a fast resolution of the problem. To improve the installation and maintenance of data services and to help avoid long service delays and customer complaints, the field forces must be provided with rapid access to technical personnel who can assist in resolving these problems.

3.02 There are two basic kinds of escalation for data service problem cases: administrative and technical. These two types of escalation and the conditions under which they apply are outlined below.

Administrative Escalation

3.03 Administrative escalation is the normal organizational technique for resolving problems that is fairly well defined in most companies. This procedure refers problem cases through the chain of command successively higher until a supervisory level is reached that can resolve the problems on an intra- or interdepartmental basis. This type of escalation is effective in dealing with administrative problems but is not always the most effective method of rapidly resolving difficult technical problems.

3.04 Administrative escalation is appropriate and effective in dealing with the following kinds of data service problems:

- Basic deficiencies in planned customer service

- Service order deficiencies—orders late, incomplete, too many supplements, etc

- System design—physical equipment layout, circuit design deficiencies, normal data set option assignment, known interface incompatibilities

- Field personnel availability

- Component availability and supply—data apparatus, key telephone units, channel equipment, and facilities

- Inadequate test equipment—quantity, quality, availability

- Difficulty in coordinating personnel for end-to-end testing

- Customer training deficiencies.

Technical Escalation

3.05 Technical escalation is the direct referral of data service problems to DATEC Support personnel by field force supervisors and subsequent referral by Support personnel to higher levels of technical assistance as required. These technical escalation procedures are intended to supplement existing administrative procedures and standard Bell System Practices by assisting the normal work groups in fulfilling their responsibilities but not supplanting them.

3.06 There are three levels of Data Technical Support available for assisting field forces on data service problems. The first level of technical support is the DATEC Support personnel in an area or division organization. The second level of technical assistance is from DATEC Support personnel at the Company Headquarters. The third level of

support is available as assistance from AT&T Headquarters.

3.07 Technical escalation of data service problems is appropriate under the following conditions:

(1) The service meets Bell System specifications but does not meet the customer's performance expectations.

(2) The service does not meet Bell System specifications and the problem source cannot be identified.

(3) The service has generated a high incidence of trouble reports.

Technical Escalation Timing

3.08 Technical escalation will only work successfully if a time limit for required actions is established and observed. Meeting the time limit will require local procedures to keep field supervision informed of the status and expected disposition of data service problems.

3.09 The following time limits for escalation are intended as a Bell System objective:

(1) When a service meets Bell System specifications but fails to meet the customer's performance expectations, ***escalate immediately*** (3.10).

(2) When a service does not meet Bell System test requirements and the problem source cannot be identified, ***escalate within 4 hours*** of the discovery of the problem (3.11).

(3) When three similar trouble reports on the same service are received within 30 days and have been closed out as "test OK", "came clear", "found OK", "no trouble found", etc, ***escalate immediately*** when the third report is received (3.12).

3.10 Situations, such as in 3.09 (1), may occur at installation when the customer attempts to use the service for the first time or on a repair visit. ***Do not optimize parameters when test results are clearly within limits.*** The test results must be available when escalating to DATEC Support personnel.

3.11 In the case of 3.09 (2), the ***within 4 hours*** limit means that escalation can occur before 4 hours but must not exceed this if a resolution of the problem is not in sight. These hours are usually considered to be working hours but could be continuous hours in the case of a severe data service problem.

3.12 The requirement for escalation in 3.09 (3) may be difficult to oversee without the aid of local maintenance groups. A local procedure should be implemented to assist in this area.

Escalation Procedure

3.13 The following is a step-by-step procedure of the activities resulting from a case of technical escalation:

(a) Field force supervisors must request technical assistance under the conditions outlined in 3.09.

(b) The Area DATEC Support designee will render initial assistance by telephone. Some stubborn cases may not be cleared quickly by phone consultation and will require travel to the problem location. He must arrange to provide ***on-the-job assistance after four hours*** have expired from the time he was first consulted if resolution of the problem is not in sight. This procedure gives the field forces up to eight hours of trouble investigation—four hours without and four hours with technical consultation by phone. Standard contingency travel arrangements should be planned in advance to all parts of the territory covered by the DATEC Support personnel.

(c) After ***eight hours of on-site assistance*** by the Area DATEC Support personnel, the designee must contact the Company Headquarters for technical support if resolution of the problem is still not imminent.

(d) Requests from Area Support personnel to the Headquarters DATEC Support personnel for information and documentation must be honored either verbally or with the actual material within two hours from the time the request was initiated.

(e) Company Headquarters DATEC Support personnel must arrange to provide on-site assistance after ***16 working hours*** have expired

from the time of their initial notification of the data service problem if the cause of the problem has not been identified.

(f) Problems referred to Company Headquarters DATEC Support personnel which remain unresolved may be referred to AT&T Headquarters for advice and assistance. The Company Headquarters designee will usually make this referral in a time interval at his discretion.

(g) AT&T Headquarters, with the aid of Bell Telephone Laboratories, Teletype Corporation, or Western Electric, will provide assistance on the problem as soon as possible.

3.14 The flow chart in Fig. 3 depicts the escalation procedures described in 3.09 through 3.13.

4. COORDINATION

4.01 This part discusses some of the coordination aspects involved with the DATEC Support effort. These coordination procedures are intended to supplement, not replace, existing administrative and control office responsibilities and practices by efficiently bringing in the proper DATEC Support assistance on complex technical data problems.

4.02 There must be efficient coordination and cooperation among all the parties concerned with the provision of data services. This applies equally to both inter- and intracompany relationships. When more than one location's DATEC Support team is involved with a particular data service problem, the team that resolves the problem should always provide feedback of the results to the other teams that have assisted.

Interdepartmental Coordination

4.03 The successful fulfillment of the DATEC Support personnel's responsibilities depends upon how well the Support personnel in turn are supported by other organizations within the company. Regardless of the department to which the designee is assigned (see 2.05), he must be able to freely contact and work with all the other company organizations involved with data services and vice versa. The quality of a customer's service is of utmost importance and the DATEC Support personnel's recommendations for improvement should be taken in that light.

Coordination Between Associated Companies

4.04 Associated company DATEC Support personnel must coordinate their efforts with other Associated Company Support personnel to obtain assistance at work locations outside their territory. Situations arise where a data service problem is escalated at one location resulting from a problem which exists at the far end or where the same data service problem is escalated at each location. In these cases, coordination is a necessity and some illustrations, which also apply to interarea situations, are shown in the following examples:

- ***Example 1:*** A data station working on the Switched Telecommunications Network in Associated Company A territory has a problem communicating with a data station in Associated Company B territory. The data service problem is escalated to DATEC Support personnel in Company A. Investigation and further testing shows the problem source appears to be within Company B territory. Company A's designee consults with Company B DATEC Support personnel and recounts the testing activity and conclusions. Company B's designee confirms the findings and agrees to assume the major investigative role for the resolution of the problem. Company A's designee assists with further testing where necessary and awaits feedback of the problem resolution from Company B's Support personnel.

- ***Example 2:*** A switched network data service between Associated Company A and Associated Company B develops a data service problem. Company A receives the first report and, eventually, the problem is escalated to Company A's DATEC Support personnel. Meanwhile, escalation occurs in Company B. While the additional testing recommended by Company A's designee is taking place, he learns of the dual escalation and contacts Company B's DATEC Support. They agree that Company A's DATEC Support will assume the major investigative role since it was the initial reporting location and Company B's Support personnel will assist where necessary. Further investigation indicated that the data problem source appears to be in Company B's territory. The two Company designees confer and decide that Company B's DATEC Support should now take on the major investigative role in his location and provide feedback of the problem resolution.

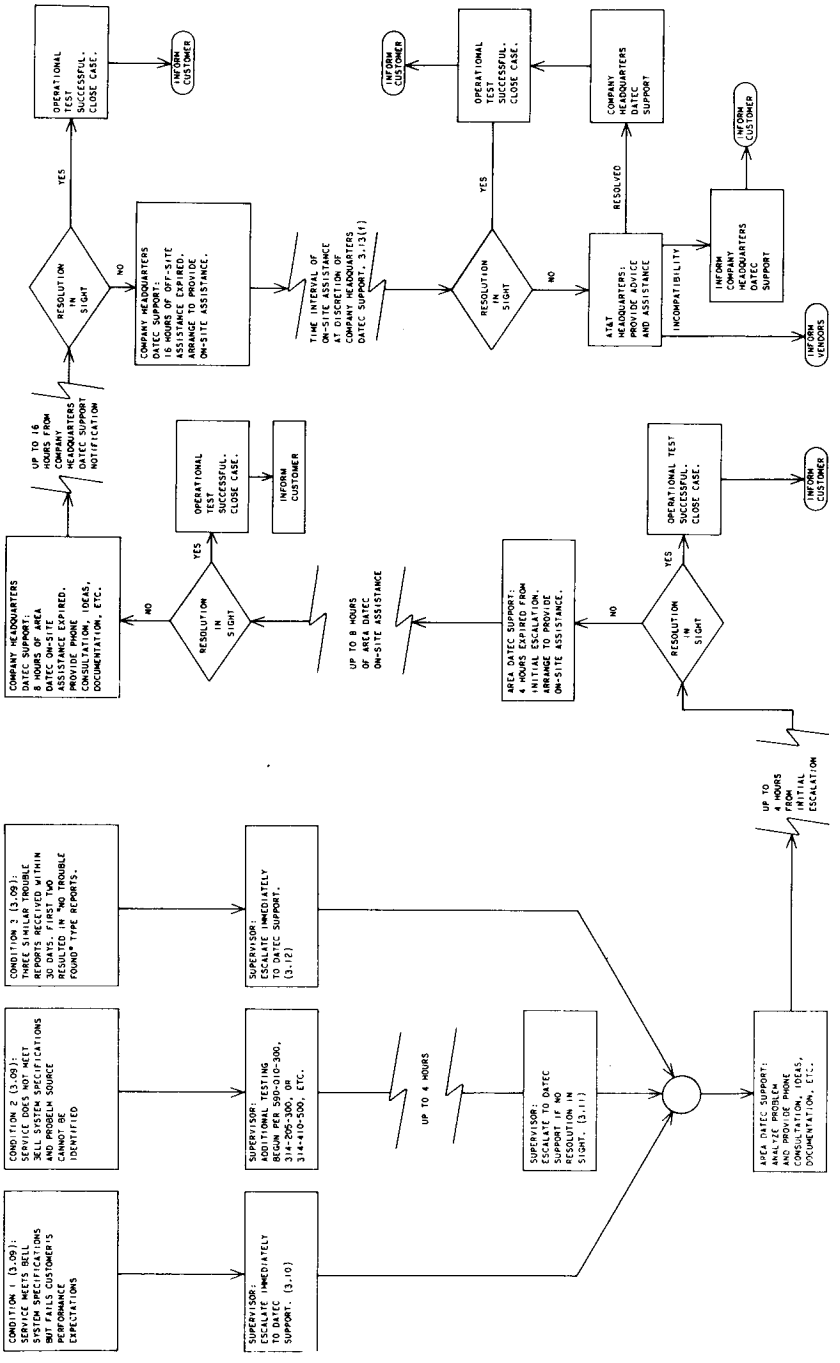

Fig. 3—Flowchart of Data Service Problem Technical Escalation

NOTES

4.05 The two examples illustrated above point out two general rules for coordination:

(1) In single escalation cases, the DATEC Support team will coordinate the problem investigation until either the case is resolved, or until it is mutually agreed that a DATEC team in another territory can more effectively handle the investigation coordination due to the problem source, main customer location, etc (Fig. 4).

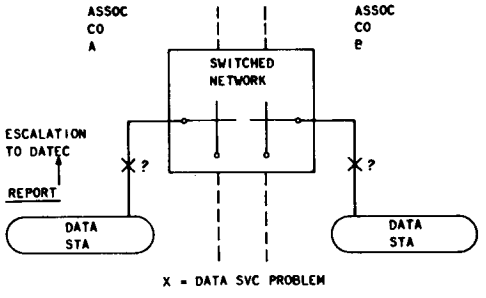

Fig. 4—Associated Company Case 1

(2) In dual escalation cases, the initial problem reporting location's DATEC Support team will coordinate the problem investigation with the assistance of the DATEC team at the other location until either the case is resolved, or the problem cause is indicated to be within the other DATEC team's territory and they agree to assume coordination (Fig. 5).

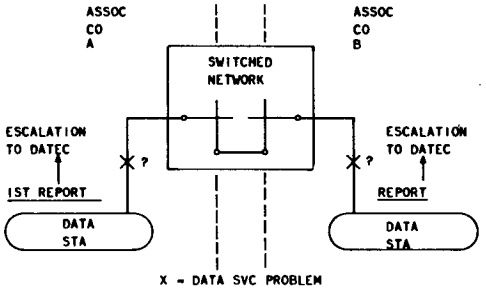

Fig. 5—Associated Company Case 2

Coordination Between Long Lines and Associated Companies

4.06 Long Lines DATEC Support personnel must coordinate their efforts with Associated Company Support personnel to obtain technical assistance at work locations outside their jurisdiction and vice versa. The coordination guidelines supplement normal control office procedures for difficult data service problems.

4.07 The following general guidelines should be used for coordinating DATEC Support activities involving Long Lines and Associated Company personnel:

(1) When a switched network data service problem has been isolated by Associated Company DATEC Support personnel to a particular group of Long Lines facilities and the problem can be corrected by temporarily bypassing the problem source, the Control Office will assume the major investigative role, escalate to its DATEC Support personnel, if necessary, and provide feedback of the problem resolution to the Associated Company support personnel (Fig. 6).

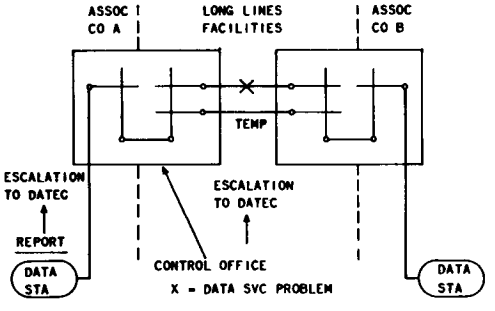

Fig. 6—Long Lines Case 1

(2) When a switched network data service problem has been isolated by Associated Company DATEC Support personnel to a particular group of Long Lines facilities and the problem source cannot be readily identified or bypassed, the Associated Company designee will notify the Control Office that he is contacting the Long Lines DATEC Support personnel to provide

assistance and assume the major investigative role (Fig. 7).

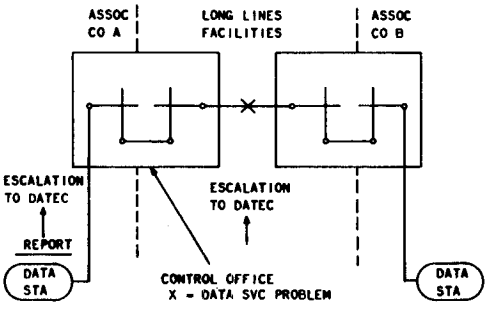

Fig. 7—Long Lines Case 2

(3) When a data service problem on a circuit involving Long Lines and Associated Company facilities is reported to the Control Office and the Control Office testing indicates the problem source is in an Associated Company's area of responsibility, escalation proceeds through the Associated Company's technical support hierarchy with Long Lines DATEC Support assistance, if necessary, until either the problem is resolved or its source is indicated elsewhere and the Long Lines Support personnel assume coordination (Fig. 8).

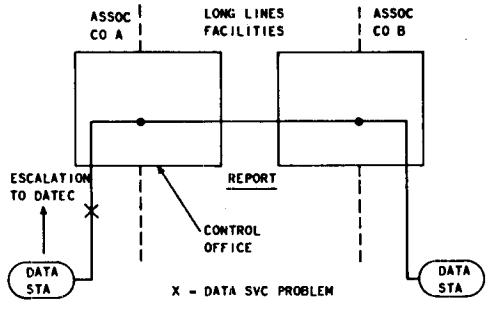

Fig. 8—Long Lines Case 3

(4) When a data service problem involving Long Lines and Associated Company facilities is reported to the Control Office and the Control Office testing indicates the problem source is in the Long Lines area of responsibility, escalation should proceed through the Long Lines technical support hierarchy, with Associated Company DATEC Support assistance, if required, until either the problem is resolved or its source is indicated elsewhere and that location's DATEC Support team could more efficiently handle coordination (Fig. 9).

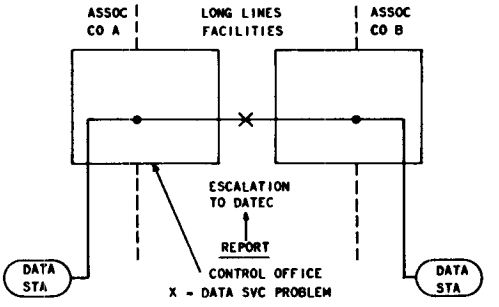

Fig. 9—Long Lines Case 4

Coordination Between Bell System and Independent Companies

4.08 Due to the traditional close-working relationship between Independent Telephone Companies and the Bell System Associated Companies, the coordination of DATEC Support efforts on services partially provided by an Independent Company should be handled by the Associated Company in whose vicinity the Independent Company operates. The coordination of data service problem investigations should proceed similar to 4.05 or 4.07, depending on the circuit configuration, and according to the guidelines of the local Bell Independent Relations department. On some particularly complex data service problems, the Independent Company may request or agree to assistance from Bell System DATEC Support personnel. This, also, should be handled according to local Bell Independent Relations procedures.

4.09 Two of the data problem situations that may arise should be handled as follows:

(1) When a problem develops on a data service jointly provided by an Independent Company and the Bell System and testing indicates the

problem source appears to be in a Bell System location, escalation and coordination of DATEC Support efforts should be handled by the Bell System Company in whose area the problem source is indicated (Fig. 10).

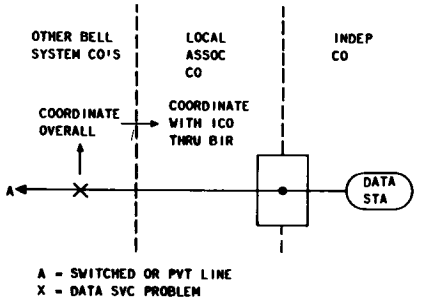

Fig. 10—Bell—ICO Case 1

(2) When a problem develops on a data service jointly provided by an Independent Company and the Bell System and testing indicates the problem source appears to be in an Independent Company location, the local Associated Company should handle coordination of DATEC Support efforts with that Independent Company and agree to provide assistance, if necessary (Fig. 11).

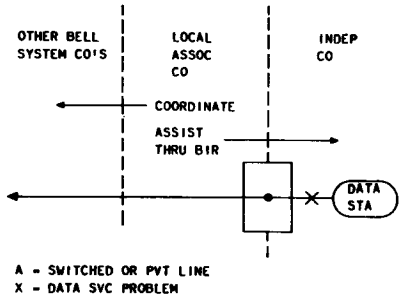

Fig. 11—Bell—ICO Case 2

5. TEST EQUIPMENT

5.01 The technically complex nature of data communications services demands that the persons involved with the installation and maintenance of these services be adequately equipped with the proper test equipment. This part provides recommendations for a basic set of voiceband test equipment for field force use and additional transmission and specialized equipment for DATEC Support personnel. Additional test equipment is necessary for narrowband and wideband services.

A. Field Force Test Equipment

Basic Test Equipment

5.02 The field forces who install and maintain the data services listed in 1.06 must be equipped to perform the basic tests outlined in the Bell System Practices on data services. These same tests are usually made when a data service problem arises for comparison to the most recently recorded benchmarks. The parameters that may be measured are as follows:

- Net loss
- Frequency response
- Impulse noise
- Message circuit noise
- Average error rate
- Envelope delay distortion.

5.03 Table A lists the types of equipment or their equivalents needed by the field forces to make the above measurements. Although the average error rate test can be made with 901, 902, and 903 Data Test Sets, a 914-type Data Test Set combines the functions of these three separate test sets along with some other valuable features. If a new data test set is to be purchased, a 914-type is preferred since it is a more highly versatile unit with many features not found in the 901, 902, and 903 test sets.

Accessible Test Equipment

5.04 Situations may arise during installation or maintenance testing of a particular type of data service in which more than the basic tests should be made. This is true in the case of high-speed Bell System modems which operate above 2400 bits per second or similar customer-provided modems which operate at information rates at or

TABLE A

SUGGESTED BASIC VOICEBAND TEST EQUIPMENT FOR DATA FIELD FORCES

FUNCTION	MODEL	REFERENCE
Net Loss and Freq. Response	3550B Portable Test Set (Hewlett-Packard) — or — TTS 4 BNH Transmission Test Set and TTS 4 BXV LID (Northeast Electronics) — or — Equivalent	Manufacturer's Instructions 103-204-100
Impulse Noise * and Message Circuit Noise †	6F Voiceband Noise Measuring Set (WECo)	103-626-100
Error Rate	914-Type Data Test Set (WECo)	107-101-100
Envelope Delay and Freq. Response	25B Voiceband Gain and Delay Set (WECo)	103-115-101

*6H Voiceband noise measuring set (WECo) may also be used (103-620-101).
†3C Noise measuring set (WECo) may also be used (103-611-101).

above 2400 bits per second. Some suggested equipment that should be available to the field forces for making these types of tests is listed in Table B. Means for centralizing field force accessible test equipment should be established where such means do not now exist.

5.05 Of particular importance to the performance of high-speed modems is the effect of phase jitter, single frequency interference, and harmonic distortion. Since these parameters are contributed primarily by carrier systems, the most logical arrangement for their measurement is between STC s or end offices where intervening carrier facilities exist. The measuring sets for these tests should be available to personnel in those offices from which the high-speed modem service is offered. These instruments are also included in Table B.

5.06 Among the most useful of the troubleshooting test equipment in Table B for field force use is the portable dual trace oscilloscope. The scopes shown have a 15-MHz bandwidth which is more than adequate for rise time measurements on dc interface signals. Other oscilloscopes may be substituted, provided they have the following features:

(a) Dual trace, separate vertical amplifiers

(b) At least 10-MHz bandwidth (3 dB down)

(c) Vertical amplifier sensitivity of at least .05 volt/div

(d) DC balance adjustment on each amplifier

(e) External trigger capability.

5.07 Suggested data field force applications of an oscilloscope are as follows:

- Verification of voltage levels or fluctuations on interface leads which must conform with EIA or other standards
- Observation of impulse noise, excessive circuit noise, distortion on line signals, or eye patterns
- Monitoring ac power lines to note the correlation between hits on the ac power

TABLE B

SUGGESTED ADDITIONAL TEST EQUIPMENT
ACCESSIBLE TO DATA FIELD FORCES

FUNCTION	MODEL	REFERENCE
Phase Jitter Phase Hits Gain Hits	48 Phase Jitter Set (Hekimian Labs) — or — Equivalent	Manufacturer's Instructions
Harmonic Distortion and Single Frequency Interference	1568A Wave Analyzer (General Radio) — or — 302 Wave Analyzer (Hewlett-Packard) — or — Equivalent	Manufacturer's Instructions Manufacturer's Instructions
Frequency Shift Measurements and Electronic Counter	5321B Electronic Counter —10 MHz (Hewlett-Packard) — or — 1192 Counter —32 MHz (General Radio) — or — Equivalent	Manufacturer's Instructions Manufacturer's Instructions
Dual Trace Oscilloscope, 15 MHz, Portable	422 Dual Trace Oscilloscope (Tektronix) — or — VP-561A Dual Trace Oscilloscope (Panasonic) — or — Equivalent	Manufacturer's Instructions Manufacturer's Instructions
X-Y Recorder	136A Two Pen Recorder (Hewlett-Packard) — or — Equivalent	Manufacturer's Instructions
Oscillator	3550B Portable Test Set (Hewlett-Packard) — or — Equivalent	Manufacturer's Instructions
P/AR Measurements	27 P/AR Measuring Set (WECo)	103-110-110
Return Loss	KS-20501 Return Loss Measuring Set (Acton Labs) — or — Equivalent	103-106-115
Singing Point Margin	2D Singing Point Test Set (WECo) — or — TTS 12A Singing Point Test Set (Northeast Electronics) — or — Equivalent	103-106-105 Manufacturer's Instructions

and errors received by Bell System data modems

- Verification of noise or spurious signals on dc interface leads.

When signals are observed on the telephone lines, a test adapter for transformer isolation must be used since the local loop is electrically balanced and oscilloscopes without differential amplifiers and some other models of test equipment are unbalanced to power ground at their inputs. A test adapter for monitor isolation is described in Section 107-180-100.

B. DATEC Support Test Equipment

5.08 The test equipment needs of the Area or Company Headquarters DATEC Support personnel fall into three categories as follows:

(a) Transmission test sets

(b) Data modem test sets

(c) Special test equipment.

5.09 The equipment recommended in these categories could be used by one or more DATEC Support groups, depending upon the number of data services within an operating area and the need. The recommendations are designed to equip the Support groups with adequate equipment usable on the wide variety of data services. The equipment should be assigned to the DATEC Support groups for use either by themselves or in particular situations by the field forces.

Transmission and Data Test Sets

5.10 The recommended transmission test equipment for DATEC Support groups is contained in Table A and Table B. Use of this equipment is basically for testing voice channels in carrier systems with the exception of gain and delay, P/AR, noise, and return loss which is also required for local loop testing. This equipment gives DATEC Support personnel the capability of measuring the following transmission parameters:

- Phase jitter (incidental FM)
- Phase and gain hits
- Harmonic distortion
- Single frequency interference
- Frequency shift (carrier offset)
- Return loss
- Singing point margin
- Envelope delay distortion
- P/AR
- Frequency response
- Noise
- Loss.

5.11 The recommended data modem test set for average error rate measurement is a 914-type. The 914-type test set, as described in Section 107-101-100, is very useful for a number of tests other than error runs which may or may not be possible to obtain from several other pieces of test equipment.

Special Test Equipment

5.12 Occasionally, data service problems develop where standard tests do not uncover the source of the problem. Some special test equipment is necessary in these instances to provide the capability of in-service monitoring of data set interfaces and line signals and performing further data equipment tests.

5.13 Information on several locally constructed units of special test equipment is available in the following sections:

- 107-180-100—Bridging Devices—Description, Application, and Construction
- 107-180-101—Digital Signal Recording and Playback Using a Pulse Transmitter/Receiver—Description, Application, and Construction
- 107-180-102—Interface Test Adapter for Data Set 303-Type—Description, Application, and Construction

- 107-180-103—Multiple Data Set 403D-Type Test Arrangement—Description, Application, and Construction Information

- 107-180-104—Wideband Data Test and Service Bay Connector Panel—Description, Application, and Construction Information.

Information on two other locally constructed items, Polling Test Set and ACU Exerciser, has been distributed to Data Specialists and Headquarters DATEC personnel in AT&T General Letter 71-01-185.

5.14 Several commercially available items which are very useful in the investigation of particularly elusive data service problems are as follows:

(a) Oscilloscope with delayed sweep capability—Tektronix Type 453 or Panasonic Model VP-551A; oscilloscopes with storage capability should also be considered

(b) Audio spectrum analyzer—Singer Model MF-5, Systron-Donner Model 710/800A, or Nelson-Roll 0—20 kHz type

(c) Light beam oscillograph and signal amplifiers—Honeywell Model 1508A Visicorder with Type M13,000 light deflecting galvanometers and 120 ips drive (see Section 107-180-100, Part 3).

5.15 It is strongly recommended that an oscillograph similar to that listed in 5.14 be made a basic tool of DATEC Support personnel. The number of such instruments, because of their high cost and relative operating sophistication, should be limited to this group of Support designees and, in some cases, shared between several groups. To effectively use an oscillograph, the Support personnel must have a good working knowledge of Bell System data set interfaces and the general operation of the business machine communication control equipment, interface, and data format and coding. It is also helpful to understand the overall operation of the customer's system—hardware and software. With sufficient facts about operating methods of particular equipment, the oscillograph provides a positive indication of whether the problem source is located somewhere in the business machine or in the Bell System portion of the service.

5.16 These special test sets are used only on a small percentage of data service problem cases and serve as a last resort when standard tests have not isolated the problem. For the DATEC Support groups, the equipment in the three categories listed in 5.08 should fill the designee's needs when field assistance must be rendered. The special test equipment should be obtained primarily for the DATEC Support groups' field use, but it may be made available to other knowledgeable personnel when difficult data problems arise.

NOTES

PART VIII

TRANSMISSION TEST EQUIPMENT

25B AND 25BR VOICEBAND GAIN AND DELAY SETS

(J94025B AND J94025BR)

DESCRIPTION, OPERATION, AND MAINTENANCE

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1. GENERAL

1.01 This section covers the description, operation, and maintenance of the 25B and 25BR voiceband gain and delay measuring sets (J94025B and J94025BR), hereafter referred to as the 25B and the 25BR sets.

1.02 This section is reissued to clarify test procedure of the 25B and 25BR voiceband gain and delay sets and to correct text and schematic diagram errors. Because of extensive changes, arrows have been omitted. This reissue does not affect the Equipment Test List.

1.03 The 25B set is portable, and the 25BR set is arranged for rack mounting. These sets have similar electrical specifications; therefore, information contained in this section will pertain to both sets unless specified otherwise.

1.04 The 25B and 25BR sets replace the 25A voiceband gain and delay measuring set (J94025A). The 25B sets are compatible with the 25A set and can be used interchangeably, unless recorder measurements are required (only the 25B sets provide recorder outputs).

2. GENERAL DESCRIPTION AND OPERATION

PURPOSE OF INSTRUMENT

2.01 The 25B and 25BR sets provide a means for measuring the envelope delay distortion and loss-frequency characteristics of transmission lines, networks, and equipment components having a characteristic impedance of either 600 or 900 ohms. These sets permit measurements in the 300- to 3500-Hz range of frequencies without the use of additional test equipment. If an external oscillator is provided, the frequency range may be extended to 25 kHz. An external frequency counter can also be used if more precise frequency measurements are required.

2.02 Gain, delay, and frequency are presented on single-scale meters for point-by-point

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measurements. Outputs of the measured data are also provided at separate jacks at the rear of the 25B set and on the front panel of the 25BR set for making continuous recordings of delay versus frequency and/or received level versus frequency with the use of an external X-Y recorder or with an oscilloscope and camera.

2.03 For circuits having 2600-Hz single-frequency signaling facilities, an automatic switching arrangement is provided for skipping the oscillator test frequency beyond 2600 Hz when sweeping through this region. A manual switching arrangement is also provided for removing the transmitted signal from test circuits having signaling frequencies other than 2600 Hz. Without these provisions, operation of the signaling system can occur and cause loss (dropping) of the test connection if the test signal has the same frequency as the single-frequency signaling system.

2.04 ***25B Set Only:*** The List 1 set (see Fig. 1) is a portable set, but with the addition of the List 2 mounting bracket, it can be mounted in a 23-inch rack. Multipled jacks and binding posts are provided on the front panel for connecting to the transmitting and receiving lines. The 309-type jacks for each line are arranged to receive a twin plug (353A type) as well as single plugs. Multipled dial jacks are also provided for connecting a dial or telephone set to the test lines to establish connections. Holding networks are provided in the set, and a switching arrangement permits the interchange of the sending and receiving test lines without losing the test connection. Power and line receptacles are also accessible through a door at the rear of the set for use in connecting to the set when it is used with the List 2 mounting bracket.

2.05 ***25BR Set Only:*** The 25BR set (see Fig. 2) is arranged to be rack mounted. With available brackets (ED-99987-50), it can be mounted in any rack 19 inches or larger. The 25BR set does not have dialing and holding features or facilities for interchanging the transmitting and

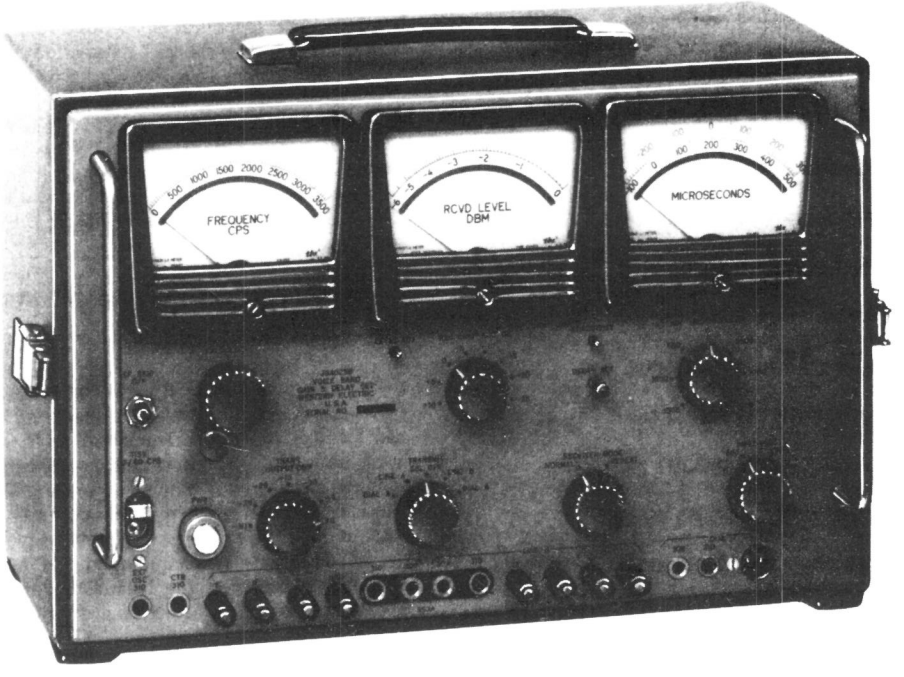

Fig. 1—25B Portable Set

receiving lines. Connectors are provided at the rear of this set for connecting power lines and the transmitting and receiving lines.

GENERAL OPERATION

2.06 Measurements may be made on either a straightaway (one-way) or loop basis. Loop measurements require only one 25-type set operating in the ***normal*** mode and a 4-wire layout. For straightaway measurements, two sets and a return voice-frequency channel are required in addition to the circuit under test.

2.07 The loop method of measurement is frequently used when delay measurements are made; the loop method is also used whenever the maximum possible accuracy of delay value is not required. Whenever measurements are made between the 4-wire terminals of a circuit, the measured loop should consist of the two directions of transmission of the ***same*** circuit. The measured value is then divided by 2 to obtain the circuit delay. The loop method is not recommended when precise delay information on a circuit is required even if the two circuits looped together seem identical in facilities and equipment. The loop method is not recommended because the total measured delay of the loop divided by 2 will usually give only an approximation of the actual delay for each direction.

2.08 Transmission loss- or gain-frequency measurements can be made in several ways:

(a) By using a 25B or 25BR set at both transmitting and receiving ends

(b) By performing a loop measurement using a single 25B or 25BR set at one end

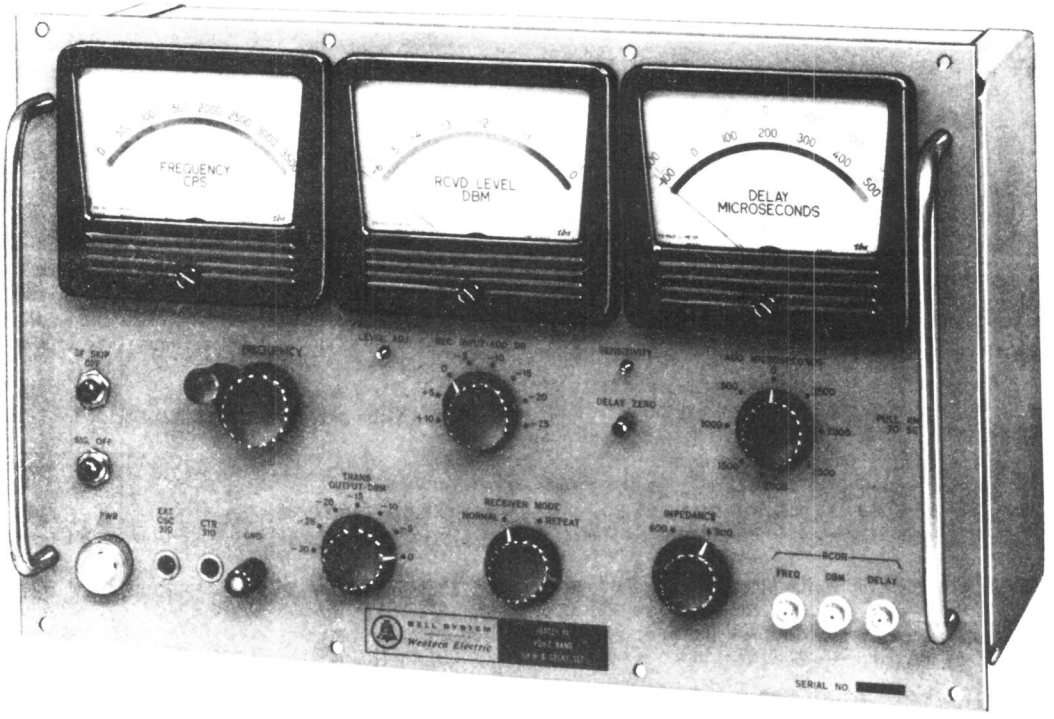

Fig. 2—25BR Rack-mounted Set

(c) By using a 25B or 25BR set as an oscillator at the transmitting end and a 23A transmission measuring set (J94023A) or equivalent at the receiving end

(d) By using a standard milliwatt supply or other suitable oscillator at the transmitting end and a 25B or 25BR set at the receiving end.

The 25B or 25BR set receiver response is flat within 0.1 dB over the 300- to 3500-Hz band of frequencies and has an accuracy of calibration within 0.2 dB at 1000 Hz. The transmitter output, which can be adjusted to an exact value, is also flat within 0.1 dB over the 300- to 3500-Hz band.

2.09 In either a loop or a straightaway (one-way) measurement, the transmitted test signal consists of a double-sideband amplitude-modulated carrier, the frequency of which may be manually varied over the band. The modulating signal is an 83-1/3 Hz sine wave.

2.10 In straightaway measurements, the far-end (or receiving) 25B or 25BR set is operated in the ***repeat*** mode. In this mode, the set recovers the 83-1/3 Hz signal and remodulates this recovered signal on a single-frequency carrier (usually 1800 Hz) and supplies it over the return path to the originating 25B or 25BR set. Because this return carrier frequency (1800 Hz) is not changed during the test, the envelope delay distortion measurement is independent of the delay characteristics of the return path facilities.

2.11 Frequency, loss or gain, and envelope delay distortion information are obtained from the three meters on the face panel. Proportional outputs of the measured data are also provided at separate jacks for making continuous recordings of delay versus frequency and/or received level versus frequency with the use of an external X-Y recorder or with an oscilloscope and camera.

2.12 Envelope delay distortion is indicated on a relative basis with reference to some arbitrary midband frequency. An 1800-Hz or a 2000-Hz frequency is frequently used as a delay reference.

2.13 During straightaway tests with the near-end (transmitting) set in the ***normal*** mode and the far-end (receiving) set in the ***repeat*** mode, the meters of the two sets will indicate as follows:

Near-End Set (Normal Mode):

(a) ***Envelope delay distortion*** of the outgoing line (line under test)

(b) ***Frequency*** of the carrier being transmitted by the near-end set

(c) ***Received level*** of the reference signal on the return path from the far-end set. Note that this loss or gain in level is, in normal operation, only a single-frequency measurement, not the entire frequency characteristic of the return facility.

Far-End Set (Repeat Mode):

(a) ***Received level*** of the signal from the near-end set over the line under test

(b) ***Frequency*** of the carrier being received over the line under test

(c) There will be ***no indication of delay*** since the delay circuits are disconnected in the ***repeat*** mode.

Note: To check the fixed carrier frequency (usually 1800 Hz) being transmitted by the far-end set over the return path, it is necessary to switch the set to the ***normal*** mode and to read the FREQUENCY meter. After the frequency is checked, the set must be returned to the ***repeat*** mode to continue the test.

PERFORMANCE SPECIFICATIONS

2.14 ***Frequency***

Range with internal oscillator:	300 to 3500 Hz
Range with external oscillator:	300 to 25,000 Hz
Accuracy using FREQUENCY meter:	±35 Hz
Accuracy using external counter:	±0.1 percent

2.15 *Amplitude*

Transmitter output:	−30 to 0 dBm (5-dB steps)
Receiver sensitivity:	−30 to +10 dBm
Receiver accuracy for 1000-Hz measurements:	±0.2 dB

Flatness of receiver:

300 to 3500 Hz	±0.1 dB
300 to 25,000 Hz	±0.25 dB

Flatness of transmitter:

300 to 3500 Hz	±0.1 dB
300 to 25,000 Hz	±0.5 dB

Flatness, back-to-back:

600 to 3000 Hz	±0.1 dB
300 to 3500 Hz	±0.15 dB
300 to 25,000 Hz	±0.5 dB

2.16 *Envelope Delay Distortion*

Range:	Unlimited
Overall delay measurement accuracy (see Note 1 below)	
600 to 3500 Hz (internal oscillator)	±10 μs
600 to 25,000 Hz (external oscillator)	±10 μs
300 to 600 Hz (internal or external oscillator)	±20 μs

Note 1: Accuracies of ±5 μs can be obtained for equalized facilities having an envelope delay distortion of 100 μs or less and a gain distortion of ±1 dB or less over the frequency range of 1000 to 2600 Hz. Accuracies of ±5 μs can also be obtained for unequalized facilities by subtracting the envelope delay distortion in the test equipment (determined by a back-to-back measurement) from the measured delay and by maintaining the received level to within ±1.0 dB at each test frequency.

Delay ripple resolution: 300 Hz

Note 2: This is the minimum separation between ripples that can be resolved in a given delay characteristic.

2.17 *Impedance*

Input and output impedance:	600 or 900 ohms
Return loss	>30 dB

Note: The impedances of the transmitter and receiver cannot be selected independently. Both the transmitter and the receiver must work at either 600 or 900 ohms.

2.18 *Longitudinal Balance*

At 300 Hz:	> 65 dB
At 5000 Hz:	> 50 dB

2.19 *Holding Resistance (25B Set Only)*

Input and output dc holding resistance:	700 ohms

2.20 *Approximate Output Voltages at Recorder Jacks (See Notes Below)*

DELAY RCDR:	22.0 μv/μs
FREQ RCDR:	3.6 μv/Hz
DBM RCDR:	1.0 mv/dB

Note 1: For all values it is assumed that a 2000-ohm terminating resistor is connected across the jack.

Note 2: Refer to 4.09 for information on suitable recorders.

2.21 *Environment (Conditions Under Which Above Specifications Should Be Met)*

Input power:	115 ±10 volts, 40 to 400 Hz
Ambient temperature range:	32° to 122° F
Minimum signal-to-noise ratio [as measured with a 3 ( ) NMS having 3-kHz flat weighting]:	20 dB

3. DESCRIPTION OF CONTROLS

3.01 The controls and connections are the same for the 25B and 25BR sets unless specified otherwise. All controls and connections appear on

the face panel of these instruments (see Fig. 1 and 2) except:

(a) For the 25B set, the alternate 115-volt power connection and the alternate test line jacks are at the rear of the set for use when rack mounting this set with the list 2 mounting bracket. Also, at the rear of this set are jacks for connecting an external recorder.

(b) For the 25BR set, the 115-volt power and the test line connections are at the rear.

3.02 ***FREQUENCY:*** This control adjusts the frequency of the subcarrier from 300 to 3500 Hz.

3.03 ***EXT OSC Jack:*** This jack disconnects the internal oscillator when an external oscillator is connected to the jack. It is generally used only for gain and delay measurements above the 300- to 3500-Hz band. The jack accepts 310-type plugs.

3.04 ***TRMTR OUTPUT—DBM:*** This control provides transmitted rms power levels from −30 dBm to 0 dBm in 5-dB steps.

3.05 ***LEVEL ADJ:*** This control is used as a calibration vernier on the TRMTR OUTPUT—DBM control to adjust the transmitted power level to an exact nominal value.

3.06 ***CTR Jack:*** This jack permits the use of an external frequency counter for precise frequency measurements and for measuring frequencies above 3500 Hz. The jack accepts 310-type plugs.

3.07 ***RCVR INPUT—ADD DB:*** The input attenuator permits adjustment of the received signal in steps of 5 dB. In use, it is set to a position that brings the RCVD LEVEL meter indication on-scale. The actual received rms power level is then the algebraic sum of the meter reading and the control setting.

3.08 ***RECEIVER MODE:*** This control permits selection of either the ***normal*** or ***repeat*** mode of operation when set to either the NORMAL or REPEAT position, respectively. Selection of either position is covered in 2.06 through 2.13.

3.09 ***TRANSMIT (25B Set Only):*** This control permits transmitting on either line A or line B. When the LINE A position is selected, the set transmits on line A and receives on line B. The LINE B position permits the reverse arrangement. The SIG OFF position, as normally used, permits the signal to be removed from the transmitting line when tests are conducted on circuits with single-frequency signaling facilities. In this position, the lines are also terminated so that test connections will not be lost. The TRANSMIT control permits interchanging the transmitting and receiving lines without releasing the test connection. It also provides a means for connecting the DIAL jacks to either line A or line B for dialing purposes. Once a line connection is established by using a dial handset, the line connection may be switched at will between the line measuring positions and the handset.

3.10 ***SIG OFF (25BR Set Only):*** This control permits removing the signal from the transmitting line when tests are conducted on circuits with single-frequency signaling facilities.

3.11 ***IMPEDANCE:*** This control provides a means for selecting either a 600- or 900-ohm interface impedance.

3.12 ***SF SKIP OFF:*** This control permits disabling the 2600-Hz skip feature.

3.13 ***ADD MICROSECONDS:*** This 8-position, continuously rotatable switch adds or subtracts 500-μs increments of delay to the DELAY meter reading. The knob pointer may be disconnected and reconnected to the switch by a push-pull action to establish a reference 0 at any switch setting.

3.14 ***SENSITIVITY:*** This control adjusts the sensitivity of the DELAY meter.

3.15 ***DELAY ZERO:*** This control is used to select a convenient delay reference point on the DELAY meter for relative measurements. It may be changed as desired to establish a relative 0 point at any particular frequency.

3.16 ***PWR:*** This switch permits controlling the 115-volt ac power to the set. A lamp is located inside the pushbutton and lights when power is on.

3.17 ***LINE A Jack Field (25B Set Only):*** This jack field consists of a multiple of two jacks and a set of binding posts. Jacks are provided for either 309- or 310-type plugs. The binding

posts will accept banana-type plugs, spade tips, or wire connections.

3.18 ***LINE B Jack Field (25B Set Only):*** This jack field is similar to the LINE A jack field but permits connection to line B.

3.19 ***DIAL Jacks (25B Set Only):*** These jacks permit connection of a telephone set to establish line connections over line A or line B, depending on the setting of the TRANSMIT switch.

3.20 ***RCDR Jacks:*** These jacks provide outputs of the measurement data for making continuous recordings with an external X-Y recorder or with an oscilloscope and camera.

3.21 ***25B Set Only:*** The LINE A and LINE B jacks are multipled to additional jacks on the rear panel of the set for use in rack-mounted installations. One of the two 115-volt power connectors is located on the rear for use in rack-mounted installations. The two power receptacles are connected to the set wiring through a FRONT-REAR slide switch on the back of the set to isolate the unused receptacle.

3.22 ***25BR Set Only:*** Connectors are provided at the rear of the set for connecting to the LINE A or LINE B inputs. A connector is also provided at the rear for connecting 115-volt power to the set.

4. OPERATING PROCEDURE

CALIBRATION—FRONT PANEL

4.01 The front panel calibration should be checked each time the power is turned on if the set has been off for an hour or more. A warm-up period of at least 20 minutes is desirable before calibration. These adjustments should also be rechecked from time to time after continuous operation for an hour or more. The following procedure should be used for calibration.

STEP	PROCEDURE
1	Connect line power to the set. For a 25B set, line power can be connected to either a front or a rear receptacle. The FRONT-REAR slide switch at the rear of this set must be set to the appropriate position. For a 25BR set, line power can be connected at a rear receptacle only.
2	Set the front panel controls as follows:

CONTROL	SETTING
FREQUENCY	To red mark on meter (approx 1800 Hz)
RCVR INPUT — ADD DB	0
TRMTR OUTPUT — DBM	0
RECEIVER MODE	NORMAL
TRANSMIT (25B Set only)	LINE A or LINE B
IMPEDANCE	600 or 900

3	Connect the set back-to-back by patching the LINE A and LINE B jacks together.
4	Allow a warm-up period of at least 20 minutes.

STEP	PROCEDURE
5	Adjust the LEVEL ADJ control to produce an exact 0 indication on the RCVD LEVEL meter. ***Note:*** If an external oscillator is used, it should be set to deliver a 2-kHz signal and its output level (approximately +3.0 dBm) should be adjusted for exactly 0 on the RCVD LEVEL meter.
6	Set the RCVR INPUT—ADD DB control to +5 and verify that the RCVD LEVEL meter reading is within ±0.05 dB of the −5 marker. If it is not, the RCVD LEVEL meter should be calibrated as described in Part H of the procedure in 6.01.
7	Return the RCVR INPUT—ADD DB control to 0 and switch the ADD MICROSECONDS control to the position that produces an on-scale DELAY meter indication.
8	Use the DELAY ZERO control to adjust the DELAY meter indication to 0 (black scale). ***Note:*** It may be necessary to change the ADD MICROSECONDS switch one position clockwise or one position counterclockwise to make this adjustment.
9	Pull out the ADD MICROSECONDS knob and reengage it with its pointer set to 0.
10	Set the ADD MICROSECONDS knob to the 3500 position and adjust the SENSITIVITY control to produce an indication of 500 on the DELAY meter.
11	Reset the ADD MICROSECONDS knob to the 0 position and readjust the DELAY ZERO control to obtain a meter indication of 0.
12	Repeat Steps 10 and 11 until both conditions are met. The set is now calibrated. ***Note:*** If any of the above conditions cannot be met, it may be necessary to adjust one or more of the internal controls (see 6.01).

LOOP MEASUREMENTS

4.02 Loop measurements are made with a single 25B or 25BR set operating in the ***normal*** mode. The transmitting and receiving facility are looped together at the far end. At the near end, these lines are terminated by the LINE A and LINE B terminals of the 25B or 25BR set. The far-end looping may be done by manual assistance or by dialing where dial circuits and looping equipment are available.

Note: Only 4-wire facilities can be inserted between the set and the looping point.

4.03 The loop method is not recommended when precise envelope delay distortion information on a circuit is required. Even if the two circuits seem to be identical, the total measured envelope delay distortion of the loop when divided by 2 will result in only an approximation of the actual delay in each circuit. Because of the rapidity of the method and because no delay set or testing help is required at the far end, the method is useful in cases when delay trouble is suspected and only an approximate measurement is required. The loop method is also used in measurements on networks or equipment components whenever both input and output terminals are in the same office. The following procedure should be used to make loop measurements.

STEP	PROCEDURE
1	Switch the RECEIVER MODE control to NORMAL.
2	Warm up and calibrate the set as described in 4.01.
3	If recorder measurements are to be made, calibrate the recorder as described in 4.11. If ocilloscope measurements are to be made, calibrate the oscilloscope as described in 4.14.
4	Set the TRMTR OUTPUT—DBM control to the desired transmitting power level. (A value of −10 dBm0 is suggested for most facilities. When testing wideband data circuits, the actual data level should be used.) ***Note:*** When circuits or networks having a wide bandwidth are measured, measurement errors may result because of harmonic distortion products produced and transmitted from the modulator. This distortion is proportionately ***less*** for lower transmitter levels, down to a level of −15 dBm. Also, when circuits or networks having a low-pass characteristic are measured, measurement errors may result due to 83-1/3 Hz leak from the modulator. The 83-1/3 Hz leak is proportionately ***higher*** for lower transmitter levels, down to a level of −15 dBm. To minimize measurement errors due to these distortions, it is preferable to operate the transmitter at a level of −15 dBm or lower when measuring wide bandwidth circuits and at a level as high as possible when measuring low-pass circuits. See Fig. 3 and 4 for maximum delay error versus relative circuit loss between the distortion and carrier frequencies.
5	To transmit over line A and receive over line B, set the TRANSMIT switch to LINE A. (The LINE B position permits the direction of transmission around the loop to be reversed.) ***Note:*** The 25BR set does not have the feature that allows reversing the direction of transmission. If this is desired, the test lines must be reversed manually at the LINE A (transmit) and LINE B (receive) jacks or at a remote jack field.
6	To set up a connection on a dialed-up basis, connect a dial handset (or equivalent) to the DIAL jack field. The DIAL A and DIAL B positions of the TRANSMIT switch (only on the 25B set) are used for dialing. When the TRANSMIT control is in the DIAL A position, the handset provides holding for the test circuit connected to the LINE A jack field, and the 25B set holding bridge provides holding for lines connected to the LINE B jack field. (The opposite is true when dialing on LINE B.) With the TRANSMIT control in either the LINE A, LINE B, or SIG OFF position, holding for both lines is provided. The TRANSMIT control shorting-type (make-before-break) switch prevents the loss of a held connection when switching from one condition to another. ***Note:*** The 25BR set does not have dialing and holding features. If these features are desired, they must be supplied separately.
7	After the test loop is established, set the IMPEDANCE control to the appropriate 600- or 900-ohm position. (The transmitter and receiver impedances cannot be set separately.)

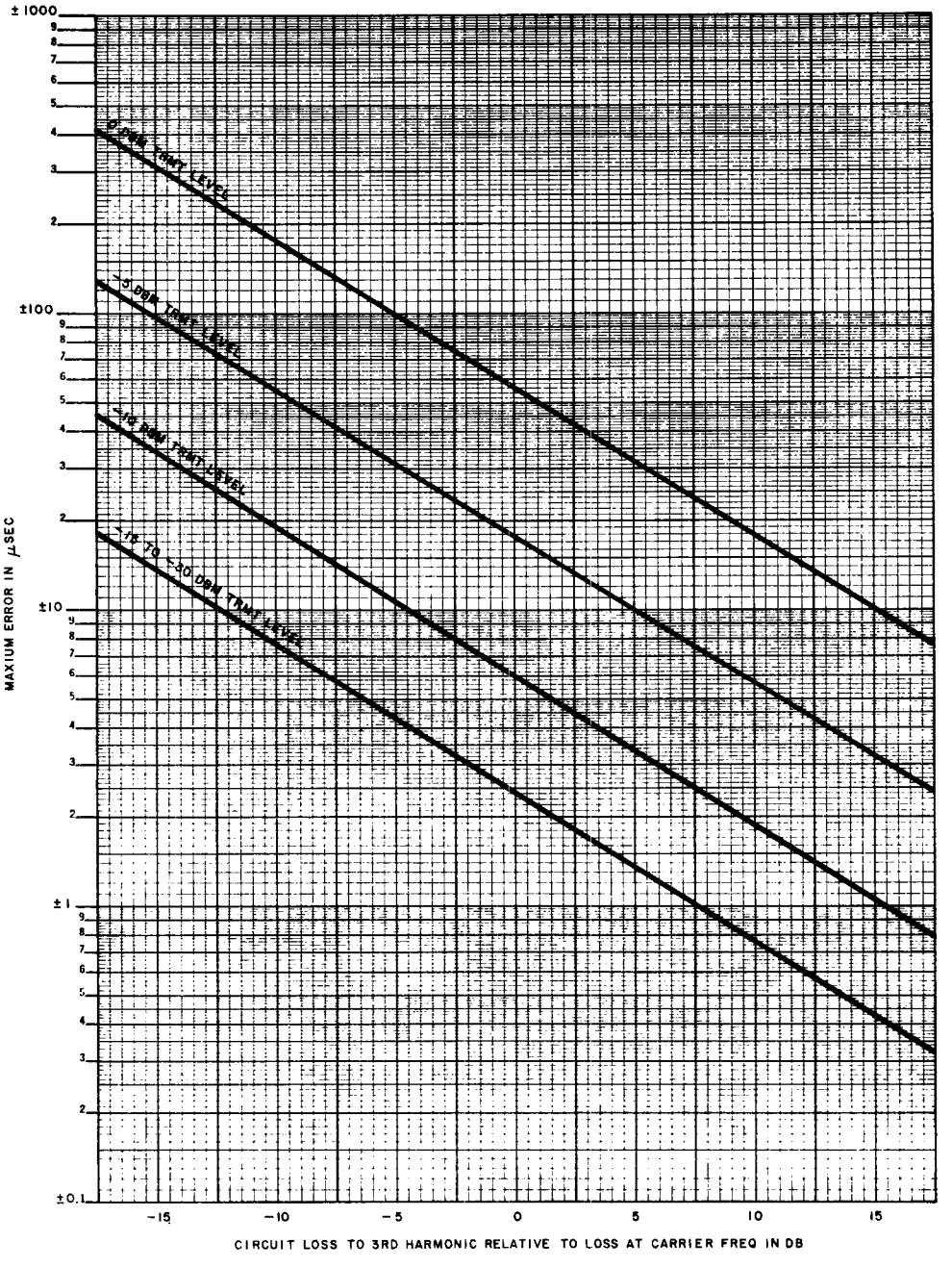

Fig. 3—Maximum Delay Error Due to Modulator Harmonic Distortion Products

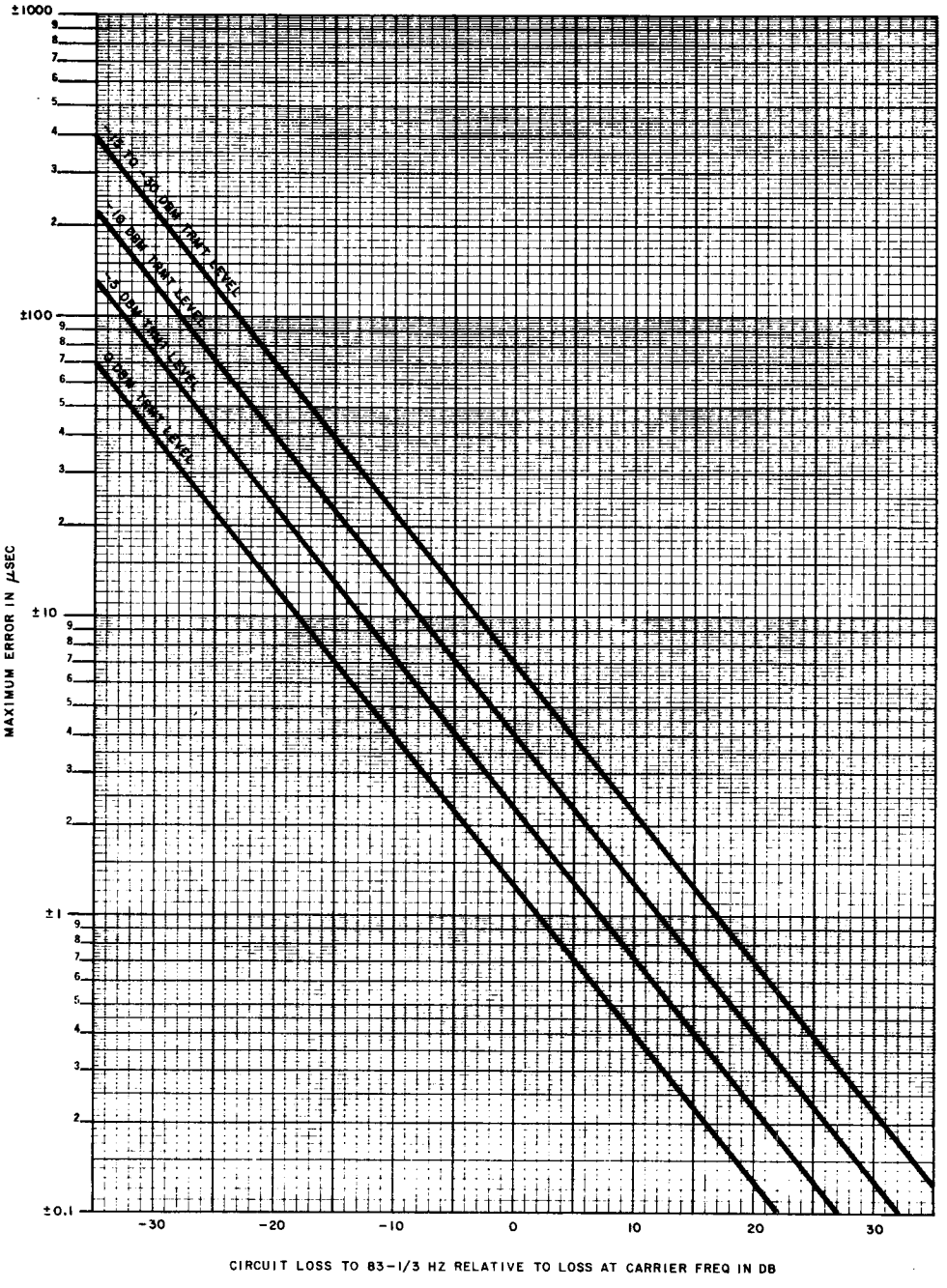

Fig. 4—Maximum Delay Error Due to 83-1/3 Hz Modulation Tone Leak

STEP	PROCEDURE

8 For preliminary adjustment, set the FREQUENCY control for a midband frequency (usually about 1800 Hz). With the set operating in the ***normal*** mode, the FREQUENCY meter indicates the transmitted frequency. An external counter can also be used.

Note: An external counter connected to the CTR jack may cause errors in the FREQUENCY meter readings due to the effects of loading. If the counter is causing loading errors, it should be disconnected before reading frequency on the FREQUENCY meter. To determine if loading is a problem, observe the FREQUENCY meter reading while connecting the external counter to the CTR jack.

9 Set the RCVR INPUT—ADD DB control to a position that causes the RCVD LEVEL meter to read onscale.

Note: An on-scale reading must be maintained on this meter at all times in order to minimize amplitude-delay error.

10 Set the DELAY meter for a 0 reference setting as follows:

(a) Obtain, as nearly as possible, a 0-μs reading by means of the ADD MICROSECONDS switch.

(b) Adjust the DELAY ZERO control to produce an exact 0 indication.

Note: The 0 can be on the black scale if predominately positive readings are expected or on the red scale if both positive and negative readings are expected.

(c) Pull out the ADD MICROSECONDS knob and set the pointer to 0. Push in the knob at this point. Reference 0 has now been obtained at the operating frequency. The reference may be established at any other scale point or any other frequency, as desired.

11 Make loop loss or gain measurements and envelope delay distortion measurements by manually sweeping the internal oscillator frequency control and reading the corresponding meter. Loss or gain is obtained by algebraically adding the RCVD LEVEL meter indication and the RCVR INPUT—ADD DB knob setting and then by subtracting the setting of the TRMTR OUTPUT—DBM knob.

Example 1:

RCVD LEVEL meter indication: -4

RCVR INPUT—ADD DB control setting: $+10$

TRMTR OUTPUT—DBM control setting: -20

(a) $(-4) + (+10) = +6$

(b) $(+6) - (-20) = (+6) + 20 = +26$, or 26-dB gain.

STEP	PROCEDURE

Example 2:

RCVD LEVEL meter indication: −3

RCVR INPUT—ADD DB control setting: −15

TRMTR OUTPUT—DBM control setting: −10

(a) (−3) + (−15) = −18

(b) (−18) − (−10) = (−18) +10 = −8, or 8-dB loss.

Example 3:

RCVD LEVEL meter indication: ±0

RCVR INPUT—ADD DB control setting: ±0

TRMTR OUTPUT—DBM control setting: −5

(a) (±0) + (±0) = ±0

(b) (±0) − (−5) = (±0) +5 = +5, or 5-dB gain.

12 Delay measurements are the algebraic sum of the DELAY meter reading and any 500-μs increments added or subtracted by the ADD MICROSECONDS control. The numbered positions of this switch assist in keeping account of additions to the reference point. It should be noted that the amount of relative delay that may be measured is unlimited; therefore, the number of complete revolutions that the ADD MICROSECONDS control is rotated from the original reference point must be remembered or recorded. The circuit delay is approximately half the delay measured around the loop.

13 The 2600-Hz skip feature automatically skips the oscillator test frequency from 2500 to 2700 Hz or vice versa whenever the test frequency approaches either 2500 or 2700 Hz. This prevents operation of 2600-Hz signaling units and prevents loss of the test connection when measuring on facilities equipped for 2600-Hz signaling. A momentary contact switch is provided for disabling the 2600-Hz skip feature if it is desired to make measurements in the 2500- to 2700-Hz region. To avoid operating single-frequency units having frequencies other than 2600 Hz while sweeping the test frequency through the critical signaling frequency region, perform the following:

(a) On a 25B set, set the transmit control to the SIG OFF position

(b) On a 25BR set, depress the SIG OFF pushbutton.

STRAIGHTAWAY MEASUREMENTS

4.04 For straightaway measurements, two sets and a return voice-frequency channel are required in addition to the line being tested. It is ***not*** essential, however, for the return path to be identical or even similar to the test circuit but only to have reasonable loss and noise characteristics at the frequency that the far-end set (repeat mode) transmits.

4.05 The near-end set operates in the ***normal*** mode and is typically arranged to transmit over the test line connected to its LINE A jacks. This set measures the delay characteristics of line A.

4.06 The far-end set operates in the ***repeat*** mode, ie, it recovers the envelope of the test signal transmitted by the near-end set, remodulates this signal on an adjustable frequency carrier (usually 1800 Hz) that remains fixed for the duration of the test, and transmits this signal back over the return path to the LINE B terminals of the near-end set.

Note: A frequency of 1800 Hz is usually chosen for the far-end set because the ***rate of change*** of delay distortion on a voice-frequency facility is generally minimal at this frequency.

4.07 Both sets should be warmed up and calibrated, as described in 4.01, except that only the LEVEL ADJ control on the far-end set requires adjustment since the delay measuring circuits of a set operated in the ***repeat*** mode are not used. In some cases, however, it may be desired to reverse the direction of measurement to measure the delay- and loss-frequency characteristics of return line B. In this case, the far-end set operates in the ***normal*** mode and the near-end set in the ***repeat*** mode. If this operation is contemplated, both sets must be fully calibrated.

4.08 A set operating in the ***repeat*** mode indicates the frequency and received level of the signal received over the test line from the near-end set. The single-frequency return carrier is usually set for 1800 Hz on the FREQUENCY meter (red marker). This frequency can be checked by switching this far-end set to the ***normal*** mode and reading the frequency on the FREQUENCY meter. Return the set to the ***repeat*** mode to continue the test. The following procedure should be used to make straightaway measurements.

STEP	PROCEDURE
	Near-End Set
1	Connect the power and warm up and calibrate the set as described in 4.01.
2	If recorder measurements are to be made, calibrate the recorder as described in 4.11. If oscilloscope measurements are to be made, calibrate the oscilloscope as described in 4.14.
3	Connect the test line to the LINE A jack.
4	Connect the return line to the LINE B jack.
5	Dial the connection, if required.
6	Set the RECEIVER MODE control to NORMAL.
7	Set the TRMTR OUTPUT—DBM control to the desired transmitting power level. A value of −10 dBm0 is suggested for most facilities. When testing wideband data circuits, the actual data level should be used. ***Note:*** When circuits or networks having a wide bandwidth are measured, measurement errors may result because of harmonic distortion products produced and transmitted from the modulator. This distortion is proportionately ***less*** for lower transmitter levels, down to a level of −15 dBm. Also, when circuits or networks having a low-pass characteristic

STEP	PROCEDURE
	are measured, measurement errors may result due to 83-1/3 Hz leak from the modulator. The 83-1/3 Hz leak is proportionately ***higher*** for lower transmitter levels, down to a level of −15 dBm. To minimize measurement errors due to these distortions, it is preferable to operate the transmitter at a level of −15 dBm or lower when measuring wideband circuits and at a level as high as possible when measuring low-pass circuits. See Fig. 3 and 4 for maximum delay error versus relative circuit loss between the distortion and carrier frequencies.
8	Set the TRANSMIT control (25B set only) to LINE A.
9	Set the IMPEDANCE control to the appropriate 600- or 900-ohm position.
10	When the far-end set is operating, set the DELAY meter for reference 0 as described in (a), (b), and (c) under Step 10 of 4.03.
11	Set the RCVR INPUT—ADD DB control to bring the RCVD LEVEL meter reading on scale. (This meter will indicate the gain or loss of the return path at 1800 Hz and should not change during the test.)
12	Slowly sweep the transmitted carrier frequency over the desired range and observe the delay characteristic of the test line on the DELAY meter.
	Far-End Set
1	Connect the power and warm up and calibrate the set as described in 4.01.
2	If recorder measurements are to be made, calibrate the recorder as described in 4.11. If oscilloscope measurements are to be made, calibrate the oscilloscope as described in 4.14.
3	Connect the test line to the LINE B jack.
4	Connect the return line to the LINE A jack.
5	Dial up the connection, if required.
6	Set the RECEIVER MODE control to REPEAT.
7	Set the FREQUENCY control for a frequency of 1800 Hz as described in 4.08.
8	Set the TRMTR OUTPUT—DBM control to the desired input level to the return line.
9	Set the TRANSMIT control to LINE A (25B set only).
10	Set the IMPEDANCE control to the apropriate 600- or 900-ohm position.
11	Set the RCVR INPUT—ADD DB control to bring the RCVD LEVEL meter on scale. (Assumes the originating set is operating.) ***Note:*** An on-scale reading must be maintained on this meter at all times in order to minimize amplitude-delay error and frequency measurement error (meter and recorder).
12	Record the frequency and the level as received over the test line from the originating set.

RECORDER MEASUREMENTS

4.09 Outputs of the measurement data (received level, delay, and frequency) are provided at jacks for making recordings of delay versus frequency and/or received level versus frequency with the use of an external recorder. Delay versus frequency or received level versus frequency can be measured separately with a single pen recorder such as the Moseley Model H14-7035A, X-Y recorder or equivalent, or can be measured simultaneously with a double pen recorder such as the Moseley Model 136A, X-Y_1-Y_2 recorder or equivalent.

4.10 When making straightaway measurements, the near-end set (***normal*** mode) provides recorder outputs for measuring only delay versus frequency of the test line; the far-end set (***repeat*** mode) provides recorder outputs for measuring only received level versus frequency of the test line. When measuring on a loop basis, the set provides recorder outputs for measuring both delay versus frequency and received level versus frequency of the loop. The following procedure should be used to make recorder measurements.

STEP	PROCEDURE
1	Connect the frequency output at the FREQ RCDR jack on the 25B or 25BR set to the X input on the recorder.
2	Connect the received level output at the DBM RCDR jack or the delay output at the DELAY RCDR jack on the 25B or 25BR set to the Y input on the recorder. ***Note:*** If a 2-pen recorder is used, both the received level and the delay outputs can be connected simultaneously to separate Y inputs on the recorder.
3	Calibrate the recorder as described in 4.11.
4	If loop measurements are being made, set up the test circuit and the test set as described in 4.03; if straightaway measurements are being made, set up the test circuit and test sets as described in 4.08.
5	Measure the loss- or gain-frequency and/or delay-frequency characteristics of the test circuit by ***slowly turning*** the FREQUENCY control over the desired range. ***Note:*** If the test frequency is changed too rapidly, some measurement error will result. This error will show up as a vertical displacement between plots of increasing and decreasing frequencies. If this displacement is significant, even when turning the FREQUENCY control slowly, an adjustment should be made as described in Part F of the procedure in 6.01.

4.11 The following procedure should be used to calibrate the recorder.

STEP	PROCEDURE

X Axis—Frequency

1 Adjust the FREQUENCY control for a frequency of 3500 Hz (or other desired full-scale frequency) on the FREQUENCY meter or on a frequency counter connected to the CTR jack if more precise frequency calibration is required.

Note 1: It may be necessary to disconnect any inputs at the Y terminals if the pen is driven off-scale vertically while making the adjustment.

Note 2: An external counter connected to the CTR jack may cause calibration errors due to the effects of loading. If a counter is used for setting a frequency and the counter is causing loading errors, it should be disconnected before calibrating the X-Y recorder. To determine whether or not loading is a problem, observe the recorder pen indication while connecting the external counter to the CTR jack.

2 Connect a shorting strap across the X input terminals of the recorder and adjust the ZERO control (X input) on the recorder for a zero-frequency pen indication.

3 Remove the shorting strap at the X input terminals and adjust the RANGE and VERNIER controls (X input) on the recorder for a 3500-Hz (or other full-scale frequency) indication of the pen.

Note: It may be necessary to disconnect any inputs at the Y terminals if the pen is driven off-scale vertically while making this adjustment.

4 The X axis is now calibrated.

Y Axis—Received Level

1 Connect the 25B or 25BR set back-to-back by patching the LINE A and LINE B jacks together.

2 Set the RCVR INPUT—ADD DB control on the 25B or 25BR set to +5 and adjust the ZERO control (Y input) on the recorder for the desired lower-scale pen indication.

3 Set the RCVR INPUT—ADD DB control to 0 and adjust the RANGE and VERNIER controls (Y input) on the recorder for the desired upper-scale pen indication.

4 Repeat Steps 2 and 3 until no further adjustment of the recorder controls is necessary when switching the RCVR INPUT—ADD DB control from +5 to 0.

5 The Y axis is now calibrated for measuring received level. Remove the connection between the LINE A and LINE B jacks and set up the test circuit as described in 4.03 or 4.08.

Y Axis—Delay

1 Connect a shorting strap across the Y input terminals (delay input) of the recorder and adjust the ZERO control (Y input) on the recorder for the desired pen indication.

STEP	PROCEDURE
2	Remove the shorting strap at the Y input terminals and adjust the ADD MICROSECONDS and DELAY ZERO controls on the 25B or 25BR set for the same pen indication as in Step 1. This should occur when the DELAY meter registers near the lower end of the scale.
3	Turn the ADD MICROSECONDS control one or more positions clockwise or counterclockwise and adjust the RANGE and VERNIER controls (Y input) on the recorder for the desired pen indication. ***Note:*** The DELAY RCDR output has a limited range due to the repetitive nature of the phase comparator. The range will be approximately centered ($\pm$2000 μs) when the ADD MICROSECONDS control is adjusted for an on-scale DELAY meter indication. This range can be optimized by adjusting the FREQUENCY control through the range of interest and determining the minimum delay reading for the network or circuit being measured with the recorder pen lifted. At the frequency of minimum delay, the ADD MICROSECONDS control can then be adjusted for a minimum recorder indication (the recorder ZERO control may require adjustment to maintain the pen on scale). This should allow a measurement range of approximately 3500 μs without any drastic changes due to the phase comparator's reaching the end of its range.
4	The Y axis is now calibrated for measuring delay. Set up the test circuit as described in 4.03 or 4.08.

OSCILLOSCOPE MEASUREMENTS

4.12 Outputs of the measurement data (received level, delay, and frequency) at the recorder jacks can be used for displaying delay versus frequency and/or received level versus frequency characteristic on an oscilloscope, and a photograph of the characteristic can be taken with a scope camera. Any oscilloscope being used for this purpose should meet the following requirements: independent X and Y inputs with variable gain and positioning controls on each input, sufficient sensitivity (see 2.20), facilities for attaching a camera, and a graticule that can be illuminated. A scope camera capable of taking one picture per full frame of film is desirable.

4.13 When making straightaway measurements, the near-end set (***normal*** mode) provides outputs at the recorder jacks for measuring only delay versus frequency of the test line; the far-end set (***repeat*** mode) provides outputs at the recorder jacks for measuring only received level versus frequency of the test line. When measuring on a loop basis, the set provides outputs at the recorder jacks for measuring both delay versus frequency and received level versus frequency of the loop. The following procedure should be used to make oscilloscope measurements.

STEP	PROCEDURE
1	Connect the frequency output at the FREQ RCDR jack on the 25B or 25BR set to the X input on the oscilloscope.
2	Connect the received level output at the DBM RCDR jack or the delay output at the DELAY RCDR jack on the 25B or 25BR set to the Y input on the oscilloscope.
3	Calibrate the oscilloscope as described in 4.14.

STEP	PROCEDURE
4	If loop measurements are being made, set up the test circuit and the test set as described in 4.03; if straightaway measurements are being made, set up the test circuit and test sets as described in 4.08.
5	Adjust the aperture on the scope camera for a minimum opening and the shutter speed for a time-exposed picture.
6	Turn the scale illumination control on the oscilloscope fully counterclockwise (minimum illumination).
7	Adjust the intensity on the oscilloscope so that the beam is just barely visible.
8	Open the shutter on the camera.
9	Adjust the scale illumination control on the oscilloscope fully clockwise (maximum illumination) for sufficient time for the oscilloscope graticule to be exposed on the film; then turn the scale illumination control fully counterclockwise.
10	Measure the loss- or gain-frequency and/or delay-frequency characteristics of the test circuit by ***slowly turning*** the FREQUENCY control over the desired range. ***Note:*** If the test frequency is changed too rapidly, some measurement error will result. This error will show up as a vertical displacement between plots of increasing and decreasing frequencies. If this displacement is significant, even when turning the FREQUENCY control slowly, an adjustment should be made as described in Part F of the procedure in 6.01.
11	Close the camera shutter and develop the picture.

4.14 The following procedure should be used to make oscilloscope calibration.

STEP	PROCEDURE
	X Axis—Frequency
1	Adjust the oscilloscope for external triggering.
2	Adjust the FREQUENCY control for a frequency of 3500 Hz (or other desired full-scale frequency) on the FREQUENCY meter or on a frequency counter connected to the CTR jack if more precise frequency calibration is required. ***Note:*** An external counter connected to the CTR jack may cause calibration errors due to the effects of loading. If a counter is used for setting a frequency and the counter is causing loading errors, it should be disconnected before calibrating the oscilloscope. To determine if loading is a problem, observe the oscilloscope deflection while connecting the external counter to the CTR jack.

STEP	PROCEDURE
3	Connect a shorting strap across the X input terminals of the oscilloscope and adjust the POSITION control (X input) until the beam indicates at the zero-frequency point.
	Note: It may be necessary to disconnect any inputs at the Y terminals if the beam is driven off-scale vertically while making this adjustment or the one in the following step.
4	Remove the shorting strap at the X input terminals and adjust the sensitivity control (X input) until the beam indicates at the 3500-Hz (or other desired full-scale frequency) point.
5	Repeat Steps 3 and 4 until the horizontal scale is calibrated.
	Y Axis—Received Level
1	Connect the 25B or 25BR set back-to-back by patching the LINE A and LINE B jacks together.
2	Set the RCVR INPUT—ADD DB control on the 25B or 25BR set to +5 and adjust the POSITION control (Y input) on the oscilloscope for the desired lower scale beam indication.
3	Set the RCVR INPUT—ADD DB control to 0 and adjust the sensitivity control (Y input) on the oscilloscope for the desired upper scale beam indication.
4	Repeat Steps 2 and 3 until no further adjustment is necessary when switching the RCVR INPUT—ADD DB control from +5 to 0.
5	The Y axis is now calibrated for measuring received level. Remove the connection between the LINE A and LINE B jacks and set up the test circuit as described in 4.03 or 4.08.
	Y Axis—Delay
1	Connect a shorting strap across the Y input terminals on the oscilloscope and adjust the POSITION control (Y input) for the desired lower scale beam indication.
2	Remove the shorting strap at the Y input terminals and adjust the ADD MICROSECONDS and DELAY ZERO controls on the 25B or 25BR set for the same beam indication as in Step 1. This should occur when the DELAY meter indicates near the lower end of the scale.
3	Turn the ADD MICROSECONDS control one position clockwise and adjust the sensitivity control (Y input) on the oscilloscope for the desired upper scale beam indication.
4	Turn the ADD MICROSECONDS control one position counterclockwise and repeat Steps 1, 2, 3, and 4 until no further adjustment of the oscilloscope controls is necessary.
5	The Y axis is now calibrated for measuring delay. Set up the test circuit as described in 4.03 or 4.08.

5. CIRCUIT DESCRIPTION

GENERAL

5.01 The following paragraphs and Fig. 5 through 9 are intended to give a general understanding of the circuit operation of the 25B and 25BR sets. Detailed circuit operation is covered in CD-99770-01 and the associated SD drawings.

5.02 The overall circuit consists of four main parts or circuit packs: the control circuit, the transmitter circuit, the receiver circuit, and the timing circuit. The power supply for the entire circuit, described later, is associated physically with the transmitter circuit pack, but the individual supply transistors are associated with the other circuits. The circuits of the 25B and 25BR sets are identical except for some differences in their control circuits. Description of the circuit operation will pertain to both sets unless specified otherwise.

5.03 The transmitter circuit (FS-6 of Fig. 5) generates the subcarrier frequency, modulates it with the 83-1/3 Hz signal, and transmits the resulting wave via the control circuit output attenuator, switches, and line jacks to the line. When the set is operating in the ***normal*** mode, the transmitter subcarrier oscillator supplies the variable frequency required for the test range desired (300 to 3500 Hz). In this mode, the modulating 83-1/3 Hz signal is received from the divider output of the timing circuit. When the set is operating in the ***repeat*** mode, however, the 83-1/3 Hz signal is received over the incoming test line through the control circuit and receiver circuit. This signal is used to modulate a fixed single frequency (usually set at 1800 Hz) from the transmitter subcarrier oscillator for transmission over the return test line. The use of an external oscillator for measurements above 3500 Hz is described elsewhere in this section. Note that the frequency meter associated with the transmitter will indicate the transmitter oscillator frequency only in the ***normal*** mode. In the ***repeat*** mode, this meter indicates the subcarrier frequency received over the test line. To check the fixed frequency of the oscillator used in the ***repeat*** mode, the mode switch must be turned to the NORMAL position. After the frequency is observed, the mode switch must be returned to the REPEAT position to continue the test.

5.04 The receiver circuit (FS-4 of Fig. 5) receives the signal from the test circuit. The signal level is indicated on the RCVD LEVEL meter. The relative envelope delay at the transmitted subcarrier frequency is indicated on the DELAY meter. When the set is operating in the ***repeat*** mode, the receiver circuit demodulates the received signal, recovers the 83-1/3 Hz envelope, and uses this recovered signal to remodulate the fixed (1800 Hz) subcarrier for return to the originating test location.

5.05 The timing circuit (FS-5 of Fig. 5) generates the 83-1/3 Hz modulating sine wave for the transmitter and a 250-Hz reference signal for envelope delay measurements in the receiver. This reference signal is a narrow pulse, controlled relative in time to the modulating signal in the transmitter. Its timing can be shifted in increments of 500 μs for comparison in the phase comparator with the signal received over the test line for relative delay measurement. When the set is operating in the ***repeat*** mode, the timing circuit is not used, but its 83-1/3 Hz filter provides additional filtering for the envelope signal (received over the test line) before remodulating the fixed frequency carrier that is returned to the near-end set.

TIMING CIRCUIT DETAILS (Fig. 6)

5.06 The 83-1/3 Hz signal is obtained by dividing the 2000-Hz output of the tuning fork oscillator by 24. This division is done in three stages: a four-to-one, a three-to-one, and a two-to-one stage. The first two stages use unijunction transistor divide circuits. The final stage is a flip-flop, or bistable, multivibrator circuit. This flip-flop circuit produces a square-wave output that is then converted to the 83-1/3 Hz sine-wave signal by the tuned filter.

5.07 The other principal function of the timing circuit is the generation of the reference signal used by the phase comparator for delay measurement. The output of the four-to-one divide

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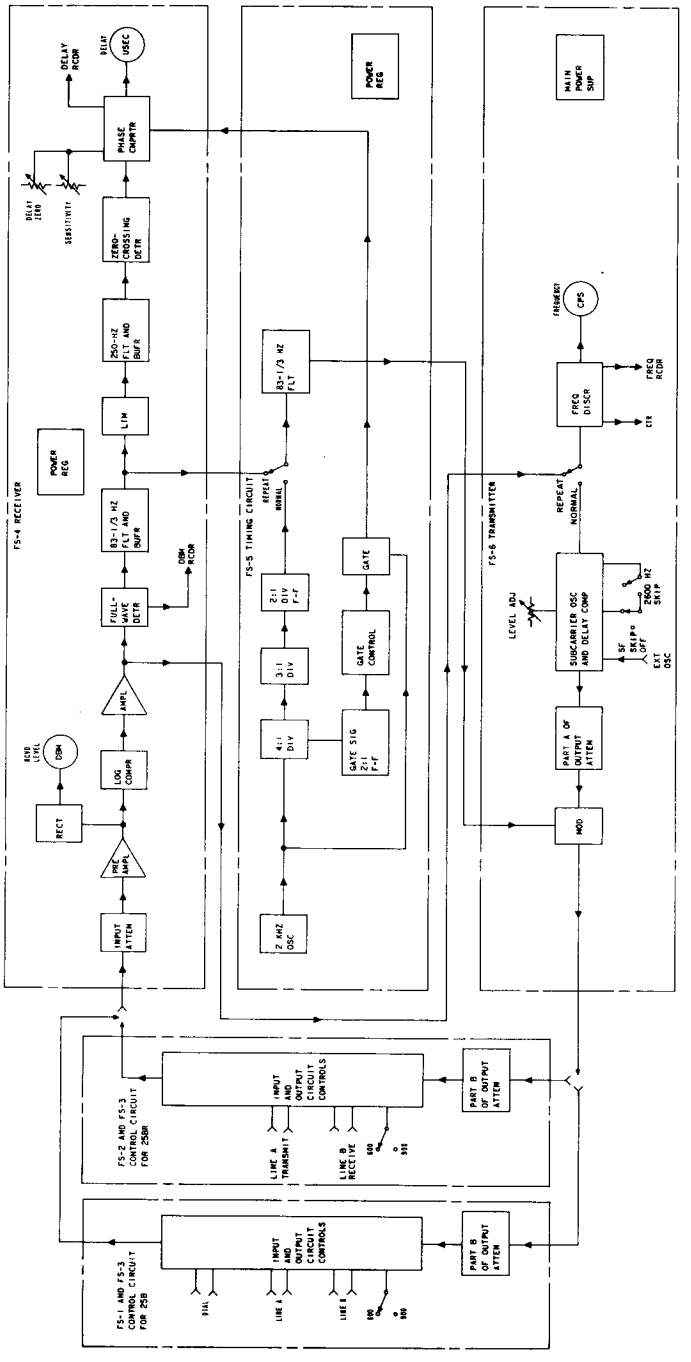

Fig. 5—Block Diagram

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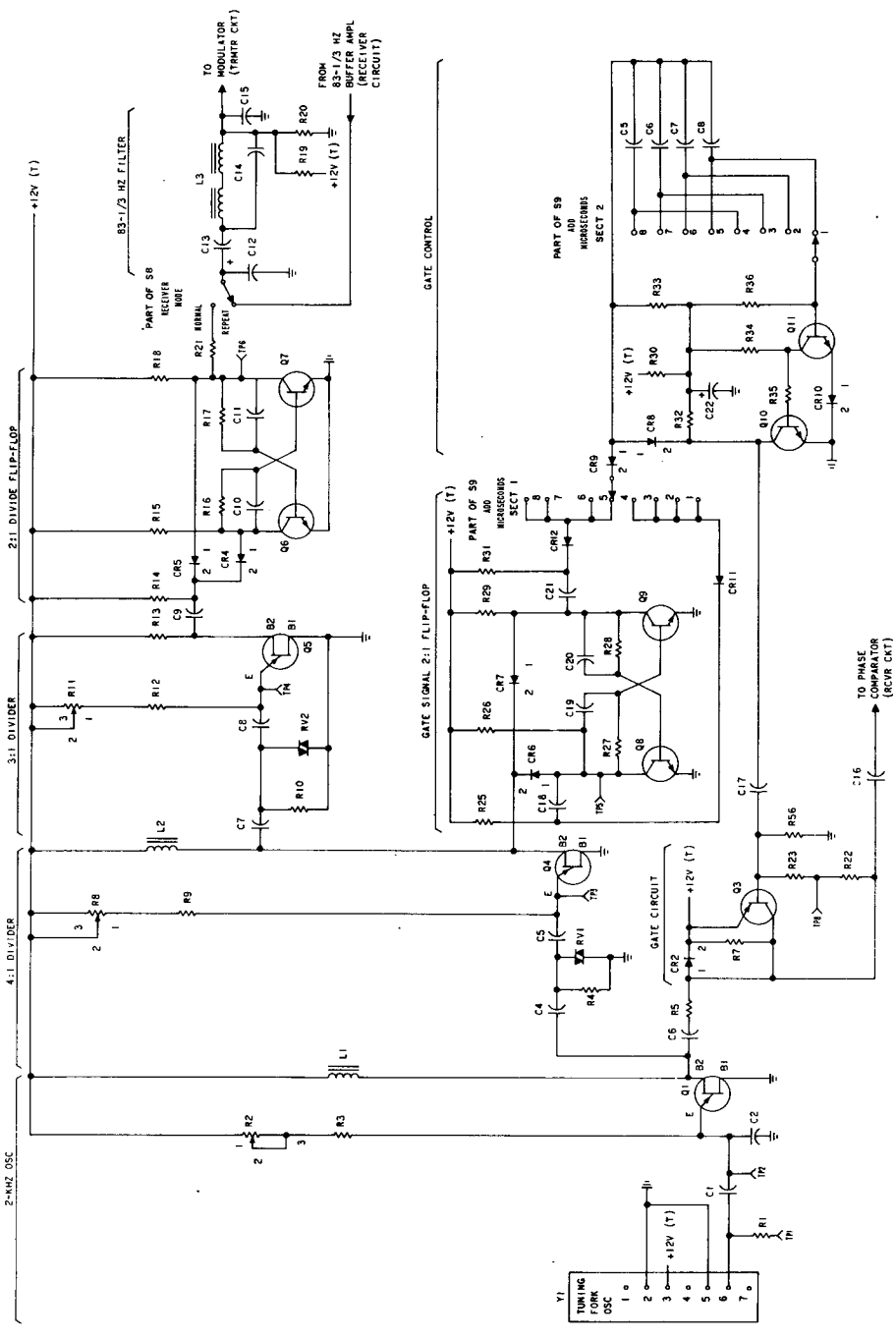

Fig. 6—Timing Circuit, Schematic Diagram

NOTES

stage (5.06) is fed to a two-to-one divide flip-flop stage to produce a 250-Hz narrow pulse signal. The 250-Hz pulse can be taken from either side of the two-to-one divide flip-flop circuit. This provides a means for delaying the 250-Hz pulse by 2 ms with respect to the 2000-Hz pulse. The 250-Hz pulse triggers the gate control circuit at a 250-Hz rate. The gate control circuit is a standard monostable multivibrator, and the time that it is in the unstable state during its 4-ms period is controlled by the ADD MICROSECONDS switch. By taking the 250-Hz pulse from both sides of the divide-by-two flip-flop, the gate control circuit generates eight different timing pulses with only four timing capacitors. The gate control circuit provides the means for activating the gate circuit for a 500-μs interval that straddles in time every eighth pulse of the 2-kHz oscillator. The gate circuit transmits every eighth pulse of the oscillator to the phase detector in the receiver circuit as a timing reference signal. Thus, the timing reference signal consists of a narrow pulse at a 250-Hz rate that may be varied in time to the reference point by 500-μs increments, depending on the setting of the ADD MICROSECONDS switch. The gate circuit is an AND type and will pass only those pulses to be used in triggering the reference side of the phase comparator in the receiver circuit.

TRANSMITTER CIRCUIT DETAILS (Fig. 7)

5.08 The transmitter oscillator is a manually tuned Wien bridge oscillator capable of supplying an output signal adjustable over a range of 300 to 3500 Hz. Its output level is adjusted by the LEVEL ADJ control and part of the TRMTR OUTPUT—DBM attenuator. The oscillator output is modulated by the 83-1/3 Hz signal from the timing circuit in the balanced modulator to produce a double sideband, 50 percent amplitude-modulated test signal. When an external oscillator is used, the internal Wien bridge oscillator is disconnected from the circuit.

5.09 The Wien bridge oscillator consists of an RC frequency selective bridge, a source follower that presents a high impedance to the bridge, a 2-stage direct-coupled amplifier, and an emitter follower. The delay compensator circuit follows the oscillator circuit. This circuit compensates for the internal delay distortion of the set so that when it is connected back-to-back (LINE A patched to LINE B), the delay meter indicates ZERO distortion over the frequency band. Compensation is accomplished by driving the DELAY meter with a current that bucks the meter current changes caused by the internal delay changes. The bucking current is obtained by sampling the subcarrier or external oscillator voltage, passing it through a frequency-weighting network, detecting the weighted signal, and transmitting the resulting dc current to the meter in the proper polarity to buck the current caused by the internal delay changes. An adjustment is provided to obtain the magnitude of bucking current.

5.10 The modulator mixes the output of the Wien bridge oscillator and the 83-1/3 Hz envelope signal from the timing circuit and feeds the composite signal to the test line through part of the TRMTR OUTPUT—DBM attenuator and either a 600- or 900-ohm impedance matching pad.

5.11 The frequency meter circuit consists of an emitter follower, a Schmitt trigger circuit, and two detection networks. The detection networks provide dc outputs proportional to the input frequency for operating the FREQUENCY meter and an external recorder. In the ***normal*** mode, the frequency discriminator detects the frequency of the subcarrier oscillator or external oscillator signal, whichever one is used; in the ***repeat*** mode, the discriminator detects the frequency of the received carrier (the action of the Schmitt trigger circuit makes it possible to read the carrier frequency of the composite received signal).

RECEIVER CIRCUIT DETAILS (Fig. 8)

5.12 The input impedance matching pad, input transformer, and level adjusting pad are followed by the 3-stage preamplifier that provides isolation between the rectifier and the log compressor circuit. The diode rectifier allows the positive portions of the received signal to be passed to the RCVD LEVEL meter for level measurement.

5.13 The log compressor circuit compresses the received signal in a way that maintains a constant peak-to-peak envelope amplitude, even if the received level changes. For this reason, the signal levels in the following envelope delay measuring circuits are independent of the received signal level. The logarithmic compressed version of the received test signal will have an envelope that remains constant for a range of about 10 dB of change in received signal amplitude.

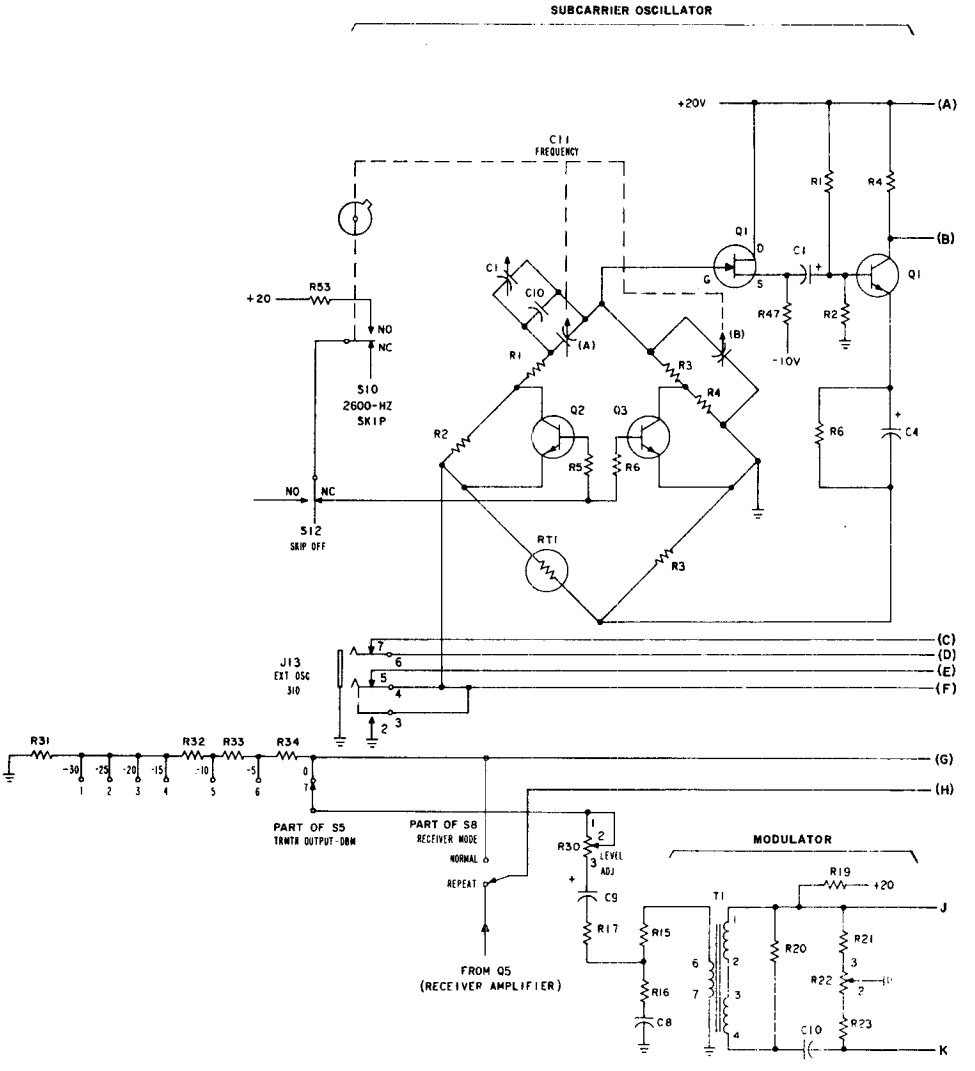

Fig. 7—Transmitter Circuit, Schematic Diagram (Sheet 1 of 2)

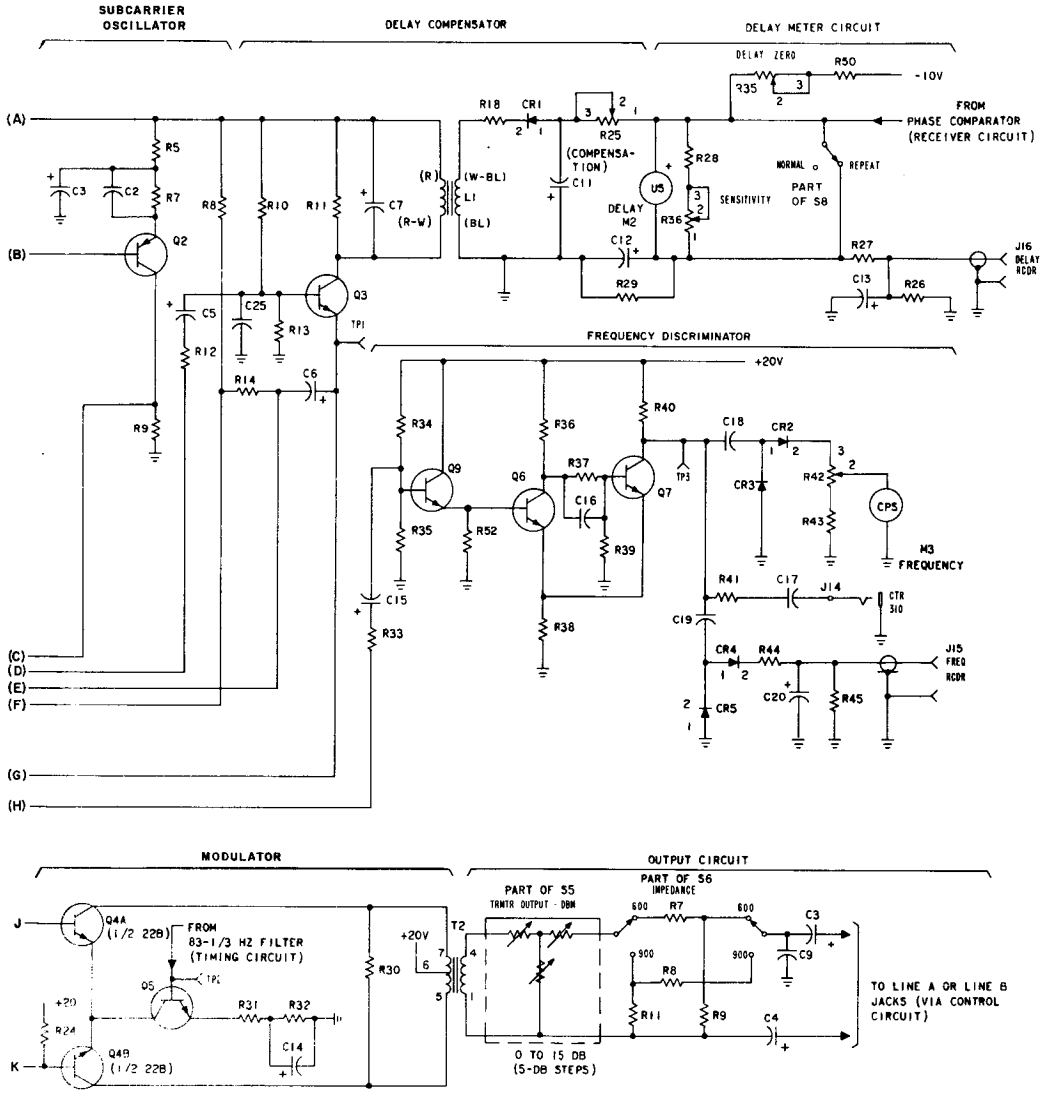

Fig. 7—Transmitter Circuit, Schematic Diagram (Sheet 2 of 2)

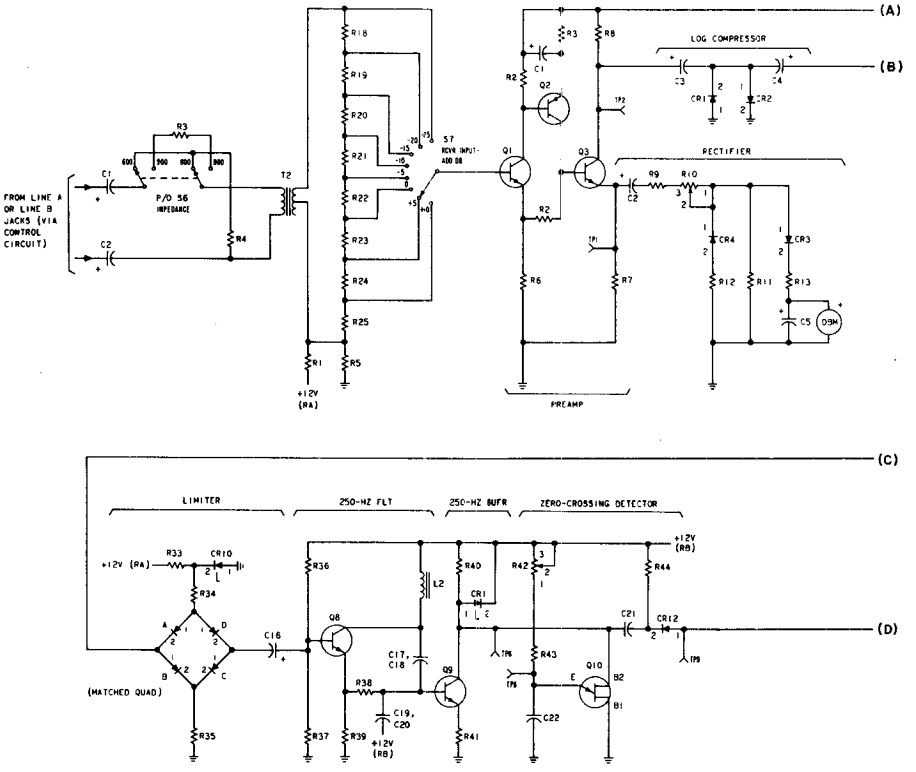

Fig. 8—Receiver Circuit, Schematic Diagram (Sheet 1 of 2)

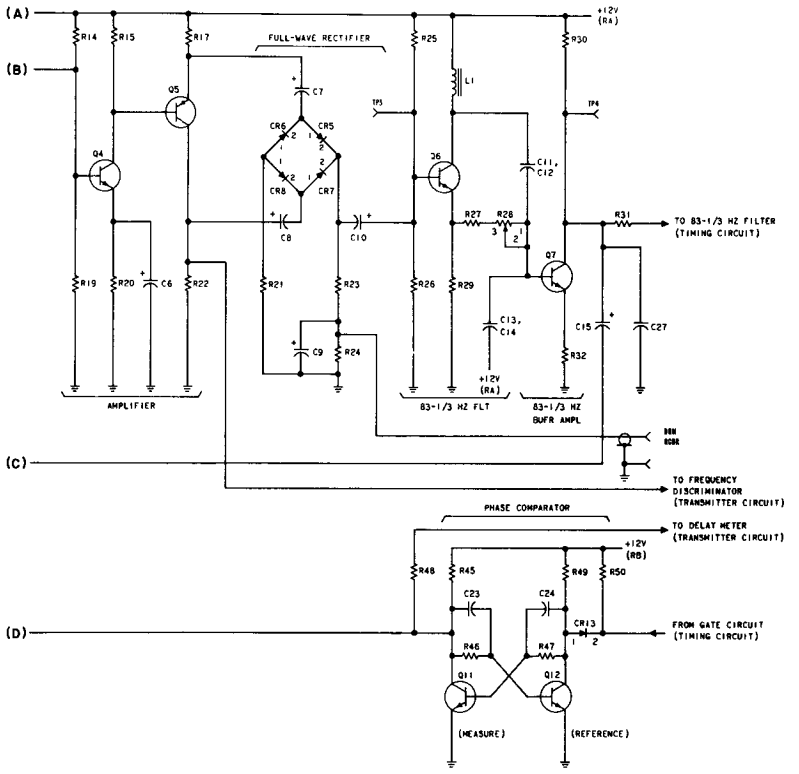

Fig. 8—Receiver Circuit, Schematic Diagram (Sheet 2 of 2)

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5.14 The log compressor is followed by an amplifier providing about 15-dB gain. The signal is then rectified to recover the envelope. After detection, the signal is passed through the 83-1/3 Hz filter to remove harmonic distortion, unwanted carrier frequency components, and noise received from the test line. A portion of the rectified signal is filtered and directed to the DBM RCDR jack for measuring received level versus frequency with an external recorder. The dc component of this signal is proportional to the logarithm of the received input signal.

5.15 The limiter and 250-Hz filter serve to multiply the 83-1/3 Hz signal by 3 to produce a 250-Hz signal. The frequency multiplication makes possible a more accurate measurement of phase shift in the signal. The phase position of the 250-Hz signal is detected in the zero-crossing detector, which generates a narrow pulse at each negative-going zero-crossing of the sine wave. The envelope delay distortion of the test circuit is then measured in the phase comparator circuit by comparing the time of occurrence of the pulses from the zero-crossing detector with the reference signal from the timing circuit.

5.16 The output of the phase comparator consists of a series of pulses at the 250-Hz rate. The pulse width is proportional to the amount of phase shift produced at any one frequency by the test circuit. Therefore, the dc component of this rectangular pulse is a measure of the envelope delay.

POWER SUPPLY DETAILS (Fig. 9)

5.17 The input transformer steps down the line voltage and feeds the full-wave diode rectifier. Some filtering is supplied by the RC network. Regulation is obtained by the combined action of current-limiting diodes CR10A and CR10B and zener diodes CR11 and CR12. The current-limiting diodes are constant-current devices that maintain a constant current through their terminals regardless of the voltage across them (within the limits of 6 to 75 volts). The current-limiting diodes provide regulation against line voltage variations by keeping the current constant through the zener diodes, which, in turn, keep close voltage control on the base of the supply transistors. In addition, the current-limiting diodes (which have a high impedance to alternating current) further reduce the ripple in the supply.

5.18 The current gain of the transistors is such that the transistors supply sufficient power for the set while permitting a small current through the constant-current diodes. The 20-volt output of Q8(CP 3) supplies the transmitter circuit. Q2(CP 2) and Q13 and Q14(CP 1) furnish 12-volt supplies for the timing and receiver circuits, respectively. Zener diode CR13 provides a regulated −10 volts for the delay zero circuit and also for the field effect transistor in the subcarrier oscillator circuit. The 12-volt supply transistors and load resistors are physically associated with the circuit packs they supply. Other components of the power supply are associated with the transmitter circuit pack.

6. MAINTENANCE AND REPAIR

CALIBRATION—INTERNAL ADJUSTMENTS

6.01 The internal calibration adjustments should be checked whenever any of the front panel adjustments cannot be made or when a trouble condition exists. In any event, these adjustments should be checked at least once every six months to ensure good performance of the set. If any of the adjustments are not effective, the instrument should be sent to a repair and calibration center such as a Western Electric distributing house. Unless otherwise stated, all internal calibration adjustments should be made with the front panel controls as described in 4.01. A warm-up period of at least 20 minutes should be allowed before any of these adjustments are made. The following procedure should be used to make internal adjustments.

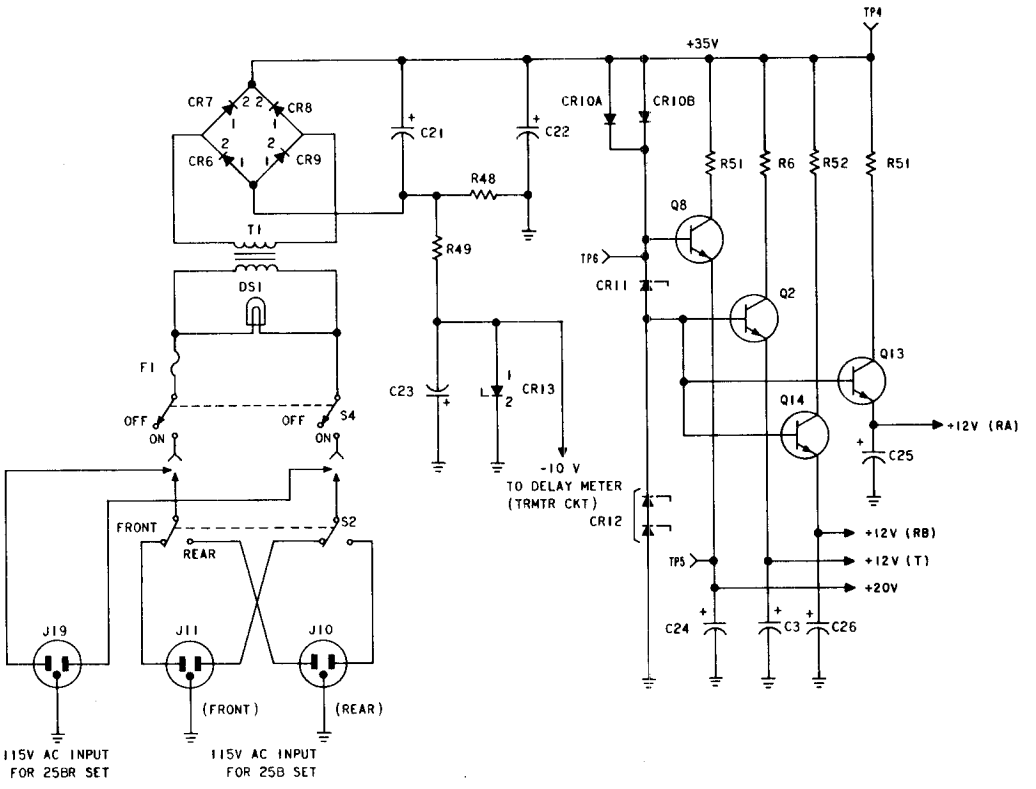

Fig. 9—Power Supply

STEP	PROCEDURE
	A. 2-kHz Oscillator Adjustment
1	Adjust R2 (on timing circuit board CP 2) to the midpoint of the range that produces successive 500-μs sawtooths at TP 2 (emitter of Q1).
2	Verify that the waveform is as shown in Fig. 10, waveform No. 1.
	B. 4:1 Divide Adjustment
1	Adjust R8 (on timing circuit board CP 2) to the midpoint of the range that produces successive 2000-μs sawtooths at TP 3 (emitter of Q4).
2	Verify that the waveform is as shown in Fig. 10, waveform No. 2. Note that the waveform scale is 500 μs/cm so that the timing pulses added to the sawtooth waveform are displayed.

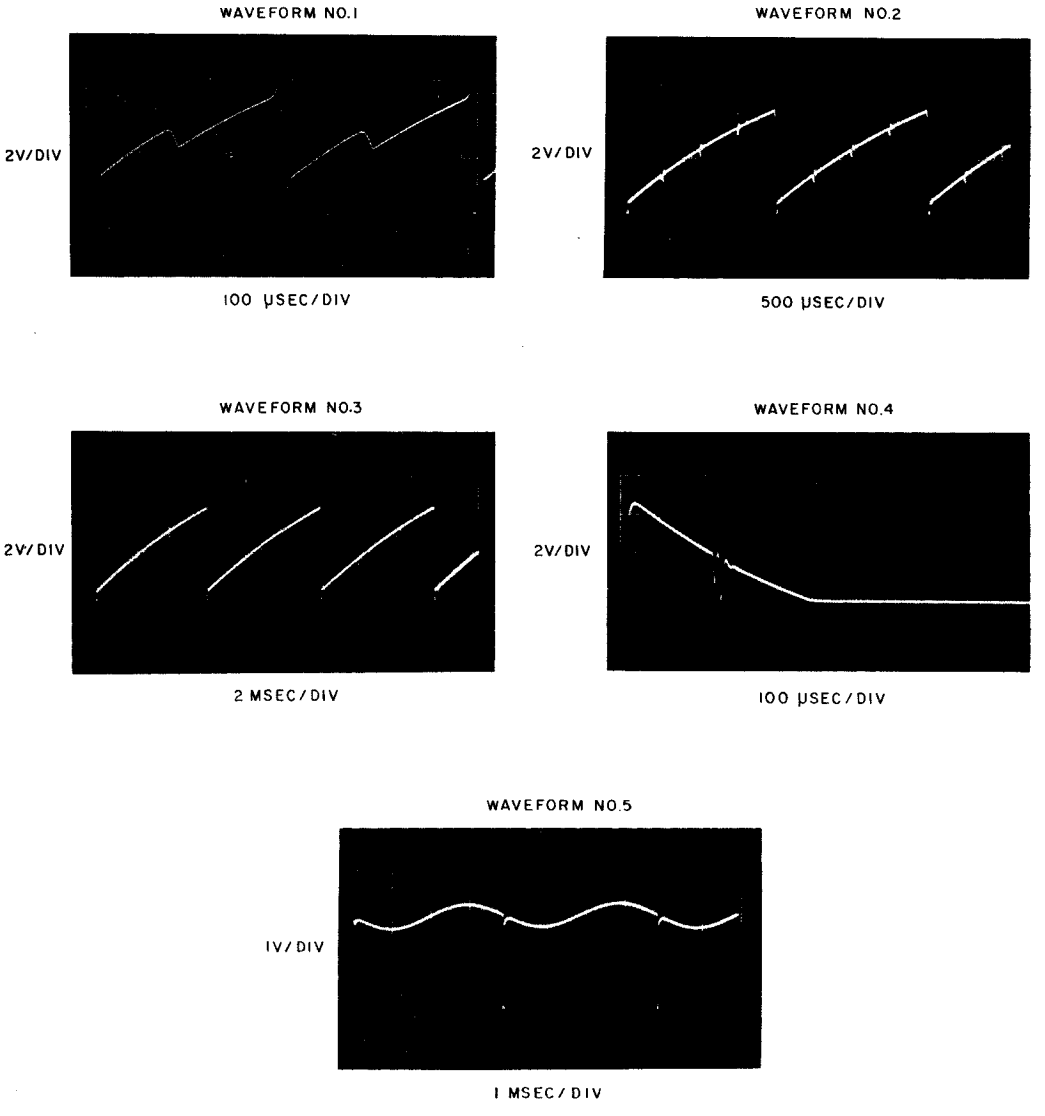

Fig. 10—Waveforms

STEP	PROCEDURE
	C. 3:1 Divide Adjustment
1	Adjust R11 (on timing circuit board CP 2) to the midpoint of the range that produces successive 6-ms sawtooths at TP 4 (emitter of Q5).
2	Verify that the waveform is as shown in Fig. 10, waveform No. 3.
3	Verify that the waveform at TP 8 (junction of R22 and R23 on timing circuit board CP 2) is as shown in Fig. 10, waveform No. 4, for all positions of the ADD MICROSECONDS control.
	D. Modulator Balance Adjustment
1	Insert a 310-type plug, shorted between tip and ring, into the EXT OSC jack.
2	Adjust R22 (on transmitter board CP 3) to minimize the peak-to-peak ripple voltage at either the LINE A or LINE B jacks or binding posts as observed on an oscilloscope.
3	Remove the 310-type plug from the EXT OSC jack.
	E. FREQUENCY Meter Calibration
1	Connect a frequency counter to the CTR jack.
2	Position the set so that the meters are in a horizontal position (facing upward) for a 25B set and in a vertical position for a 25BR set.
3	Adjust the FREQUENCY control for 3500 Hz on the counter.
4	Disconnect the frequency counter and adjust R42 (on transmitter board CP 3) for a reading of 3500 Hz on the FREQUENCY meter.
	F. Subscriber Oscillator Adjustment
	Note: This adjustment should be made only if excessive hysteresis (displacement between plots of increasing and decreasing frequencies) is observed when plotting the received level versus frequency with an X-Y recorder. The 2600 CPS SKIP adjustment (see Part G in the procedure in 6.01) should be checked following any adjustment of this control (C1 on CP 4). The adjustment procedure is:
1	Connect LINE A to LINE B.
2	Connect the FREQ RCDR and DBM RCDR outputs to the respective X and Y inputs of the X-Y recorder.
3	Calibrate the X-Y recorder for a full-scale sensitivity of approximately 5 dB as described in 4.11.
4	Slowly sweep the subcarrier frequency from 300 to 3500 Hz and plot the back-to-back received level on the X-Y recorder.

STEP	PROCEDURE
5	Repeat Step 4, but this time slowly sweep the frequency from 3500 to 300 Hz.
6	Observe the plots of the X-Y recorder. If the two plots fall on top of each other, C1 is in adjustment. If they do not coincide, C1 (CP 4) should be adjusted by trial and error until the deviation between the plots of increasing and decreasing frequencies is minimized.
	G. 2600 CPS SKIP Adjustment
	Note: This adjustment should be made following any adjustment of C1 (see Part F of the procedure in 6.01). The adjustment procedure is:
1	Connect a frequency counter to the CTR jack.
2	Ensure that all shields near the FREQUENCY capacitor (C11) are in place and tightly secured.
3	Adjust the vernier adjustment on the cam, which is mounted on the FREQUENCY capacitor shaft, and the FREQUENCY knob by trial and error until the frequency counter reads 2495 $\pm$5 Hz just before the 2600 CPS SKIP switch actuates when the FREQUENCY knob is turned in a clockwise direction.
	Note: If the vernier adjustment does not have sufficient range, release the two set screws on the cam and position the cam so that the vernier adjustment range is centered at approximately 2495 Hz.
4	Adjust the FREQUENCY knob in a clockwise direction to the point where the 2600 CPS SKIP switch just actuates and verify that the frequency counter reading is 2705 $\pm$20 Hz.
	H. RCVD LEVEL Meter Calibration
1	Remove the connection between LINE A and LINE B.
2	Position the set so that the meters are in a horizontal position (facing upward) for a 25B set and in a vertical position for a 25BR set.
3	Set the TRANSMIT knob to LINE A (25B set only).
4	Set the RCVR INPUT—ADD DB knob to the 0 position.
5	Connect a 1-kHz sine-wave generator, having either a 600- or 900-ohm source impedance and an output level of 0 $\pm$0.03 dBm, to the LINE B input.
6	Set the IMPEDANCE knob to correspond to the source impedance of the 1-kHz generator.
7	Make sure that the set has been turned on for at least 20 minutes before continuing the calibration.
8	Adjust R10 (on receiver board CP 1) for a 0-dBm reading on the RCVD LEVEL meter.
9	Disconnect the 1-kHz generator from LINE B.

STEP	PROCEDURE
10	Patch LINE A to LINE B so that the set is operating back-to-back.
11	Adjust the LEVEL ADJ control (R30) on the front panel assembly for a 0-dBm reading on the RCVD LEVEL meter.
12	Set the RCVR INPUT—ADD DB knob to the +5 position.
13	Adjust the ZERO-ADJUST screw on the front of the RCVD LEVEL meter for a −5 dBm meter reading.
	Note: If this control does not have sufficient range, a coarse control on the rear of the RCVD LEVEL meter should be adjusted to center the adjustment range of the front ZERO-ADJUST control.
14	Set the RCVR INPUT—ADD DB knob to the 0 position and repeat Step 8.
15	Repeat Steps 12, 13, and 14 until the RCVD LEVEL meter reads 0 dBm with the RCVR INPUT—ADD DB knob in the 0 position and reads −5 dBm with the RCVR INPUT—ADD DB knob in the +5 position.
	I. 83-1/3 Hz Buffer Amplifier Output Adjustment
1	Patch LINE A to LINE B so that the set is operating back-to-back.
2	Adjust R28 (on receiver board CP 1) for a peak-to-peak voltage of 4.8 volts at TP 4 (collector of Q7).
	J. Zero-Crossing Detector Adjustment
1	Patch the LINE A and LINE B jacks together.
2	On a 25B set, set the TRANSMIT knob to SIG OFF; on a 25BR set, depress the SIG OFF pushbutton.
3	Adjust R42 (on receiver board CP 1) for a sawtooth period of 4 ms at TP 8 (emitter of Q10).
4	Set the TRANSMIT knob to LINE A on a 25B set or release the SIG OFF pushbutton on a 25BR set and adjust R42 so that the negative-going pulses which are superimposed on a slightly distorted 250-Hz sine wave at TP 6 (base 2 of Q10) coincide with the negative-going zero crossings of the 250-Hz sine wave.
5	Verify that the waveform is as shown in Fig. 10, waveform No. 5.
6	Turn the ADD MICROSECONDS control through all eight positions and verify that the positive portion of the rectangular pulse at TP 9 (collector of Q11 on receiver board CP 1) changes by 500-μs increments with each step of the switch.

STEP	PROCEDURE
	K. Delay Compensation Adjustment
1	Patch the LINE A and LINE B jacks together.
2	Set the IMPEDANCE knob to 600.
3	Set the FREQUENCY knob for a subcarrier frequency of 3 kHz.
4	Adjust the DELAY meter sensitivity as described in Steps 8 through 12 of the procedure in 4.01.
5	Adjust the ADD MICROSECONDS control and the DELAY ZERO control for a reading of zero on the DELAY meter (red scale).
6	Set the FREQUENCY knob for a subcarrier frequency of 300 Hz and adjust R25 (the delay compensation control on transmitter board CP 3) for a reading of zero on the DELAY meter (red scale).
7	Repeat Steps 3, 5, and 6 until the DELAY meter reads zero at both 300 and 3000 Hz without adjustment of the R25 or the DELAY ZERO control.

REPAIR

6.02 If any item of the set is malfunctioning or defective or if it is required that the internal adjustments be made and the necessary test equipment is not available locally, the set should be sent to a repair and calibration center such as a Western Electric distributing house.

6.03 Most trouble conditions will become apparent when the front panel controls are calibrated (see 4.01). These adjustments should be checked frequently to detect a possible trouble condition. If any of the front panel adjustments cannot be made, the internal adjustments should be checked as described in the procedures in 6.01. In general, these adjustments should be checked in the order listed. In this way, a trouble condition can be isolated to a particular circuit. Transistor voltages, waveforms, and a detailed description of the circuit are contained CD-99770-01 to assist in troubleshooting and in repairing a trouble condition. Waveforms are also shown near test points on SD-99770-01 to help isolate a trouble.

7. REFERENCES

7.01 The following documents provide supplementary information for this BSP:

CD-99770-01 SD-99770-01	Common Systems—Transmission Measuring—25B and 25BR Voiceband Gain and Delay Sets
801-250-160	J94025—Type Voiceband Gain and Delay Set—Common Systems

NOTES

6F AND 6FR VOICEBAND NOISE MEASURING SET
(J94006F AND J94006FR)
DESCRIPTION, OPERATION, AND MAINTENANCE

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1. GENERAL

1.01 This section covers the description, operation, and maintenance of the 6F and 6FR voiceband noise measuring sets (J94006F and J94006FR). The 6F set is portable and the 6FR set is arranged for rack mounting. These sets are receiving instruments which are primarily intended for making noise measurements on voiceband circuits. Specifications for the 6F and 6FR sets are shown in Table A.

1.02 This section is reissued to change information regarding the plug-in weighting networks used in the 6F and 6FR voiceband noise measuring sets. The 497G network (C-notched at 2800 Hz) has been replaced with the KS-21567, L2 network (C-notched at 1010 Hz). The KS-21567, L2 network consisting of C-notched and flat weighting will be provided in future 6F and 6FR noise measuring set shipments. This revision does not affect the Equipment Test List. Since this is a general

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TABLE A

6F AND 6FR NMS SPECIFICATIONS

ITEM	SPECIFICATION
Sensitivity	(a) 0 to 99 dBrn for metallic message circuit noise. (b) 30 to 129 dBrn for longitudinal message circuit noise. (c) 30 to 127 dBrn for metallic impulse noise. (d) 60 to 157 dBrn for longitudinal impulse noise.
Bandwidth	50 Hz to 25 kHz with flat weighting or as determined by other plug-in weighting network, for all inputs.
Input Impedance	(a) 735 ohms balanced for metallic noise measurements normally made at 600 and 900 ohms on a terminating basis. (b) 50,000 ohms balanced for metallic noise measurements on a bridging basis. (c) 50,000 ohms longitudinal for longitudinal noise measurements.
Balance	(a) Greater than 70 dB at 1 kHz. (b) Greater than 45 dB at 25 kHz.
Maximum Counting Rate	7 counts per second.
Maximum Counting Capacity	9999 counts per register relay.
DC Supply Voltage Range	(a) 7.5 to 11.5 volts for a 6F set. (b) 44 to 52 volts for a 6FR set.
Temperature Range	0° to 50° C.
Accuracy	±0.5 dB at calibrating frequency (see Part 4C).

revision, no revision arrows have been used to denote significant changes.

1.03 The 6F and 6FR noise measuring sets (NMS) provide a means for measuring impulse noise distribution and the root mean square (rms) value of circuit noise in the frequency range of 50 Hz to 25 kHz. Plug-in weighting networks provide a means for selecting the frequency weighting used for measurements.

1.04 The KS-21567, L2 plug-in weighting network, which replaces the 497G network, introduces a method of measuring impulse noise on compandored or compandored-noncompandored mixed circuits with the holding tone filtered out (C-notched) at around 1000 Hz as opposed to 2800 Hz for the 497G network. Filtering the holding tone at 1000 Hz allows impulse noise to be measured on the 6F and 6FR NMS at the same frequency as gain hits and phase hits are measured. Also, 1000 Hz is the frequency that the various links in a facility are aligned, permitting a more accurate prediction of holding tone level at intermediate points.

2. EQUIPMENT DESCRIPTION

2.01 The 6F portable set (Fig. 1) is self-contained and operates from seven D-type, 1.5-volt flashlight batteries in series. In normal use (combined count on four counters of less than 1000 counts per hour), the batteries should provide a minimum of 250 hours of operation. The condition of the batteries can be observed on the meter when the FUNCTION switch is in the CAL-CTR-BAT position and the POWER switch is turned on.

Fig. 1—6F Portable Set

2.02 The 6FR rack-mounted set (Fig. 2) can be mounted in a rack ranging in size from 19 inches up. It operates from the -48 volt office battery.

2.03 The plug-in weighting network used with the 6F and 6FR NMS is shipped separately from the NMS. Each plug-in network consists of two weighting networks used separately for test applications. Insertion of the plug-in unit activates the weighting network which is in the upright position indicated by the network label. Reinsertion of the plug-in unit, after disengaging and rotating 180°, will activate the other network.

2.04 The following plug-in weighting networks were supplied in previous 6F and 6FR NMS shipments. They are still available at most locations. (The KS-21567, L2 network C-notched at 1010 Hz and flat weighting networks will be supplied with future 6F and 6FR NMS shipments.)

- 497D for C-message and flat weighting
- 497F for 50-kilobit/second and flat weighting
- 497G for C-notched at 2800 Hz and flat weighting.

2.05 An internal calibration oscillator generates a standard signal of approximately 1000 Hz for checking the sensitivity of the meter circuit amplifier and for adjusting the threshold levels of the counter circuits. Once it is adjusted, it provides

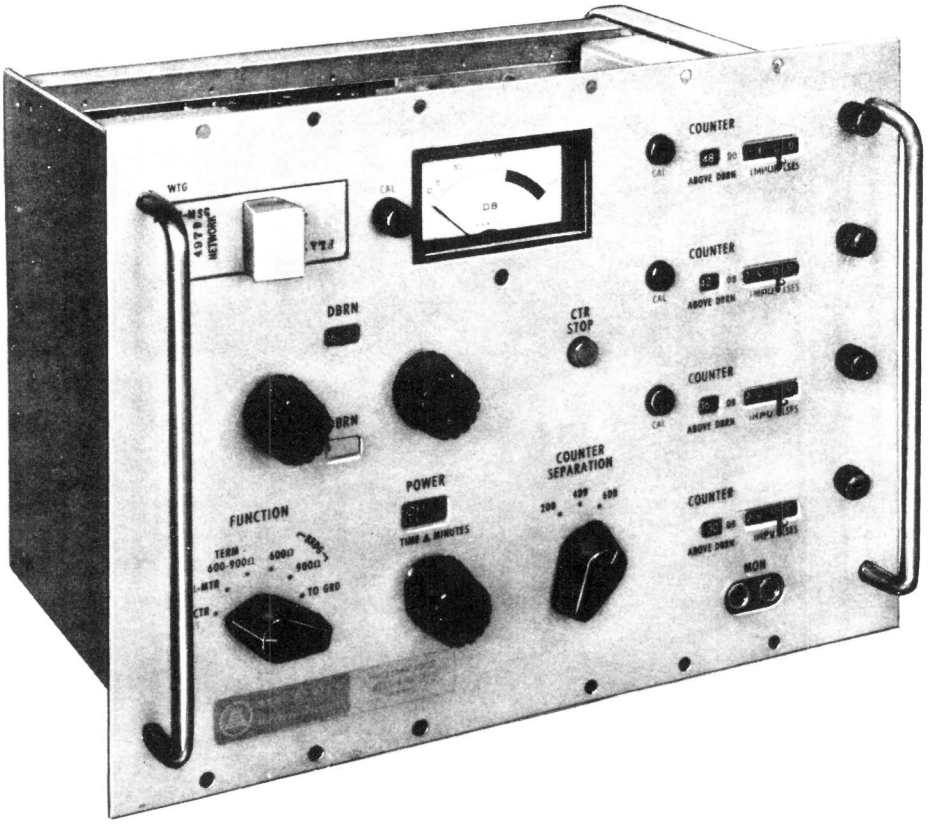

Fig. 2—6FR Rack-Mounted Set

a stable calibration source for several months without readjustment regardless of dc supply voltage and ambient temperature variations.

2.06 Amplified outputs of the received noise are provided at jacks for monitoring purposes. A 723A receiver with a W2FS cord is supplied with each 6F set for listening to the measured noise. The 6FR set has jacks for connecting a 52S telephone headset (must be supplied locally). It also has provision for wiring the monitor output to a separate jack field if desired.

2.07 The 6F set weighs 19-3/4 pounds and measures 14-1/4 inches wide, 10-3/4 inches high, and 10-1/2 inches deep (including cover, hinges, feet, and carrying handle). Space is provided inside the cover of this set for storing the 723A receiver and W2FS cord when not in use. The 6FR set weighs 15-1/2 pounds and measures 12 inches wide, 10 inches high, and 9-1/8 inches deep (including case, jack on rear of set, and forward projections on front panel).

2.08 An internal timer of the 6F and 6FR NMS provides for measuring impulse counts over a preset time interval while the NMS is unattended. The timer is adjustable from 0 to 60 minutes. It also may be locked out (HOLD position) for continuous test intervals of greater than 60 minutes.

3. CIRCUIT DESCRIPTION

A. General

3.01 The 6F and 6FR sets are identical electrically except for their input and power supply circuits. Figure 3 shows a block diagram for these sets. The diagram may be categorized into the following circuits:

(a) Input Circuit

(b) Attenuators

(c) Buffer Amplifier

(d) Weighting Network

(e) 60-dB Amplifier

(f) Full-Wave Rectifier

(g) Counter Separation Attenuators

(h) Standard Trigger Circuits

(i) Trigger and Register Circuits

(j) Meter Circuit

(k) Monitor Circuit

(l) Calibration Oscillator

(m) Power Circuit.

B. Input Circuit

3.02 The input circuit consists of input connections, a holding and terminating resistor, dc blocking capacitors, and a transformer to provide a balanced input. The input circuit of the 6F set provides for connecting 309- and 310-type plugs, banana-type plugs, spade tips, or wires at the front panel of the set. SLV and GRD binding posts are also provided for grounding the sleeve connection on the input cable if required by the test conditions. A link, which is permanently connected to the GRD binding post, is used for this purpose.

3.03 The 6FR set has provision for wiring the input connections to a jack at the rear of the set. A plug and jack arrangement allows for removing the set from its case without disconnecting the wires at the jack. Transformer T1 provides a high input impedance, in the order of 50,000 ohms, for making bridging measurements. Resistor R1 is connected across the input, to shunt down the impedance to 735 ohms, when making terminating measurements. This impedance is the geometric mean of 600 and 900 ohms and is used for making measurements that are normally made at 600 or 900 ohms. R1 also provides a dc path for the circuit under test for holding purposes. Capacitors C1, C2, and C3 provide dc isolation and some low-frequency shaping.

3.04 Resistors R2, R3, and R4 provide a high input impedance for measuring longitudinal (FUNCTION switch set to TO GRD) noise. They introduce a 30-dB insertion loss which is automatically corrected on the DBRN dial when the FUNCTION switch is operated to the TO GRD position. Resistors R36 and R37 equalize the insertion loss in the terminating and bridging input circuits. Both metallic and longitudinal noise are directed to the common 2000-ohm circuit by the FUNCTION switch.

C. Attenuators

3.05 The attenuators consist of a 10-dB and a 1-dB step attenuator. They are 2000-ohm pads and provide a total of 79 dB of attenuation in 1-dB steps for setting the desired threshold for measurements of impulse noise or the desired meter reading for measurements of message circuit noise.

D. Buffer Amplifier

3.06 The buffer amplifier is a 2-stage feedback amplifier which provides a gain of about 12 dB to make up for losses in the input circuit. It provides an input impedance of about 750,000 ohms and therefore has very little shunting effect on the 1-dB attenuator. It also isolates the weighting network from the input circuits and provides an output impedance of 600 ohms for matching to the 600-ohm networks. Some temperature compensation is included in the buffer amplifier to make up for temperature effects in the amplifier, meter, and trigger circuits.

E. Weighting Networks

3.07 The KS-21567, L2 plug-in weighting network contains two passive weighting networks: a resistive pad and a C-message weighting network with a sharp notch centered at 1010 Hz. Each

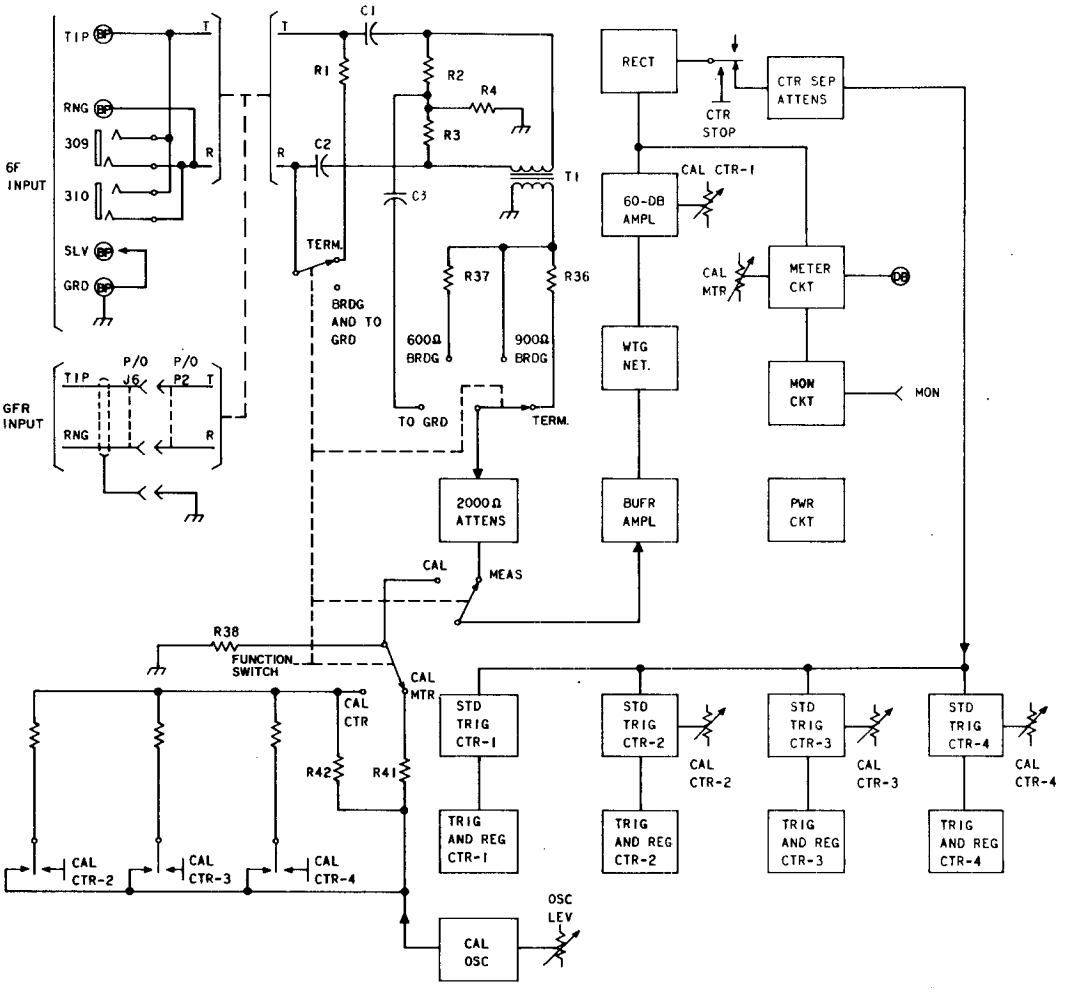

Fig. 3—6F and 6FR Voiceband Noise Measuring Sets—Block Diagram

weighting network has 600-ohm impedance with a voltage input level of 0.15 volts rms ±0.05 volts. (Voltage may be 0.8 volts ±0.2 volts when specified attenuation for the network exceeds 50 dB.) Insertion of the KS-21567, L2 plug-in network with the C-notch label upright provides C-message weighting with a 50-dB band-reject notch (see Fig. 4) and a 4-dB flat insertion loss. Reinsertion of the plug-in with the FLAT label upright provides 5-dB flat attenuation.

F. 60-dB Amplifier

3.08 The 60-dB amplifier provides sufficient gain to the received signals to drive the rectifier and trigger circuits. It consists of a 3-transistor stage, feedback amplifier. The COUNTER 1 CAL control provides about 6 dB of adjustment on the amplifier gain for calibrating the threshold level of the COUNTER 1 circuits.

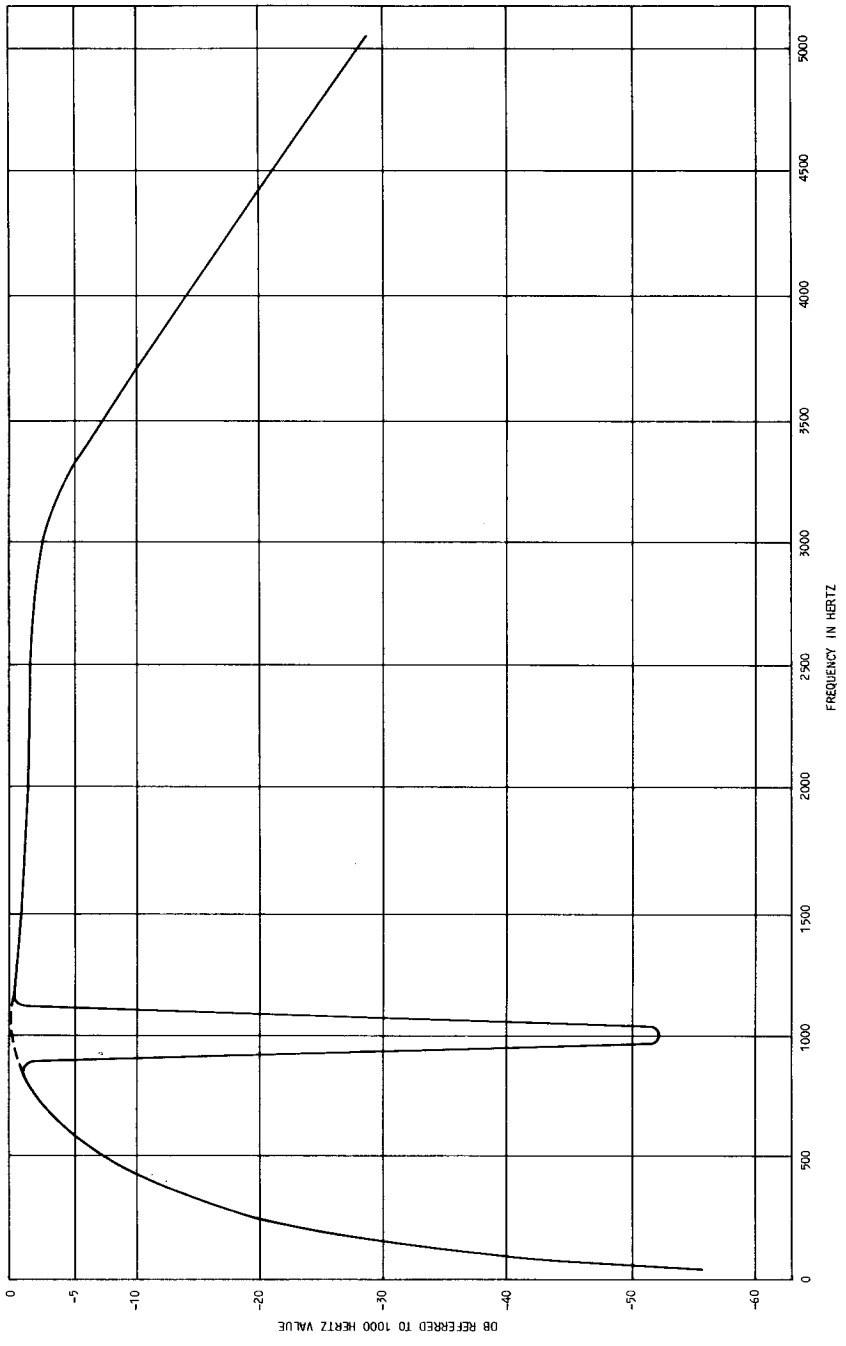

Fig. 4—Typical Frequency Characteristic With C-Notched Weighting at 1010 Hz of the KS-21567 L2 Plug In Network

G. Full-Wave Rectifier

3.09 Full-wave rectification is employed in order to detect both positive and negative impulse noise peaks. This is accomplished by a transformer-coupled diode rectifier. An emitter-follower provides a high-impedance load for the rectifier and a low source impedance for the standard trigger circuits. The rectified signals are coupled through the normally closed contacts of the CTR STOP switch. This is a pushbutton-type switch which provides for disconnecting signals to the standard trigger circuit inputs while the register relays are being reset.

H. Counter Separation Attenuators

3.10 The rectified signals are coupled through voltage divider networks to four separate standard trigger circuits. The COUNTER SEPARATION switch selects the proper voltage division to each input to provide separations of either 2, 4, or 6 dB between the thresholds of successive trigger circuits.

I. Standard Trigger Circuits

3.11 The four standard trigger circuits operate identically. They each consist of a single-transistor, blocking oscillator circuit. When a positive signal from the rectifier exceeds the threshold voltage of a blocking oscillator, the transistor is drawn into saturation and hence develops a large negative pulse at its collector for operating the trigger and register circuit. The regenerative action of the blocking oscillator causes the transistor to saturate quickly and provides a sharp threshold. The COUNTER 2, 3, and 4 standard trigger circuits have provision for adjusting their threshold levels. These adjustments are used for calibration purposes.

J. Trigger and Register Circuits

3.12 The four trigger and register circuits are identical and all operate the same. The trigger circuit consists of a 2-transistor, monostable multivibrator circuit. Normally one transistor is turned on while the other is off. When a negative pulse from the standard trigger circuit is applied, the multivibrator changes state, causing the "on" transistor to turn off and the "off" transistor to turn on.

3.13 The register relay is in the collector circuit of the normally off transistor so that when the circuit changes state, current flows through the register relay and causes it to register a count. A timing capacitor is included to prevent the multivibrator from going back to its normal state, to accept another impulse, until the register relay has had enough time to reset. This limits the speed of the register relay to about 7 counts per second.

K. Meter Circuit

3.14 Signals from the output of the 60-dB amplifier are applied to the meter circuit. This circuit consists of two transistor stages which provide gain for driving the meter and also provide isolation between the meter circuit and the 60-dB amplifier. The meter CAL potentiometer provides about 5 dB of adjustment on the gain of the meter circuit for calibration purposes.

3.15 Output signals from the meter amplifier are full-wave rectified with a bridge rectifier before being applied to the meter. The meter is connected to the output of the rectifier for all positions of the FUNCTION switch except the CAL-CTR-BAT position. For this position, the meter measures the battery voltage for a 6F set and the dc supply voltage applied to the buffer amplifier, calibration oscillator, and 60-dB amplifier for a 6FR set.

L. Monitor Circuit

3.16 The monitor circuit consists of a single-transistor stage. It provides about 12 dB of gain and also isolates any monitoring device from the meter circuit. The 6F set is equipped with a single MON jack on the front panel assembly. A 723A receiver and W2FS cord, which can be plugged into this jack, are provided with each 6F set. The 6FR set is equipped with a double-jack arrangement on the front panel assembly to accept a 52S telephone headset (supplied locally). In addition, the monitor output appears at the jack at the rear of the 6FR set for wiring to a separate jack field, if desired.

M. Calibration Oscillator

3.17 The calibration oscillator provides a standard signal at 1000 Hz for adjusting the sensitivity of the meter circuit and for adjusting the threshold

levels of the counter circuits. The oscillator is compensated for dc supply voltage and ambient temperature variations. Once its output level is adjusted, it provides a stable calibration source for long periods of time without readjustment.

3.18 Calibration signals are directed through L-type attenuator networks which determine the proper signal level applied to the buffer amplifier input during calibration of the meter and counter circuits. Resistor R38 provides the shunt arm for all networks. Resistor R41 provides the series arm of the network during calibration of the meter circuit. Resistor R42 and the resistor in parallel with it provide the series arm for the attenuation network when calibrating the counter circuits. The parallel resistor is determined by the combination of the COUNTER SEPARATION switch setting and the position of the counter CAL pushbutton switches.

N. Power Circuit

3.19 Power for the 6F set is provided by seven 1.5-volt, type D flashlight cells connected in series. Power for the 6FR set is provided by the -48 volt office battery.

3.20 Three separate zener voltage regulating circuits divide the office battery voltage down to approximately 9 volts for the buffer amplifier, 60-dB amplifier, and calibration oscillator circuits, for the standard trigger and register circuits, and for the meter and monitor circuits. This arrangement filters out noise on the office battery and reduces the effects of interaction between the various circuits in the 6FR set. Power to the 6F and 6FR circuits is controlled by a switch which is part of the timer unit.

4. OPERATION

A. Description

4.01 The 6F and 6FR sets are primarily intended for making noise measurements on voiceband circuits. In general, the receiving end of the circuit to be tested will be connected directly to the 6F or 6FR set (through a test pad when specified), and the far end will be terminated in the office impedance. These sets provide for measuring both metallic (FUNCTION switch to TERM or BRDG) and longitudinal (FUNCTION switch to TO GRD) noise.

4.02 A 735-ohm balanced input impedance is provided for measurements normally made at 600 or 900 ohms. This impedance is the geometric mean of 600 and 900 ohms which makes the mismatch identical for 600- and 900-ohm measurements. The effects of this mismatch are corrected for in the calibration of the set. A 50,000-ohm balanced input impedance is provided for making bridging measurements and a 50,000-ohm longitudinal impedance is provided for making longitudinal noise measurements.

4.03 Multipled jacks and binding posts on the front panel of the 6F set provide for connecting 309- and 310-type plugs, banana-type plugs, spade tips, or wires. SLV and GRD binding posts are also provided on the 6F set for grounding the sleeve of the circuit under test if required by the test conditions. A shorting link is permanently attached to the GRD binding post for this purpose.

4.04 The 6FR set has no input jacks on its front panel but has provision for wiring the input circuit to a separate jack field. A plug and jack arrangement at the rear of the 6FR set provides for making the input connection as well as the monitor output and office battery connections, and also provides for removing the set from its case without disconnecting any wiring.

4.05 The 6F and 6FR sets can measure the cumulative distribution of impulse noise by simultaneously counting impulses having a ***peak*** value exceeding one or more of four threshold levels. The thresholds of the four counter circuits can be separated by either 2, 4, or 6 dB as selected by the COUNTER SEPARATION switch.

4.06 Adjacent to each counter is a window (ABOVE DBRN). The value indicated in the window is the threshold level at which the counter will operate when noise impulses exceed the combined value set in the DBRN window and the ABOVE DBRN window. The threshold level of the first counter circuit is a fixed 30 dB above the DBRN dial setting regardless of the position of the COUNTER SEPARATION switch. The threshold levels of the remaining three counter circuits are determined by the COUNTER SEPARATION switch setting. The numbers in the ABOVE DBRN windows near these counter circuits are automatically corrected when this switch setting is changed.

4.07 The threshold level of each counter circuit is determined simply by adding the DBRN dial setting to the number in the ABOVE DBRN window near the associated counter. This applies for longitudinal as well as metallic noise measurements.

4.08 The upper DBRN window is open and the lower DBRN window is closed when the FUNCTION switch is in any position other than TO GRD. When the switch is in the TO GRD position, the window operation is reversed. A 30-dB insertion loss in the longitudinal noise input circuit is automatically corrected on the lower DBRN dial reading. The dial setting is added to the ABOVE DBRN readings to determine the threshold levels at which the counters operate.

> ***Example:*** It is desired to measure the distribution of impulse noise in the range of 65 to 77 dBrn. Since this is a range of 12 dB, the COUNTER SEPARATION switch should be set to 4 dB. This provides for measuring over a 12-dB range with the four counters. The threshold level of each counter is the number of decibels indicated in the window near the associated counter, above the DBRN dial setting. To achieve the DBRN dial setting for any counter, the desired threshold level must be subtracted from the number in the associated window. Since the first counter is a constant 30 dB above the DBRN dial setting, for all positions of the COUNTER SEPARATION switch, it provides a good reference for setting up the DBRN dial. The procedure is then: ***DBRN dial setting = (lowest threshold to be measured) - (30).*** For this example, the lowest threshold to be measured is 65 dBrn. Therefore, the DBRN dial should be set to 65 - 30 = 35. This example applies for either metallic or longitudinal noise measurements.

4.09 The ***rms*** value of message circuit noise or transmission levels can be measured on the meter. The meter has a 20-dB range. Metallic noise can be measured over a range from 0 to 99 dBrn and longitudinal noise can be measured over a range from 30 to 129 dBrn when the meter reading is combined with the DBRN dial setting.

4.10 A measurement is made simply by stepping the DBRN dial until an indication is observed on the meter. For best accuracy, the upper half of the meter scale should be used whenever possible. The level in dBrn is then the sum of the DBRN dial setting and the meter reading. This applies for both metallic and longitudinal noise measurements since the DBRN dial window arrangement automatically corrects for differences of insertion loss in the two circuits.

4.11 The timer provides for measuring impulse counts for a preset time interval while the set is unattended. The timer, having dial markings at 1-minute intervals, is adjustable from 0 to 60 minutes. At the end of the preset interval, the timer will disable the counting circuits by removing power from all circuits in the 6F and 6FR sets.

> ***Note:*** To insure accurate timing when setting the timer for 5 minutes or less, first adjust the timer to 10 minutes or greater and then return it to the desired value.

4.12 The register relays will not be reset so that the total impulses received in a preset interval can be read from the registers. The registers must be reset for additional testing. The timer may be locked out (HOLD position) for continuous test intervals of greater than 60 minutes.

4.13 The trigger and register circuit response times are limited electrically so that impulses separated by approximately 140 ms (about 7 counts per second) or more will be recorded on the register relays. This insures that the register relays, after counting, will have sufficient time to reset properly before accepting another count.

4.14 The MON jacks provide amplified outputs of the received noise for listening with a headset or other monitoring device or for observation with an oscilloscope. This may be useful in identifying the type of noise or the location of the source.

4.15 A 723A receiver with a W2FS cord is supplied with each 6F set. It can be connected to a single jack on the front panel of the set. The 6FR set has a double jack on the front panel for connecting a 52S telephone headset (must be supplied locally). This set also has provision for wiring the monitor output, at the jack at the rear of the set, to a separate jack field if desired.

4.16 Impulse noise measurement on a compandored facility (T- or N-Carrier or No.4 ESS) is accomplished using a holding tone of 1000 Hz to

simulate active data or voice transmission. The C-notched network of the KS-21567, L2 network allows measurements with tone based on C-message weighting by filtering out or attenuating the holding tone 50 dB between 995 Hz and 1025 Hz. This 30-Hz band-reject is shown as a 50-dB notch in the C-message curve shown in Fig.4. The resultant noise reading on the 6F or 6FR set, by eliminating the holding tone, is the summation of background or quantizing noise, amplitude and phase jitter above 120 Hz, and harmonic distortion.

4.17 Figures 5 and 6 show typical frequency characteristics with flat weighting for the impulse and message circuit noise for the 6F and 6FR sets, respectively. These curves apply for terminating, bridging, or longitudinal measurements concerning white noise. Both curves are similar and have 3-dB points at about 50 Hz and 25 kHz.

B. Calibration Procedure

4.18 The 6F and 6FR sets are calibrated through the weighting networks, and any variation in flat loss between the networks can be calibrated out. The desired weighting is obtained by proper orientation of the network when plugging it into the set.

4.19 The 6F and 6FR sets employ a nominal 1000-Hz internal oscillator for calibration. The KS-21567, L2 C-notched network centered at 1010 Hz, used in the CAL function, would cause the meter reading to be off-scale on the low side. However, inverting the plug-in network to the FLAT weighting will permit calibration in the normal manner.

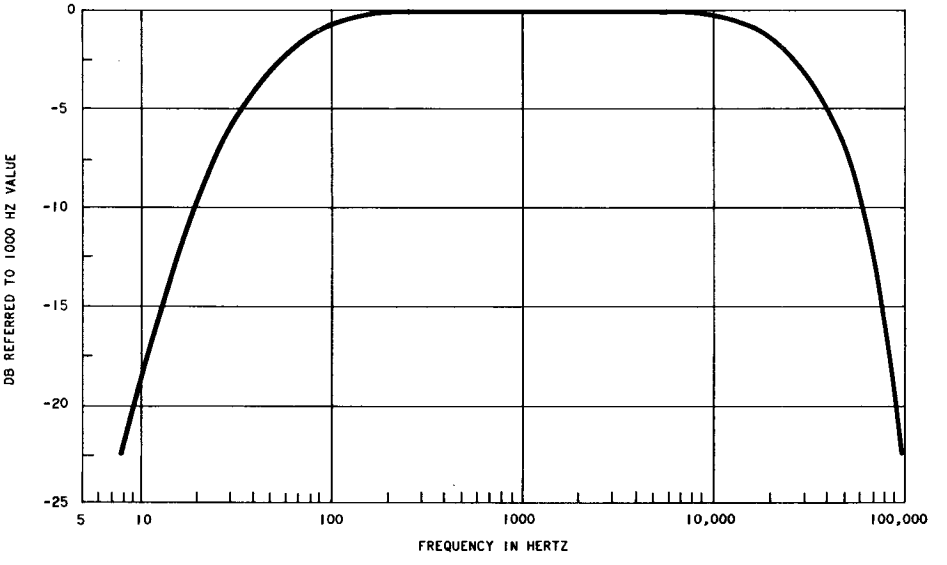

Fig. 5—Typical Frequency Characteristic of Impulse Noise Circuits With Flat Weighting

4.20 To insure good measurement accuracy, the 6F and 6FR sets should be calibrated frequently, preferably every time they are used. Calibration of the sets compensates for battery decay and ambient temperature change effects. The following calibration procedure is simple and requires no external equipment.

STEP	PROCEDURE
1	Plug the desired weighting network into the set and make sure that it is oriented for the proper weighting.
2	Set the COUNTER SEPARATION switch to the desired position.
3	Set the FUNCTION switch to CAL-CTR-BAT and turn the POWER switch on.
4	Verify that the meter indicates in the BAT GOOD area. If it does not, replace the batteries in a 6F set per Part 5C or check the office battery connection for a 6FR set.
5	Adjust the COUNTER 1 CAL control until the associated counter just counts (the count will be erratic when properly adjusted).
6	Adjust the COUNTER 2, 3, and 4 CAL controls by depressing the associated pushbutton switch and adjusting the associated CAL control until the counter just counts, as in Step 5. ***Note:*** During this calibration procedure, only one counter will operate at a time. For example, if COUNTER 4 is being calibrated, COUNTERs 1, 2, and 3 will not operate even though the calibration signal would normally be large enough to cause all four counters to count; COUNTERs 1, 2, and 3 have been disconnected for this part of the calibration procedure.
7	Set the FUNCTION switch to CAL-MTR and adjust the meter CAL control for a meter indication at the CAL marking.
8	Repeat the above procedure when changing the weighting network or when changing the COUNTER SEPARATION switch setting. ***Note:*** If it is suspected that the internal calibration oscillator is out of adjustment or if more than 6 months have elapsed since it was adjusted, it should be readjusted per Part 5B.

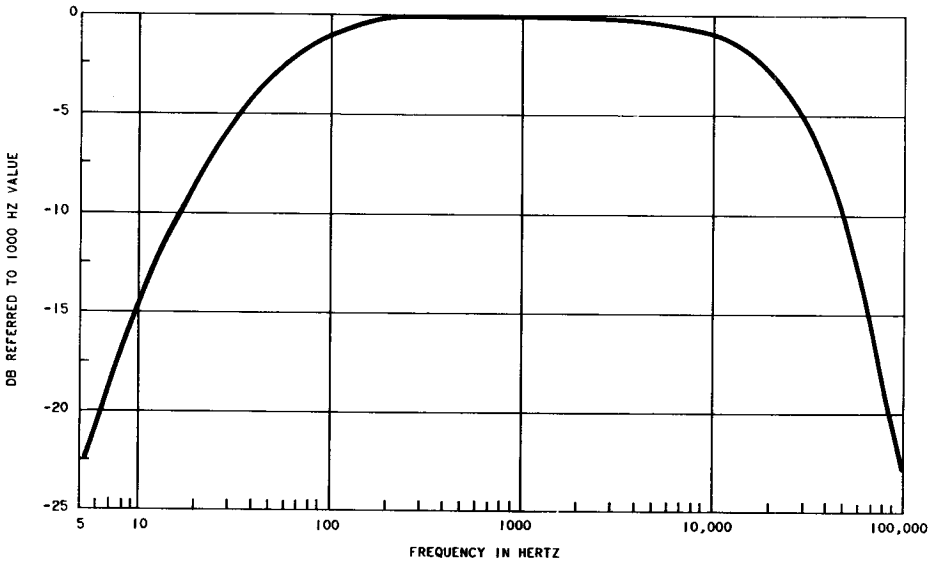

Fig. 6—Typical Frequency Characteristic of Message Circuits With Flat Weighting

C. Measurement—Description and Procedure

4.21 The measurement accuracy of the 6F and 6FR sets is dependent on the frequency of the signals being measured. For message circuit noise measurements, it is also dependent on what part of the meter scale is used. The set has its best accuracy when measuring noise having principal component frequencies close to the calibrating frquency (1000 Hz). The measurement accuracy is proportionately poorer for noise component frequencies further away from this frequency. When the set is properly calibrated, the measurement accuracy near the calibrating frequency is within ±0.5 dB for both impulse and message circuit noise measurements. This assumes that message circuit measurements are made on the upper half of the meter scale and that the weighting network is oriented for flat weighting. For other frequencies and other conditions, the measurement accuracies for impulse and message circuit noise measurements with FLAT weighting are itemized in Tables B and C, respectively. These accuracies apply for battery voltages of 7.5 to 11.5 volts for a 6F set and 44 to 52 volts for a 6FR set and for ambient temperatures of 0° to 50°C, assuming that the set is properly calibrated and that flat weighting is used. They also apply for measurement of both metallic and longitudinal noise.

TABLE B

MEASUREMENT ACCURACY FOR IMPULSE NOISE MEASUREMENTS USING FLAT FILTER WEIGHTING

FREQUENCY (Hz)	ACCURACY (dB)
50	−2.8 ±1.6
200	−0.2 ±0.7
1,000	0 ±0.5
10,000	−0.2 ±0.8
25,000	−2.2 ±1.8

TABLE C

MEASUREMENT ACCURACY FOR MESSAGE CIRCUIT NOISE MEASUREMENTS USING FLAT FILTER WEIGHTING

FREQUENCY (Hz)	METER READING (dB)			
	0-5	5-10	10-14	14-20
	ACCURACY (dB)			
50	−2.8 ±2.6	−2.8 ±1.9	−2.8 ±1.7	−2.8 ±1.6
200	−0.2 ±2.1	−0.2 ±1.2	−0.2 ±0.9	−0.2 ±0.7
1,000	0 ±2.0	0 ±1.1	0 ±0.8	0 ±0.5
10,000	−0.6 +2.2	−0.6 ±1.3	−0.6 ±1.0	−0.6 ±0.8
25,000	−3.8 ±2.7	−3.8 ±2.0	−3.8 ±1.9	−3.8 ±1.8

4.22 When using filters other than the flat filter, the measurement accuracies listed in Tables B and C must be modified to include the frequency characteristic of the particular filter being used. Figure 7 shows the ideal frequency characteristic for the C-message (497D) weighting network. Figure 8 shows the typical frequency characteristic for the C-notched weighting network (497G). The 497G C-notched weighting network has a frequency characteristic similar to that of the C-message filter with a band-rejection filter centered about 2800 Hz to permit measurements on compandored or mixed compandored-noncompandored circuits. The KS-21567, L2 network (Fig. 4) also has a frequency characteristic similar to the C-message filter with a band-rejection filter centered about 1010 Hz which permits measurements on compandored or mixed compandored-noncompandored circuits. Figure 9 shows the typical frequency characteristic for the 50-kilobit/second weighting network. This network provides for making measurements on 50-kilobit wideband facilities. The 3-dB points are approximately at 45 Hz and 28 kHz.

4.23 Impulse noise distribution measurements are made by simultaneously counting impulse noise peaks exceeding any of four threshold levels. The thresholds of the four counter circuits can be separated by either 2, 4, or 6 dB as selected by the COUNTER SEPARATION switch. The rms value of message circuit noise is indicated on the meter. At the beginning of a measurement period, counters should be reset for the new count. A pushbutton switch (CTR STOP) provides for disconnecting signals from the trigger circuits while the counters are being reset.

4.24 A bridging input impedance is provided for both metallic and longitudinal noise measurements. A terminating input impedance is also provided for metallic noise measurements. Holding is provided when measurements are made on a terminating basis.

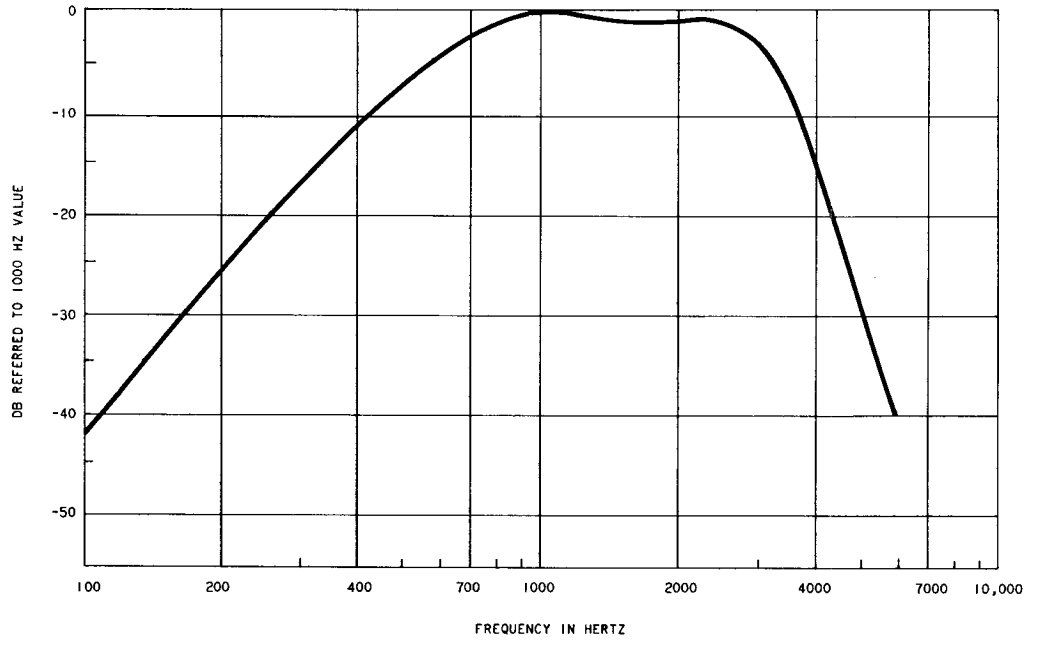

Fig. 7—Ideal Frequency Characteristic of C-Message Weighting Network of the 497D Plug-In Network

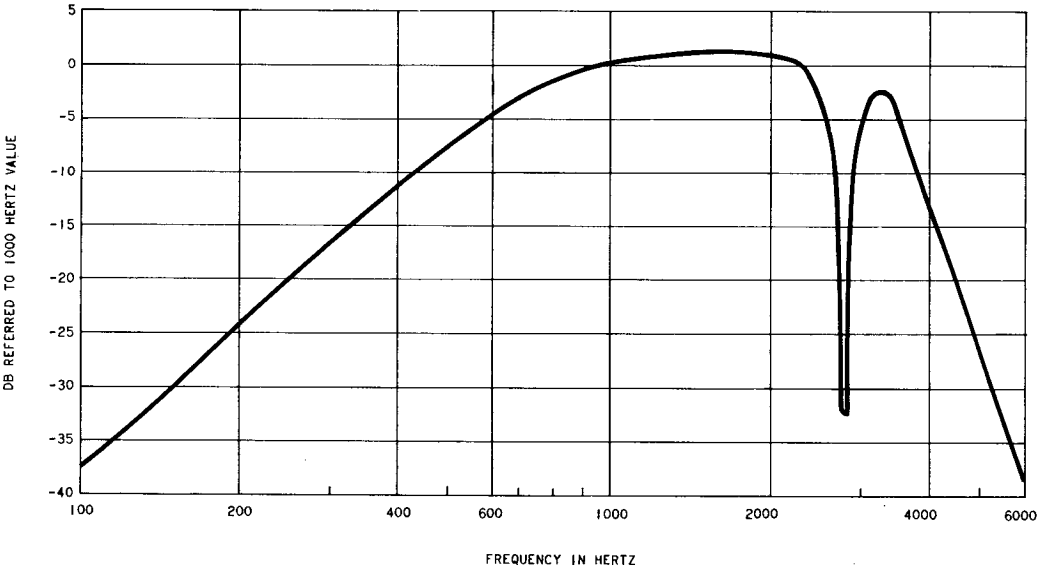

Fig. 8—Typical Frequency Characteristic With C-Notched Weighting at 2800 Hz of the 497G Plug-In Network

4.25 The following is a typical measurement procedure.

STEP	PROCEDURE
1	Calibrate the 6-type NMS per Part 4B.
2	Verify that the circuit to be tested has been turned down from service.
3	Using proper cordage, connect circuit to be tested to the input of the NMS.
4	Set the FUNCTION switch to the proper setting.
5	Measure the message circuit noise by adjusting the DBRN dial for an on-scale meter reading using the upper half of the meter scale whenever possible. ***Note:*** The message circuit noise level in dBrn will be the sum of the meter reading and the DBRN dial setting.
6	Using the following guide, set the DBRN dial for measuring impulse noise as follows: ***DBRN dial setting = (Lowest threshold level) - (30)***
7	Verify that the threshold level of each counter in dBrn is the sum of the DBRN dial setting and the number in the window near the associated counter. ***Note:*** When the COUNTER SEPARATION switch is changed, the counters should be recalibrated per Part 4B to ensure the best measurement accuracy.
8	Connect a headset, oscilloscope, or other monitoring device to the MON jack for listening to or observing the measured noise. ***Note:*** To avoid possible measurement errors due to noise pickup from a monitoring device, remove any monitoring device from the MON jack before making an impulse or message circuit noise measurement unless noise sources are being investigated. To determine whether noise is being picked up by a monitoring device under these conditions, disconnect the test circuit from the input of the set, terminate the input of the set with a 600- or 900-ohm resistor, and observe the meter and counters.
9	Set the TIME-MINUTES dial to the desired time. ***Note:*** To insure accurate timing when setting the timer for 5 minutes or less, first adjust the timer to 10 minutes or greater and then return it to the desired value.
10	Depress the CTR STOP pushbutton and reset the counters to zero. Release the CTR STOP pushbutton. ***Note:*** At the end of the preset time interval, the timer switch will remove power from the set. The total number of impulses measured by each counter in this interval will be retained on the counters until they are reset for another test.

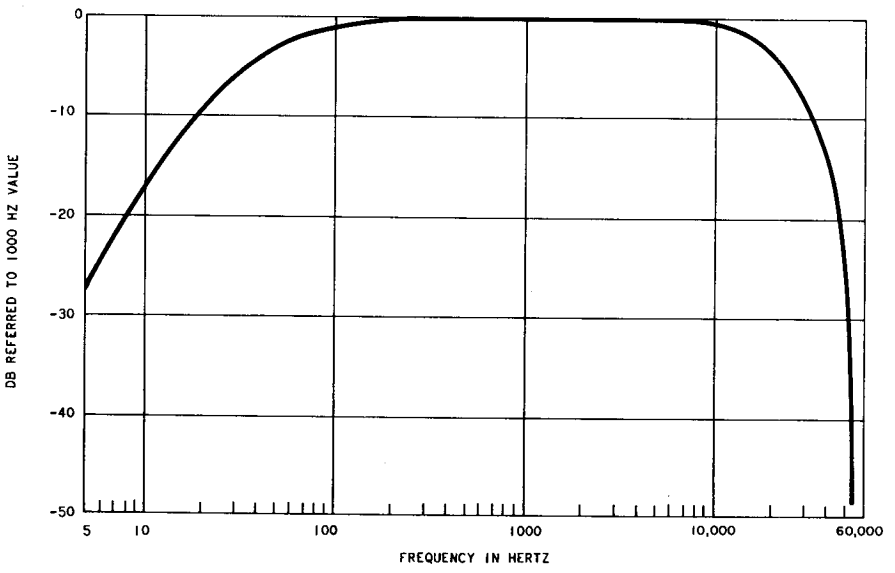

Fig. 9—Typical Frequency Characteristic of Impulse Noise Circuits With 50-Kilobit/Second Weighting of the 497F Plug-In Network

5. ADJUSTMENT AND MAINTENANCE

A. General

5.01 Adjustment and maintenance will normally consist of adjusting the internal calibration oscillator and replacing the batteries (6F set only). ***The internal calibration oscillator should be adjusted at least once every 6 months.*** When adjusted properly, it serves as a stable source over long periods of time for calibrating the set regardless of dc supply voltage and ambient temperature variations.

B. Internal Calibration Oscillator Adjustment

5.02 The only external equipment needed for adjusting the internal calibration oscillator is a 600- or 900-ohm, 1000-Hz generator, such as the J94071-type milliwatt generator or milliwatt outlet, having a nominal level of 0±0.05 dBm. If this equipment is available, the internal calibration oscillator can be adjusted locally when it is required. If calibration requirements cannot be met or if the necessary equipment is not available locally, the set should be sent to a repair and calibration center such as a Western Electric Service Center. The adjustment procedure is as follows.

STEP	PROCEDURE
1	Remove the set from its case.
2	Plug the weighting network into the set in the position which gives flat weighting (FLAT under WTG panel stamping).
3	Set the FUNCTION switch to CAL-CTR-BAT.

STEP	PROCEDURE
4	Connect the 0±0.05 dBm, 600- or 900-ohm output of the 1000-Hz generator or outlet to the input of the set.
5	Set the DBRN dial to 63. (The 6F and 6FR sets are calibrated to measure the peak value of impulse noise. Since the peak value of a sine wave is 3 dB above the rms value, the DBRN dial must be set to 63 rather than to 60.)
6	Turn the POWER switch on (see Note) and check that the meter indicates in the BAT GOOD area. If it does not, take the necessary steps to see that it does before continuing the calibration procedure (see Parts 5C and 6). ***Note:*** For a 6FR set, first connect -48 volts to the 502A plug at the rear of the set before turning the POWER switch on. Make sure that the positive voltage is connected to terminal 16 and the negative voltage is connected to terminal 20.
7	Set the FUNCTION switch to TERM and adjust the COUNTER 1 CAL control until the associated counter just counts (the count will be erratic when properly adjusted).
8	Set the FUNCTION switch to CAL-CTR-BAT and adjust the calibration oscillator potentiometer, R47 (on circuit board), until COUNTER 1 just counts, as in Step 7.
9	This completes adjustments of the interval calibration oscillator. Set the POWER switch to OFF and restore the set to its case.

C. Power Supply

5.03 For a 6F set, the condition of the batteries can be observed on the meter when the FUNCTION switch is placed in the CAL-CTR-BAT position after the POWER switch is turned on. In normal use, the battery life will be about 250 hours. If the meter indicates outside the BAT GOOD area due to battery failure, the batteries should be replaced. KS-6522 type flashlight batteries should be used whenever possible. If they are not obtainable, any leakproof, type D flashlight batteries can be used as substitutes.

5.04 When replacing the batteries in a 6F set, care should be taken that the batteries are inserted properly in the holders. A special clip is provided at the positive terminal of each holder. This allows the batteries to make contact at both terminals only when they are inserted properly. After inserting a new set of batteries, check that each battery fits snugly into its holder. If any does not, it may be necessary to bend the holder slightly (with the battery removed) to insure that good electrical contact is made.

5.05 With new batteries in place, verify that the meter indicates in the BAT GOOD area when the FUNCTION switch is set to the CAL-CTR-BAT position and the POWER switch is turned on. With a new set of batteries, the meter should indicate about three-fourths of the way up in the BAT GOOD area.

5.06 For a 6FR set, the meter indicates the dc supply voltage applied to the buffer amplifier, 60-dB amplifier, and calibration oscillator circuits when the FUNCTION switch is set to the CAL-CTR-BAT position and the POWER switch is turned on. The meter should normally indicate near the lower edge of the BAT GOOD area. If it indicates outside this area, a trouble condition exists. In this case, check the office battery connections and refer to Part 6 for corrective measures.

6. TROUBLE INDICATION AND REPAIR

6.01 If any item of the set is malfunctioning or defective or if it is required that the internal calibration oscillator be adjusted and the necessary equipment is not available locally, the set should be sent to a repair and calibration center such as a Western Electric Service Center.

6.02 Most trouble conditions will become apparent during calibration of the set. The calibration procedure is simple and requires no external equipment (see Part 4B). Table D provides a guide to aid in localizing the more common trouble conditions.

7. REFERENCES

7.01 The following references provide supplementary information for this section.

NUMBER	TITLE
CD-99737-01 SD-99737-01	Common Systems—Transmission Measuring—6F and 6FR Voiceband Noise Measuring Sets
J94006— 801-250-154	Transmission Measuring— 6-Type Noise Measuring Equipment — Common Systems
DL-3265	Notes on the KS-21567 C-Notch Networks
KS-21567	C-Notch Network
314-410-500	Voice Bandwidth Tests and Requirements

TABLE D

TROUBLESHOOTING CHART

TROUBLE	PROBABLE CAUSE	CORRECTIVE MEASURES
1. Meter indicates outside BAT GOOD area with FUNCTION switch in CAL-CTR-BAT position.	(a) Batteries in a 6F set defective.	Replace batteries.
	(b) Bad connection to office battery for a 6FR set.	Check office battery connections at plug P2 and jack J6.
	(c) Regulating circuit for a 6FR set defective.	Check that voltage across capacitor C50 is within limits of 8.0 to 9.6 volts.
	(d) Resistor R5 defective.	Replace resistor.
	(e) Diode CR3 defective.	Replace diode.
	(f) Meter defective.	Replace meter.
2. COUNTER 1 CAL control does not have sufficient range.	(a) Check Item 1a for a 6F set or Items 1b and 1c for a 6FR set.	
	(b) Internal calibration oscillator out of adjustment.	Adjust internal calibration oscillator per 5.02.
	(c) Internal calibration oscillator defective.	Check voltages at transistor Q3 and waveform No. 1.*
	(d) Buffer amplifier defective.	Check voltages at transistors Q1 and Q2.*
	(e) Weighting network defective.	Replace network.
	(f) 60-dB amplifier defective.	Check voltages at transistors Q4, Q5, and Q6 and waveform No. 2.*
	(g) Rectifier defective.	Check voltages at transistor Q7 and waveform No. 5.*
	(h) Attenuation pad defective.	Check waveform No. 6.*
	(i) Standard trigger circuit defective.	Check voltages at transistor Q8 and waveform No. 10.*
	(j) Trigger and register circuit defective.	Check voltages at transistors Q9 and Q10 and waveform No. 11.*

* Voltages and waveforms are listed in CD-99737-01.

TABLE D (Cont)

TROUBLE	PROBABLE CAUSE	CORRECTIVE MEASURES
3. COUNTER 2 CAL control does not have sufficient range.	(a) Check Items 2a through 2g.	
	(b) Attenuation pad defective.	Check waveform No. 7.*
	(c) Standard trigger circuit defective.	Check voltages at transistor Q14 and waveform No. 10.*
	(d) Trigger and register circuit defective.	Check voltages at transistors Q15 and Q16 and waveform No. 11.*
4. COUNTER 3 CAL control does not have sufficient range.	(a) Check Items 2a through 2g.	
	(b) Attenuation pad defective.	Check waveform No. 8.*
	(c) Standard trigger circuit defective.	Check voltages at transistor Q17 and waveform No. 10.*
	(d) Trigger and register circuit defective.	Check voltages at transistors Q18 and Q19 and waveform No. 11.*
5. COUNTER 4 CAL control does not have sufficient range.	(a) Check Items 2a through 2g.	
	(b) Attenuation pad defective.	Check waveform No. 9.*
	(c) Standard trigger circuit defective.	Check voltages at transistor Q20 and waveform No. 10.*
	(d) Trigger and register circuit defective.	Check voltages at transistors Q21 and Q22 and waveform No. 11.*
6. Meter CAL control does not have sufficient range.	(a) Check Items 2a through 2f.	
	(b) Meter circuit defective.	Check voltages at transistors Q11 and Q12 and waveform No. 3.*
	(c) Meter rectifier defective.	Check diodes CR1, CR2, CR3, and CR4.
	(d) Meter defective.	Replace meter.
7. Counter and meter circuits can be calibrated but no input signals can be measured.	(a) Defective circuit between input and buffer amplifier.	Check input circuit, attenuators, and FUNCTION switch connections.

*Voltages and waveforms are listed in CD-99737-01.

TABLE D (Cont)

TROUBLE	PROBABLE CAUSE	CORRECTIVE MEASURES
8. Counter and meter circuits can be calibrated but measurements seem to be in error.	(a) Internal calibration oscillator out of adjustment.	Adjust internal calibration oscillator per 5.02.
	(b) Level of external calibration source in error.	Check level of calibration source with J94022A milliwatt reference meter or equivalent and adjust internal calibration oscillator per 5.02.
	(c) Defective attenuators.	Check attenuator steps against external attenuator.
9. A register relay fails to operate.	(a) CAL control does not have sufficient range.	Under Trouble column, check Items 2, 3, 4, or 5 for counter circuits 1, 2, 3, and 4, respectively.
	(b) Register relay defective.	Replace register relay.

*Voltages and waveforms are listed in CD-99737-01.

J94003C NOISE MEASURING SET (3C)

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1. GENERAL

1.01 This section describes the J94003C (3C) noise measuring set which is used to measure noise on various circuits in the telephone plant.

1.02 This section is reissued to add the KS-21567, L1 C-notch network as an optional plug-in unit for use with the 3C NM set. The changes made in Addendum 103-611-101, Issue 1, dated October 1969, also are incorporated in this reissue. This revision does not affect the Equipment Test List. Since this is a general revision, change arrows have been omitted.

1.03 The 3C noise measuring (NM) set is a portable instrument contained in a metal case and cover. It is normally powered by a self-contained 45-volt battery; however, an arrangement is provided whereby the set can be powered from 120 volts 60 Hz by means of an external J87281A power supply. The principal differences between the 3C set and the 3A noise measuring set are (1) the dialing and holding features and (2) an input jack which accommodates a 310 plug.

1.04 The 3C NM set may be used to measure weighted or unweighted noise metallic (bridging and terminating) referred to 0 dBrn (10^{-12} watt of 1000-Hz power dissipated at the point of measurement) and to measure noise to ground referred to +40 dBrn. In the latter case, 40 is added to the attenuator plus the meter readings to reference the result to 0 dBrn.

1.05 The input impedance (terminating) is 735 ohms which is the geometric mean between 600 and 900 ohms, as described in Part 4. The meter is calibrated to read the correct power level for either impedance, since the error (in dB) is the same.

1.06 Dialing and holding features permit a distant termination to be dialed while the set is connected to the circuit under test and to hold the connection during the noise measurement. A jack and clip-on posts are provided for connecting to a dial telephone hand test set or equivalent.

1.07 The use of the 3C NM with external meters and recorders is described in Part 9 of this section. The 3C set may be used with the 106A current and 107A voltage Telephone Influence Factor (TIF) coupling units for measurements of kilovolts times TIF product (KV.T) and current times TIF product (I.T) product from which the telephone interference factor is determined.

1.08 The 3C set has been designed to characterize quantitatively the effects of noise on the listener, so that noises which are judged equally interfering are assigned the same numerical magnitude. To accomplish this, the 3C noise measuring set performs the following functions:

(a) Weights the components of a given noise voltage in proportion to their interfering effect.

(b) Adds the weighted voltage components on an rms (power) basis.

(c) Indicates the result on a meter with suitable dynamic characteristics.

The 3C noise measuring set weighs approximately 14 pounds and is 11 inches long, 7 inches wide, and 8 inches deep. Figure 1 is a photograph of the set with the cover removed.

2. DESCRIPTION OF APPARATUS

A. External Arrangement

2.01 In Fig. 1 two input arrangements are provided: (1) a jack which accepts a 310-type plug and (2) binding posts marked T, R, and S which are connected to the tip, ring and sleeve terminals of the input jack. The binding posts will accept cords having banana plugs, bare wire, 35-type cord tips, or a number of standard clips or spade terminals. The two inputs are electrically identical.

2.02 Directly below the input connectors are two possible means of connecting dialing apparatus. The jack accepts a 310-type plug. The connectors marked T and R accept test-type clips such as those provided on a W2EY cord.

2.03 Adjacent to the clip connectors is the GRD binding post which is equipped with a sliding strap. Normally, this strap is inserted under the S binding post and a ground wire is attached to the GRD post. However, if the test connection is such that no ground should be present on the sleeve, the strap is disconnected from the S binding post.

2.04 Below the connectors is a 2-position slide switch marked DAMP-NORM. Ordinarily, noise measurements are made with this switch in the normal (NORM) position. When measuring rapidly fluctuating noise, the switch may be operated to the DAMP position. Additional information on the effect of this switch is contained in paragraph 7.01(i).

2.05 Situated below the damping switch is the FUNCTION switch, which selects the proper input circuitry and provides a means for dialing and holding, checking the battery, and calibrating the set.

2.06 To the right of the FUNCTION switch is a meter calibrated in dBrn. A red line and a

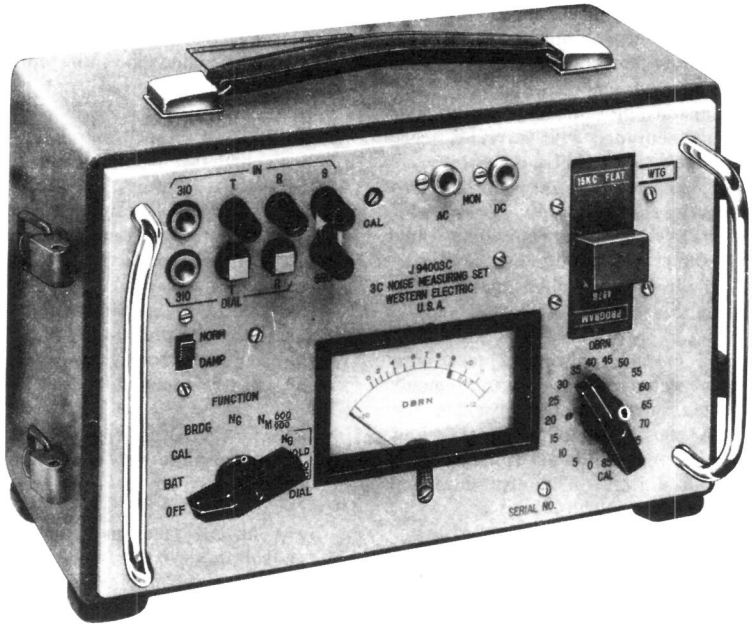

Fig. 1—J94003C Noise Measuring Set

shaded area provided on the meter scale are used for calibration and checking the battery.

2.07 To the right of the meter is the DBRN switch which controls the attenuator in the set. Attenuation is provided in 5-dB steps from 0 to 85 dB.

2.08 Above the DBRN switch is the WTG receptacle which accommodates the various weighting networks. Three separate plug-in units, each containing two networks, are available. The proper weighting network to be used for a specific application is discussed in Part 3 of this section. When a unit is plugged into the set, the upright lettering indicates which of the two networks is connected. The other network of that unit may be used by simply removing the plug-in unit, rotating it 180°, and reinserting it. The 1-kHz insertion loss of each of the networks is the same; therefore, the set does not require a new primary calibration when the network is changed.

2.09 To the left of the WTG receptacle are two monitoring jacks, one marked DC MON and the other AC MON. The DC MON jack provides a dc output suitable for driving external recorders or other DC measurement equipment. Insertion of a type 347 or equivalent plug into this jack disconnects the indicating meter. The AC MON jack provides a means for high-impedance monitoring with a 723A receiver equipped with a W2FS cord. ***It should be noted that this receiver and cord assembly cannot be used with the 3A noise measuring set or vice versa (see 2.22).*** A type 347A, 347B, or equivalent plug may be used to connect the monitoring output to an external AC meter. The indicating meter is not disconnected in this case.

2.10 To the left of the monitoring jacks is a screwdriver-operated calibration potentiometer marked CAL. This potentiometer provides for adjustment of the sensitivity of the set when calibrated with a reference milliwatt source or the internal reference oscillator. The procedure for making this check is described in Part 5.

2.11 The four captive screwdriver-slotted latch screws on the rear of the case may be unscrewed, but not removed, to permit removal of the panel for internal calibration and other maintenance. All apparatus except the battery is mounted on the panel.

2.12 Access to the battery is gained through an opening in the side of the set.

2.13 If desired, an external power supply (J87281A) may be connected to the 3C NM set. Access to the power connector is through a compartment door on the opposite side of the case from the battery opening. Opening the door switches the circuitry from the battery to the power connector.

2.14 Inside the cover of the set are compartments for storing the 723A receiver with its cord and the additional weighting network. Operating instructions are inscribed on the inside of the cover. The cover also provides a protruding guide which fits over the knob of the function switch. This guide prevents the cover from properly fitting on the set unless the function switch is in the OFF position.

B. Electrical Features

2.15 Figure 2 is a simplified block diagram of the 3C NM set.

FUNCTION SWITCH

2.16 The FUNCTION switch changes the circuit to provide the nine functions required of the set.

(a) The OFF position shorts the meter (M1) and disconnects the battery.

(b) The BAT position arranges the meter as a voltmeter to indicate the battery voltage under normal load.

(c) The CAL position applies battery to the internal oscillator. A 1000-Hz tone from the oscillator is connected directly to the attenuator for calibration purposes, as shown in Fig. 3.

(d) The BRDG position is used to measure noise on circuits without removing them from service.

(e) The NG position is used to measure noise voltages between a circuit and ground, such as those resulting from longitudinal induction.

(f) The NM 600/900 position is used as a termination when a metallic measurement at either 600 or 900 is specified.

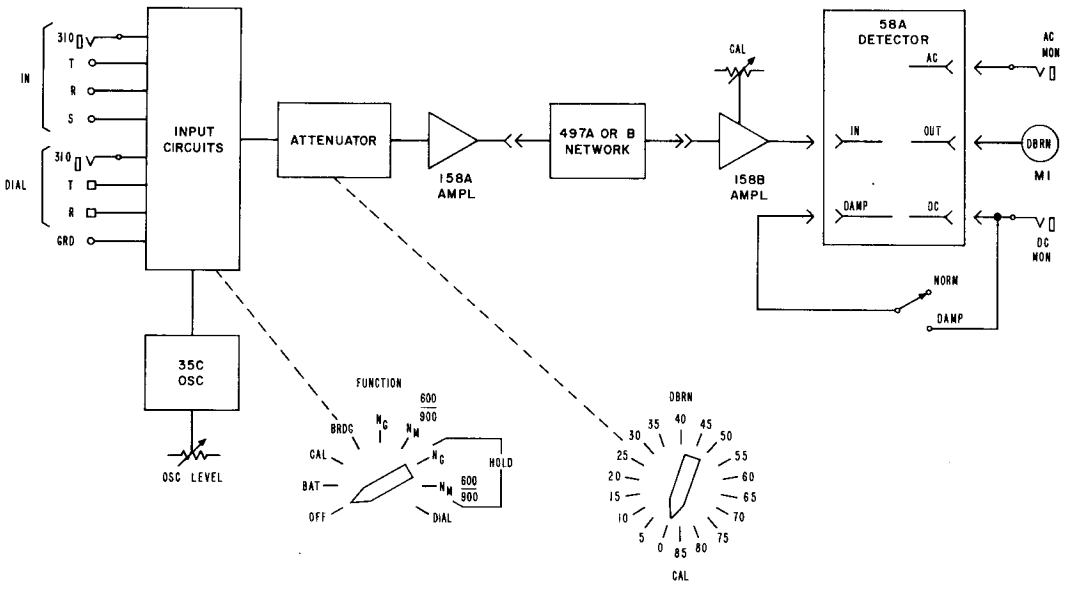

Fig. 2—J94003C Noise Measuring Set, Block Diagram

(g) The N_G HOLD position has the same function as the NG position and in addition, connects a holding network with a dc resistance of 700 ohms across the input circuit.

(h) The NM 600/900 HOLD position has the same function as the NM 600/900 position and provides in addition, for connecting a holding network with a dc resistance of 700 ohms across the input circuit. The holding network used in this and the previous case permits holding the connection after it is dialed, while making the noise measurement.

(i) The DIAL position connects the input T and R connectors to the dial T and R connectors and disconnects the input connectors from the input circuit of the set. This position is used for dialing the far end test termination over the line under test when required for making the noise measurement.

ATTENUATOR

2.17 The attenuator consists of π and L resistive pads combined by the switching arrangement to introduce the proper loss at each step of the DBRN dial. It has a range of 85 dB in 5-dB steps.

158A AMPLIFIER

2.18 The 158A amplifier is the input amplifier for the set and provides about 23 dB of voltage gain. The input impedance (about 15,000 ohms) serves as a termination for the attenuator. The output impedance of 600 ohms serves as the driving point impedance for the plug-in networks.

497A AND 497B NETWORKS

2.19 The 497A and 497B networks, in conjunction with the characteristics of the set, provide C-message, 3-kHz flat, program, and 15-kHz flat weighting.

KS-21567 NETWORKS

2.20 The KS-21567, L1 network contains two passive weighting networks, one a 3 kHz Butterworth filter shape with a 12 db per octave roll off and the other contains a C-message weighting with a 50 dB band-rejection notch from 995 Hz

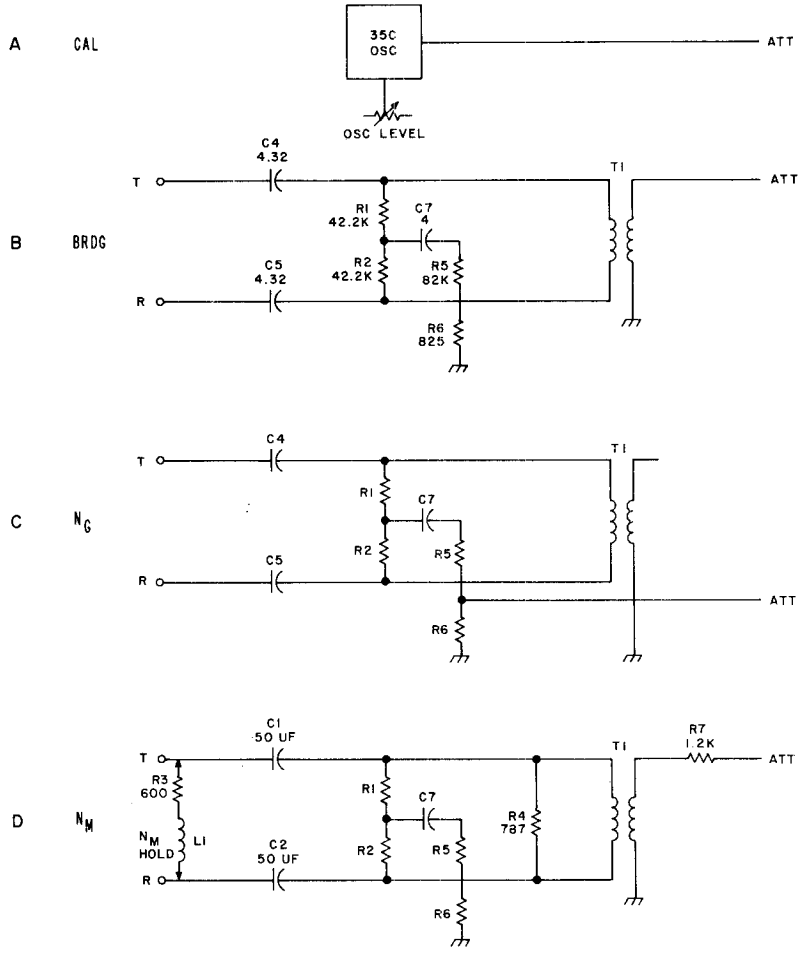

Fig. 3—Input Circuits, Simplified Schematic

through 1025 Hz. This filter permits measurement of noise on a facility with a 1 kHz holding tone by notching out the holding tone.

158B AMPLIFIER

2.21 The 158B amplifier is the power amplifier for the noise measuring set and provides from 67 to 71 dB of voltage gain, depending on the setting of the CAL control. The input impedance is 600 ohms and serves to properly terminate the weighting network. The output impedance of the amplifier is approximately 50 ohms.

58A DETECTOR

2.22 The 58A detector provides quasi-rms rectification of the input signal. Normally, the rectified signal is fed to the indicating meter. When the DC MON jack is used, the meter is disconnected and the rectified signal is fed to the DC MON jack.

2.23 The 58A detector also supplies the AC monitoring output. The output impedance of the AC MON jack is approximately 15,000 ohms. ***It is important to note that this output impedance is different from that of the AC MON jack of the 3A noise measuring set, which is only 600 ohms. The 3A set thus requires a 723 receiver with a special cord assembly (2W46A) which has a built-in 15,000-ohm resistor to reduce the bridging effect of the receiver on the meter indications. The cord (W2FS) used with the 723 receiver for the 3C set has no built-in resistor. Care should, therefore, be exercised to avoid the association of the wrong receiver and cord assembly with the 3A and 3C sets. Use of the receiver and cord of the 3C set with the 3A set will result in erroneous indications. Use of the receiver and cord of the 3A set with the 3C set will result in low receiver output.***

3. FREQUENCY WEIGHTING

A. C-Message Weighting

3.01 The C-message weighting characteristic, is shown in Fig. 4. This weighting is used for the measurement of noise on circuits where C-message weighting is specified. The shape of the C-message characteristic was determined by subjective tests on the relative interfering effects of single frequencies, as heard over a 500-type telephone set. It may also be used for the measurement of noise with respect to the 300-type telephone set. The C-message weighting (C MESSAGE) network, associated with this characteristic, is part of the plug-in 497A network package.

B. C-Notch Weighting

3.02 The C-notch weighting characteristic, is shown in Fig. 5. The C-notch characteristic has the C-message frequency weighting with a 50 dB notch, 30 Hz wide, centered at 1010 Hz. The notch attenuates typical holding tones from 995 Hz through 1025 Hz. Noise measured with a holding tone on a compandored facility (such as N- to T-Carrier) is a more accurate guide to performance than a noise measurement without a holding tone. The C-notch filter removes the holding tone to permit the 3C noise measuring set to measure the remaining noise on the facility. The noise measured after the holding tone is removed is the summation of background noise, phase jitter above 120Hz, and harmonic distortion.

3.03 The KS-21567, L1 network consists of two passive weighting networks in the same plug-in package for use with the 3C and 3CR NM set. Inserting the L1 package, with the C-NOTCH label upright, provides C-notch weighting. Inserting the L1 package with the 3 kHz FLAT label upright provides a filter identical to the 3-KC FLAT network of the 497A plug-in package. When the KS-21567,L1 option is ordered with the NM set the 497A network should be omitted.

C. 3-kHz Flat Weighting

3.04 The 3-kHz flat weighting frequency characteristic, including manufacturing tolerances, is shown in Fig. 6. The 3-kHz flat (3KC FLAT) network, associated with this characteristic, is included in the package of the 497A network and is used when it is desired to weight all frequencies in the band equally. This is often useful for detecting the presence of low-frequency noise (20-Hz ringing current or 60-, 120-, and 180-Hz energy from power induction).

D. Program Weighting

3.05 For measurements of noise on program circuits of bandwidths up to approximately 8,000 Hz, the characteristic of the weighting used including manufacturing tolerances, is shown in Fig. 7. The program weighting (PROGRAM) network, associated with this characteristic, is part of the 497B network package. Program weighting differs from the C- message weighting in that the design of the weighting takes into account the relative interfering effects of the various frequencies on program transmission.

E. 15-kHz Flat Weighting

3.06 The typical 15-kHz flat weighting frequency characteristic, including manufacturing tolerances, is given in Fig. 8, which shows the nominal frequency response of the overall set, exclusive of any frequency shaping as determined by the weighting networks. This 15-kHz flat weighting (15 KC FLAT) network is packaged in the 497B plug-in unit. This network provides a loss equal to the insertion loss at 1 kHz of the other networks without introducing additional

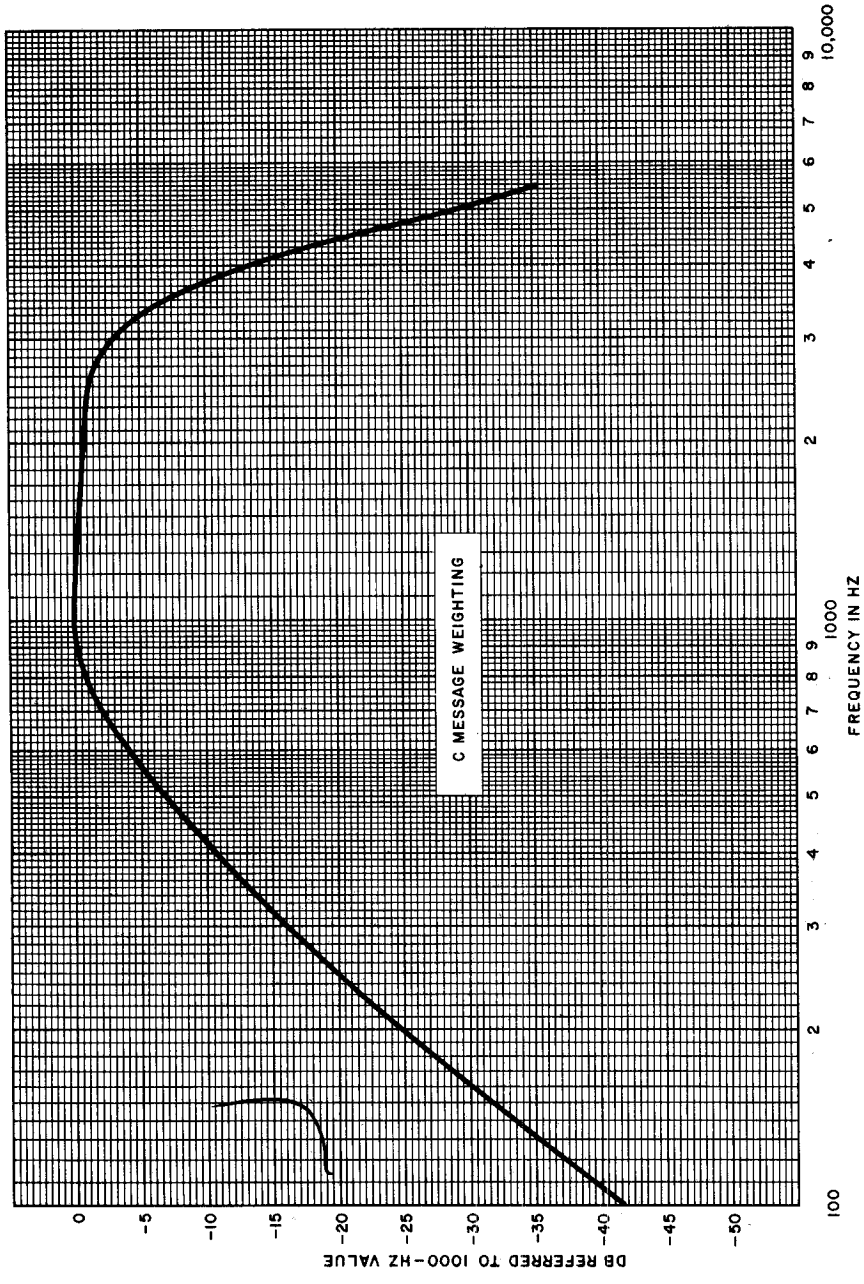

Fig. 4—C-Message Characteristic Curve

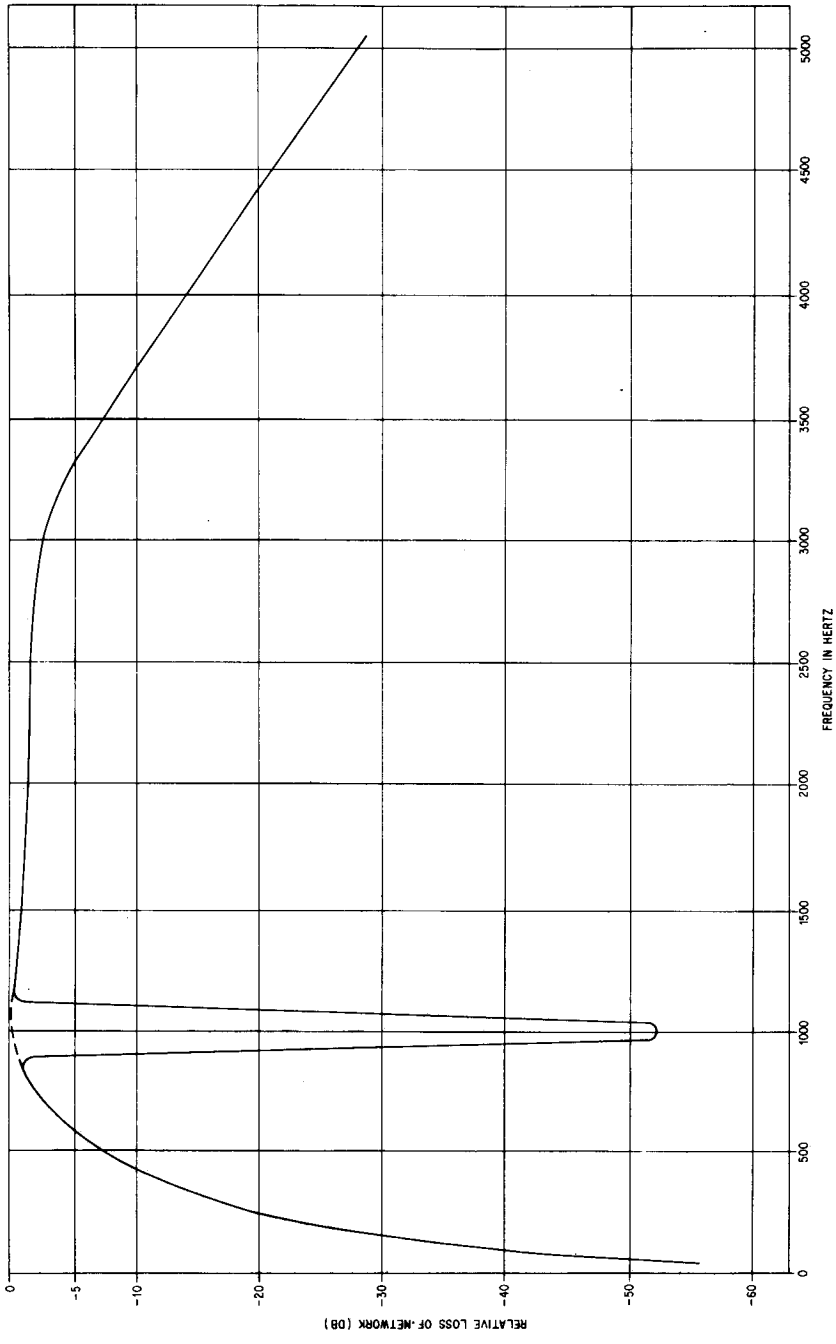

Fig. 5—Notch Characteristic Curve

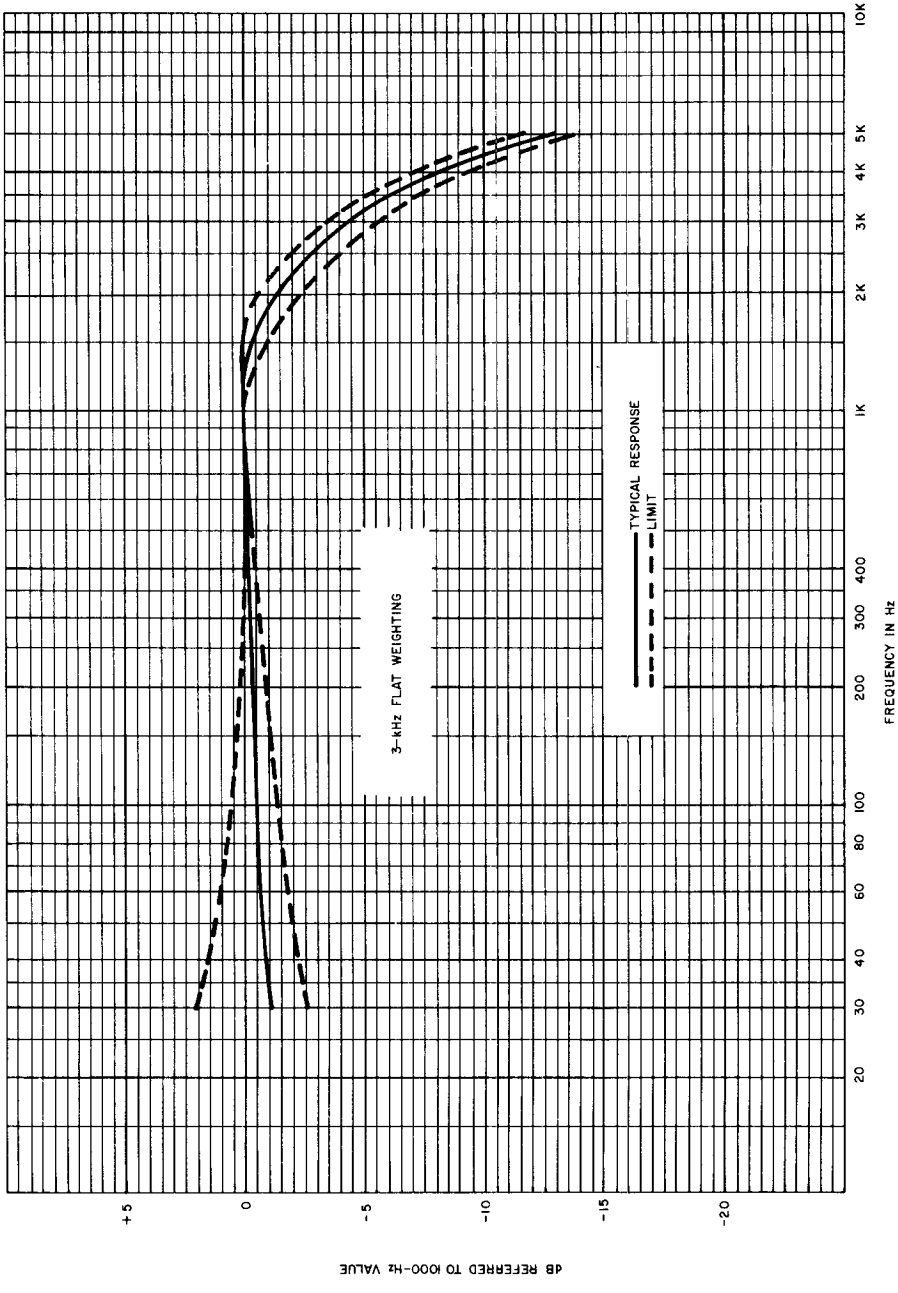

Fig. 6—3-kHz Flat Weighting Characteristic Curve

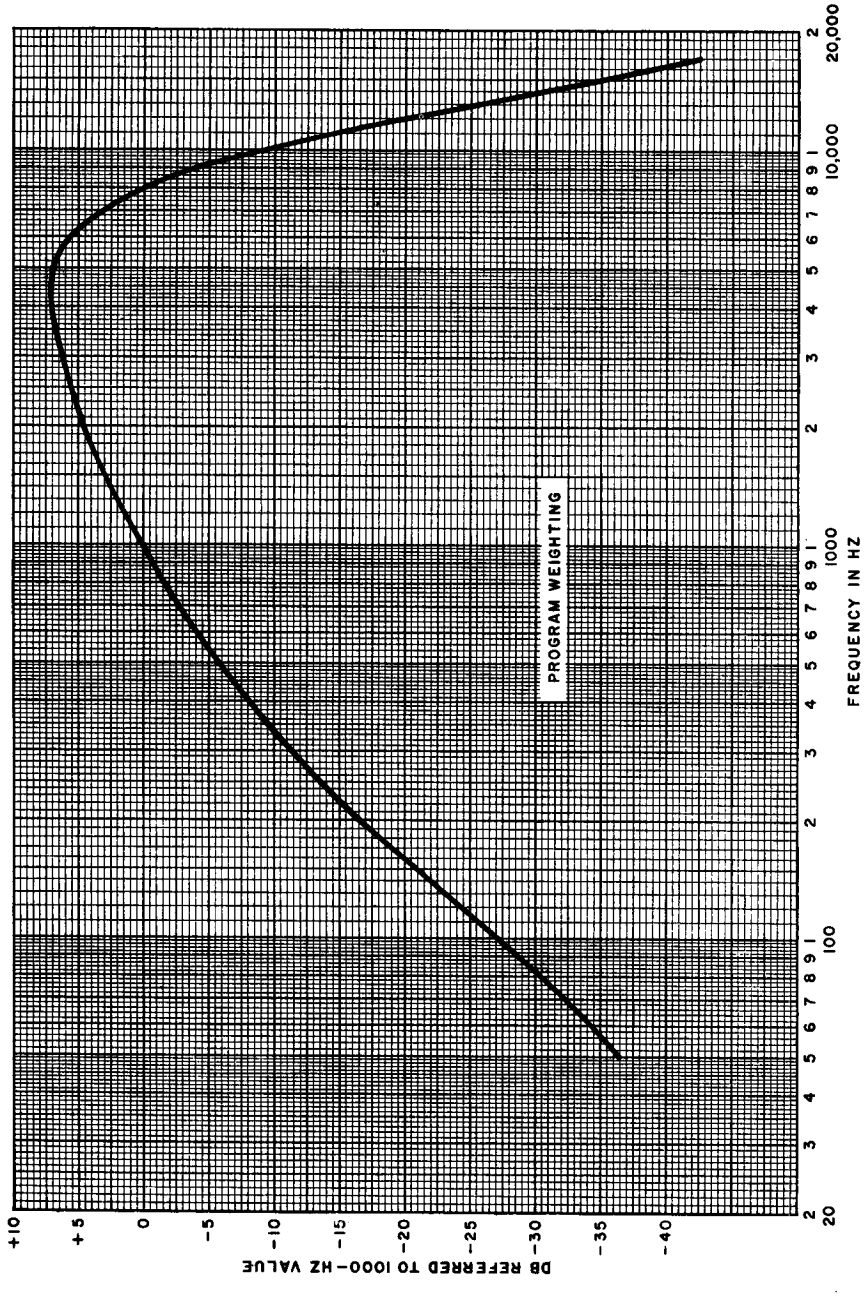

Fig. 7—Program Weighting Characteristic Curve

shaping. The 15-kHz flat weighting is used to measure noise in program circuits having a bandwidth of 15 kHz.

4. CHARACTERISTICS

A. Input Circuits

4.01 The BRDG input circuit (Fig. 3B) provides an input impedance of approximately 10,000 ohms. Input blocking capacitors, C4 and C5, are chosen to have the smallest value consistent with the transmission requirements of the set. This is done so as to prevent interference to dial pulses on a working line. Results of bridging measurements made across lines of 600-ohm impedance need no correction. Table A gives corrections to be applied to the readings of the set when bridging measurements are made across circuits having impedances other than 600 ohms.

4.02 The noise-to-ground (N_G) input circuit (Fig. 3C) provides an impedance of approximately 80,000 ohms between the input terminals and 100,000 ohms between the input terminals and ground. Except for a change in the point where the signal is sampled within the set, the circuitry is the same as for BRDG. Noise-to-ground measurements are made by bridging the input terminals of the measuring set across the metallic circuit on which the noise to ground is to be measured and connecting the GRD binding post to ground.

4.03 The N_M 600/900 input circuit (Fig. 3D) provides an input impedance of 735 ohms, which is the geometric mean of 600 and 900 ohms. The input capacitors, C1 and C2, are changed in value to be consistent with the termination. Resistor R7 is inserted between the input circuit and the attenuator to provide a change in signal level that is required because of the 735-ohm termination.

4.04 A 735-ohm termination dissipates the same power when connected to either a 600- or a 900-ohm source. When calibrated with test power from a 600- or 900-ohm source, the 3C test set indicates correctly on either 600- or 900-ohm circuits.

4.05 When circuits being measured depart from 600 or 900 ohms, measurements with the 3C NM set differ slightly from measurements with a set whose input impedance is 600 or 900 ohms. Figure 9 shows the errors encountered when measuring such circuits by comparing the differences in indications of a 3C NM set and a set such as the 3A, having discrete 600- or 900-ohm terminations. The 735-ohm input impedance is satisfactory for the applications for which the 3-type noise measuring sets are intended. However, the 3C set should not be used in the terminated condition in critical applications, such as return-loss measurements, that require more precise termination. In such applications, the BRDG input should be used with a 600- or 900- ohm resistor bridged across the input terminals.

4.06 The N_M 600/900 HOLD input circuit connects resistor R3 and inductor L1 to the T and R input connectors and provides a dc holding resistance of approximately 700 ohms. The AC impedance, however, is high enough so that it has only a neglible effect on the measurements. This input permits a noise measurement to be made on a line or trunk while holding the connection to a far end test termination which has previously been dialed over the line or trunk.

B. Sensitivity, Accuracy and Internal Noise

4.07 The sensitivity (unweighted) is such that the 3C NM set detects -90 dBm. The internal noise is approximately -110 dBm. The accuracy of noise measurements is about ±1 dB over a temperature range of 0° to 122° F.

C. Noise Reference Level DBRN

4.08 The reference level for noise measurement with the 3C set is 10^{-12} watt of 1000-Hz power. The measured unit is called DBRN (dB above reference noise). When a value of noise is given, the weighting used is always shown (eg, 30 dBrn 30 dBrnc message, 40 dBrn 3 kHz, 15 dBrn program, or 10 dBrn 15 kHz flat).

D. Measurements on Circuits Equipped With E-Type Signaling Units

4.09 The path to ground of the input circuit of the 3C N_M set includes a 4-μF capacitor, C7, as shown on Fig. 3D, to prevent false keying of certain types of E-type signaling units.

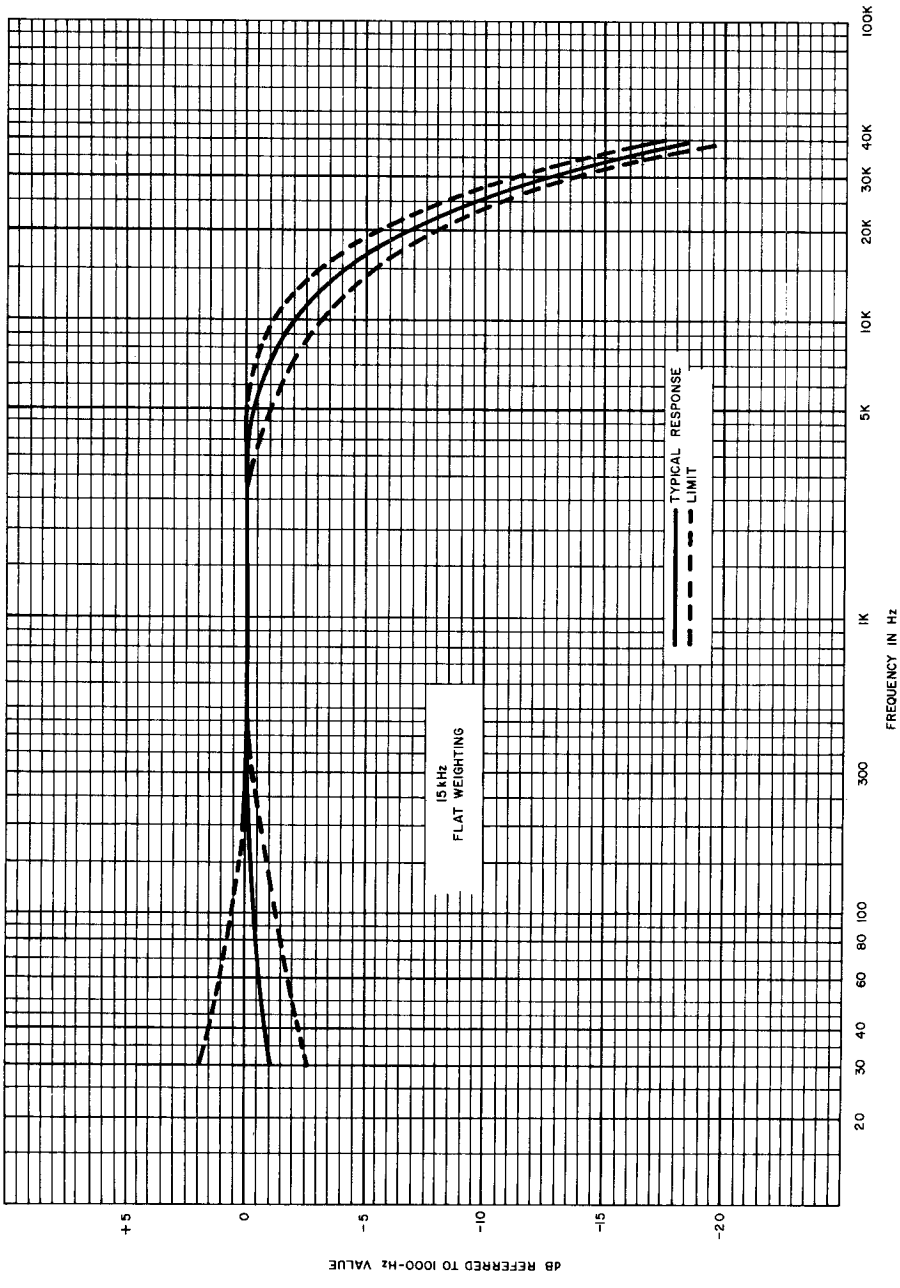

Fig. 8—15-kHz Weighting Characteristic Curve

TABLE A

CORRECTIONS FOR BRIDGING MEASUREMENTS	
CIRCUIT IMPEDANCE	ADD TO NOISE METER INDICATION
200	+5
400	+2
600	0
900	−1
1200	2
2000	−4

5. CALIBRATION

A. Primary Calibration

5.01 The purpose of primary calibration is to check the internal calibration of the 3C NM set. Primary calibration should be performed every 6 months. Primary calibration is performed in the following manner.

(a) With the FUNCTION switch at OFF, set the meter pointer over the base line at the left end of the scale. Turn the FUNCTION switch to BAT, and make sure the meter indicates in the shaded area.

(b) Use a 1000-Hz or 1004 Hz oscillator or calibrated milliwatt outlet having an output impedance of 600 of 900 ohms and an output level of 0 dBmm (±0.1 dBm) to supply a calibration signal.

(c) Insert any of the weighting networks, except the C-notch network of the KS-21567, L1 filter because this filter will notch out the 1000- or 1004 Hz.

(d) Adjust the DBRN dial to 85.

(e) Turn the FUNCTION switch to NM 600/900. Connect the GRD binding post to ground.

(f) Connect the input terminals of the set to the 0-dBm, 1000-Hz output which was measured as discussed in (b).

(g) Adjust the CAL control on the face of the panel for a meter indication of +5. Insert a screwdriver through the front panel hole for this adjustment (85 + 5 = 90 dBrn = 0 dBm).

(h) Turn the FUNCTION switch to OFF.

(i) Remove the set from its case. This may be done by simply unscrewing the captive screws on the back of the set.

(j) Turn the FUNCTION switch to CAL.

(k) Adjust the OSC LEVEL potentiometer (Fig. 10) until the 3C set meter indicates on the red line of the scale.

(l) Turn the FUNCTION switch to OFF, replace the 3C set in its case, and tighten down the captive screws. The set is now accurately calibrated and may be relied upon to retain its internal calibration for 6 months.

B. Field Calibration

5.02 The 3C noise measuring set should be calibrated in the field at each test location before any measurements are made. If the battery is fresh, and the temperature is constant, the initial calibration will remain within ±0.1 dB for a period of at least 2 hours.

(a) Turn the FUNCTION switch to OFF and see that the meter pointer is properly adjusted [see paragraph 5.01(a)]. The meter pointer adjustment is on the meter case.

(b) Insert the proper weighting network except for the C-notch network of the KS-21567, L1 network.

(c) Turn the DBRN switch to 85.

(d) Turn the FUNCTION switch to BAT. If the meter fails to indicate in the shaded area marked BAT, turn the FUNCTION switch to OFF and replace the battery (see paragraph 6.01). If the external J87281A power supply is being used, check the AC voltage or rectifier in accordance with Section 167-256-301.

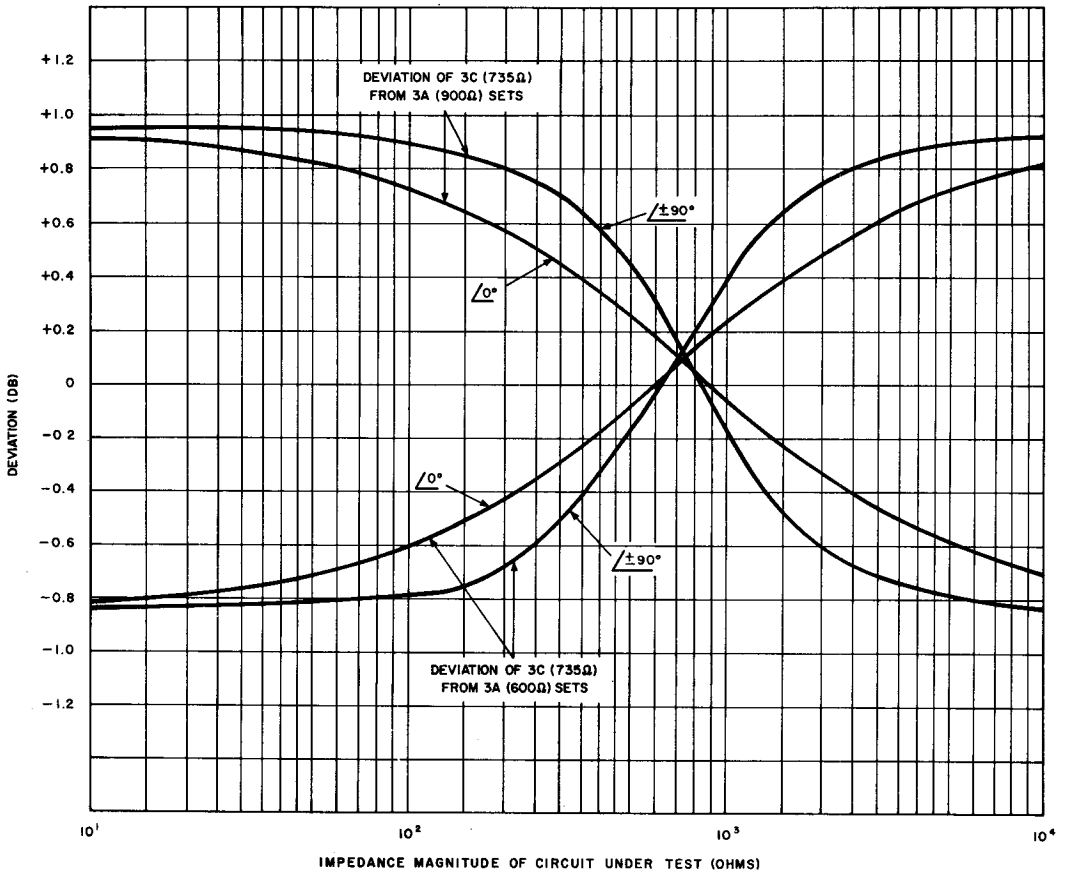

Fig. 9—Measurement Comparison Between 3C and 3A Noise Measuring Sets

C. Calibration With KS-21567 Network

5.03 When the C-NOTCH network is used in the CAL position, the reading should be off scale on the low side. Inverting the network permits calibration in the normal manner.

5.04 The internal oscillator of the 3C has a permissible frequency variation so large that the nominal 1000 Hz calibration tones may not fall in the C-notch (995 Hz through 1025 Hz). For this reason do not use the internal oscillator for calibration, nor to check the depth of the notch.

6. BATTERY INSTALLATION AND POWER SUPPLY CONNECTION

6.01 To remove the battery in the 3C NM set, unscrew the captive screws and remove the cover plate as shown in Fig. 11. Slide the battery out of the compartment and remove the battery plug from the old battery. Replace the battery with a new equivalent battery listed below:

Eveready	484
Burgess	B30
Bright Star	30-03
Mallory	M207
Marathon	4207
Montgomery Ward	49
Philco	P305
Ray-o-Vac	207
RCA	VS012
Sears Roebuck	6462
Usalite	624
Zenith	Z550

6.02 When the set is to be operated from the external power supply, open the door near the handle by unscrewing the captive screw. Insert the plug from a J87281A power supply into the receptacle on the 3C set (see Fig. 12).

6.03 A switch located beneath the door disconnects the battery and connects the set circuitry to the power connector when the door is opened. ***This door must be securely fastened when operating from the internal battery.***

7. MEASURING PROCEDURE

7.01 The measuring procedure is given below.

(a) Select the proper weighting network for the measurement to be made as discussed in Part 3 and plug it into position, with appropriate orientation.

(b) Calibrate the set as described in 5.02.

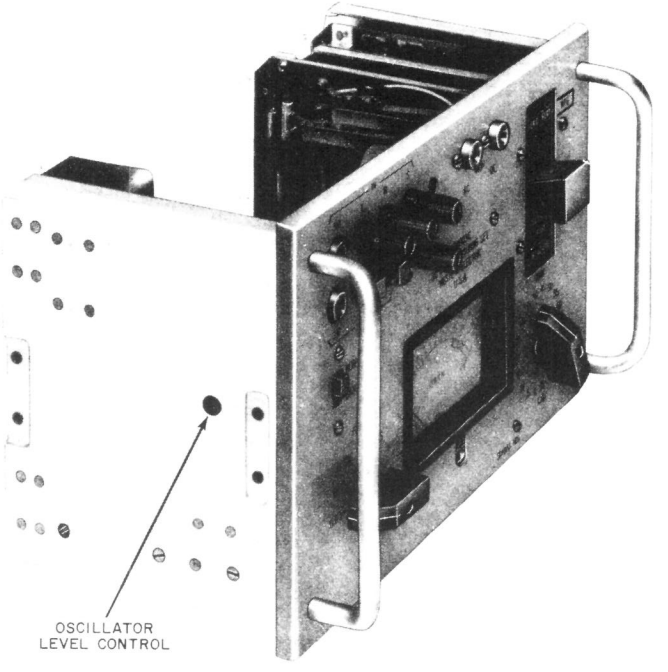

Fig. 10—Location of Oscillator Level Control

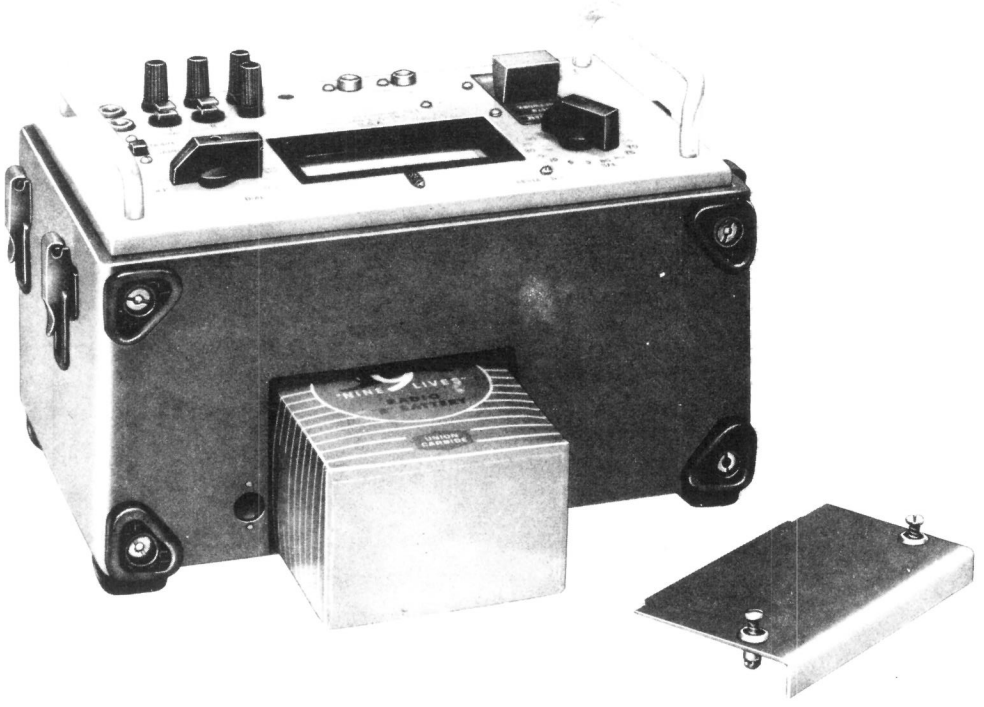

Fig. 11—J94003C Noise Measuring Set Showing Access to Battery

(c) Turn the FUNCTION switch to the position which will be used for the measurement.

(d) Check for pickup from external magnetic and electrostatic fields. With no input connected to the set, adjust the DBRN dial to 0. If there is a deflection on the meter, orient or position the set to minimize the deflection. ***Make sure the GRD post of the 3C set is connected to a ground.***

(e) Restore the DBRN dial to 85.

(f) Connect the circuit to be tested to the input of the set, using the appropriate cord.

Note: If the measurement requires that a distant test termination be dialed over the circuit to be tested, connect a 1011-type hand test set or equivalent to the DIAL jack or the DIAL T and R connectors. Turn the FUNCTION switch to DIAL and dial the appropriate code to reach the distant test termination. When the distant termination has been reached or connected, turn the FUNCTION switch to NM 600/900 HOLD to hold the connection during the measurement.

(g) Adjust the DBRN switch for a meter indication between +2 and +9. Observe the meter for about 10 to 30 seconds, and establish the point at which the meter needle appears ***most of the time.*** (Disregard highest occasional peaks.) Add the meter indication and the DBRN switch setting for total dBrn with respect to the weighting used.

(h) Always use the monitoring receiver provided with the set in the course of measurements to aid in identifying the noise. The character of the noise heard in the monitoring receiver should be recorded along with the noise indication.

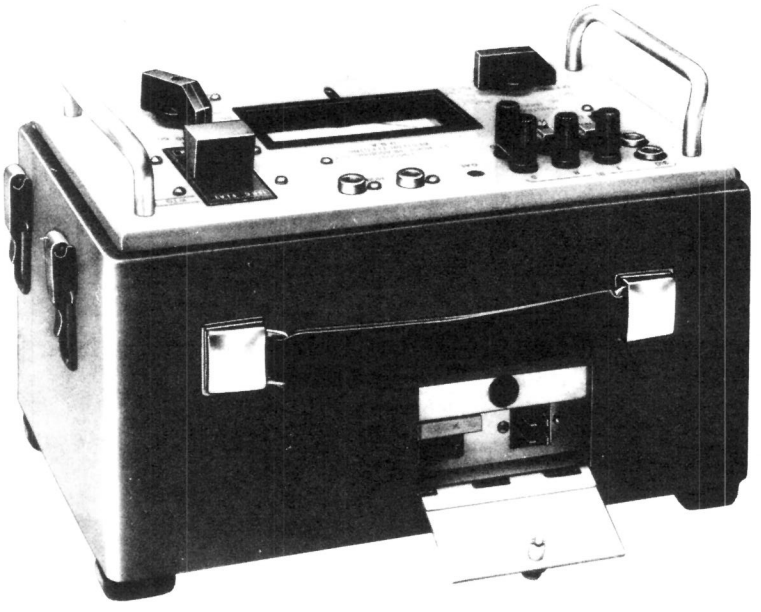

Fig. 12—J94003C Noise Measuring Set Showing Access to Power Connector

(i) Rapidly fluctuating noise (ie, atmospheric static or switching-type noise) can be more conveniently read on the meter by operating the DAMP-NORM switch to the DAMP position. When the switch is in the DAMP position, the meter should be read to include the maximum of the most frequently occurring peaks. Note, however, that this type of measurement does not provide an indication of the actual noise peaks.

8. PRECAUTIONS

8.01 Always set the DBRN switch to 85 before connecting the 3C NM set to an external circuit or when changing from circuit to circuit. This will prevent possible damage to the meter movement.

8.02 ***Do not attempt to use central office battery to power the 3C NM set.*** (See Part 6 for 60-Hz operation.)

8.03 If the 3C set is used for bridging measurements on circuits having impedances that are not nominally 600 ohms, a correction factor must be applied to the dBrn indication. The correction needed is dependent upon the circuit impedance and is given in Table A.

9. OTHER USES

9.01 The 3C NM set can be used for a number of purposes in addition to those discussed above. A few of these uses are described in this part of the section. Auxiliary apparatus is required as an addition to the 3C set to make some of the measurements, while for other tests, the set alone will be sufficient.

A. Measurement of Open-Circuit Longitudinal Voltage

9.02 The noise-to-ground input (NG) can be used to provide a measure of open-circuit longitudinal voltage in a telephone circuit. Such a measurement is useful in determining the longitudinal balance of the circuit. Due to the input circuit, it is

necessary to add 40 dB to the measurement to convert it to the same reference used for the metallic noise measurement.

B. Level Measurement

9.03 Where only an approximate indication is required, the 3C set can be used for measuring power levels either on a terminated or a bridging basis. It should not be used for any of the transmission measurements covered in other sections unless its use is specifically called for or permitted. Typical frequency characteristics are shown on Fig. 6 and 8. Over the frequency range from 200 Hz to 7000 Hz, the set should have an accuracy of about ±1.0 dB when using the 15-kHz flat weighting network. This accuracy is determined by the frequency characteristic and other tolerances within the set.

9.04 The FUNCTION switch is operated to the proper position and, if other than 1 kHz is to be measured, the 3 KC or 15 KC FLAT WTG is used. To convert dBrn indications to equivalent dBm, subtract 90 from the dBrn indication.

C. Crosstalk Measurements

9.05 The 3C NM set may be used to obtain a measure of crosstalk volume.

(a) Using the C MESSAGE WTG and the BRDG or NM 600/900 input circuit, adjust the DBRN dial to 85.

(b) Operate the DAMP-NORM switch to NORM.

(c) Decrease the setting of the DBRN switch until the average indication on the meter is between +2 and +9.

(d) Observe for the maximum of the frequently occurring peaks, excluding the occasional high peaks.

(e) The approximate crosstalk volume in dBm is equal to the total dBrn (dial plus meter) minus 90 (see paragraph 9.06).

9.06 Part of the indication on the measuring set may be contributed to noise on the circuit under test. Allowance for this may be made by taking a reading when the crosstalk is absent (as determined by monitoring), in addition to a reading when both crosstalk and noise are present. Then subtract from the latter reading a correction obtained from Table B.

TABLE B

CORRECTIONS TO BE MADE WHEN MEASURING CROSSTALK IN PRESENCE OF NOISE	
DB DIFFERENCE BETWEEN READING OF CROSSTALK AND NOISE AND READING OF NOISE ALONE	DB CORRECTION—SUBTRACT FROM CROSSTALK AND NOISE READING TO GIVE CROSSTALK VOLUME
1	7
2	4
3	3
4 to 5	2
6 to 8	1
Over 8	0

D. Use As Flat-Gain Amplifier

9.07 The 3C set may be used as a flat-gain amplifier with either the BRDG or N_M 600/900 input circuits and either the 3-kHz or 15-kHz flat weighting. The maximum voltage gain is 90 dB. The signal to be amplified is inserted at the input jacks or terminals and the output is available at the AC MON jack. The output impedance of this jack is approximately 15,000 ohms.

9.08 The maximum undistorted open-circuit output voltage at the AC MON jack is about 9 volts rms. However, into a 600-ohm load, the maximum undistorted output voltage is about 0.25 volt rms. At these voltages, the meter indicates off scale, but the set is not overloaded. Pegging of the meter in this condition is not harmful.

E. Use with DC Recorders

9.09 The 3C NM set may be used to drive many different types of DC recorders. Figure 13 has been prepared to assist in determining the types which may be used.

9.10 Knowing the input impedance and full scale current of a recorder, a point may be

determined on Fig. 13 which will fall within one of the areas. For instance, suppose the recorder that is available has an input impedance of 3000 ohms and a full-scale current of 500 microamperes. The point determined by these two numbers falls in region 2, which indicates that this recorder may be used with the 3C set (see Fig. 13). If the point had fallen in region 1, the set would not be able to drive the recorder to full scale. If the point had fallen in region 3, a suitable pad could be designed which would make the recorder usable. For example, suppose the recorder has an input impedance of 10,000 ohms and a full-scale sensitivity of 20 microamperes. If R2 (Fig. 14) is chosen to be 500 ohms, the apparent input impedance is essentially 500 ohms and the full-scale sensitivity is decreased by a factor of 21 (10,500/500), making the full-scale current 420 microamperes. Then choose R1 to be approximately 3500 ohms; in this case, the combination looks like a recorder with a 4000-ohm input impedance and a 420-microampere sensitivity which now falls in region 2 of Fig. 13.

9.11 To calibrate the recorder, use the equipment setup shown in Fig. 14. (Do not disturb any necessary pad arrangement.) Make no connection to the DC MON jack. Follow the procedure outlined below.

(a) Turn the FUNCTION switch of the set to NM 600/900. Set the DBRN switch to 50 and the external attenuator loss to 40 dB. Adjust the oscillator level at 1000 Hz so that the meter on the 3C set indicates +9.

(b) Connect the DC recorder to the DC MON output on the set and decrease the attenuator loss until the recorder indicates near full scale. Note the attenuator setting and subtract that number from 49. Mark this number (49 minus the attenuator setting) on the recorder paper at the recorder indication.

(c) Add attenuator loss in 1-dB steps. Mark the recorder scale value for each step. Do this until the scale range has been covered.

Note: In this calibration procedure, do not set the attenuator loss at more than 49 dB. The internal noise of the set may begin to affect the indication if this is done. When the 3C set is restored to regular service it will be necessary to make a field calibration. (See paragraph 5.02.)

9.12 The measuring procedure for using the DC recorder after calibration is as follows.

(a) Turn the FUNCTION switch to CAL. Adjust the CAL control for a recorder indication of +9 (the noise measuring set meter is disconnected and will have no indication).

(b) Turn the FUNCTION switch to either BRDG or NM 600/900 as required.

(c) Turn the DBRN switch in a counterclockwise direction until a convenient recorder deflection is obtained. The noise indication in dBrn is then the recorder indication plus the DBRN switch setting.

Note: A convenient recorder deflection should be one that anticipates any expected change in the noise. For example, if increases are expected, set the DBRN switch so that the chart indication starts at or near the low end of the scale.

9.13 The voltage at the DC MON output is negative with respect to the set case.

9.14 Continuous operation of the 3C set subjects the battery to constant drain. With continuous operation, a new battery may be expected to last for only about 48 hours. Therefore, it is preferable to use the 3C set on the external AC power supply when a recorder is used. Frequent checks of the battery should be made.

10. MAINTENANCE

10.01 The 3C NM set requires very little maintenance except for the replacement of the battery or worn mechanical parts such as knobs, jacks, rubber feet, etc.

10.02 A new battery should provide satisfactory service for approximately 100 hours if the set is used for about 2 hours each day or for approximately 48 hours if used for continuous operation. The normal shelf life of a new battery is about 12 months when the battery is stored in a cool, dry location.

10.03 Replacement of the battery is discussed in Part 6.

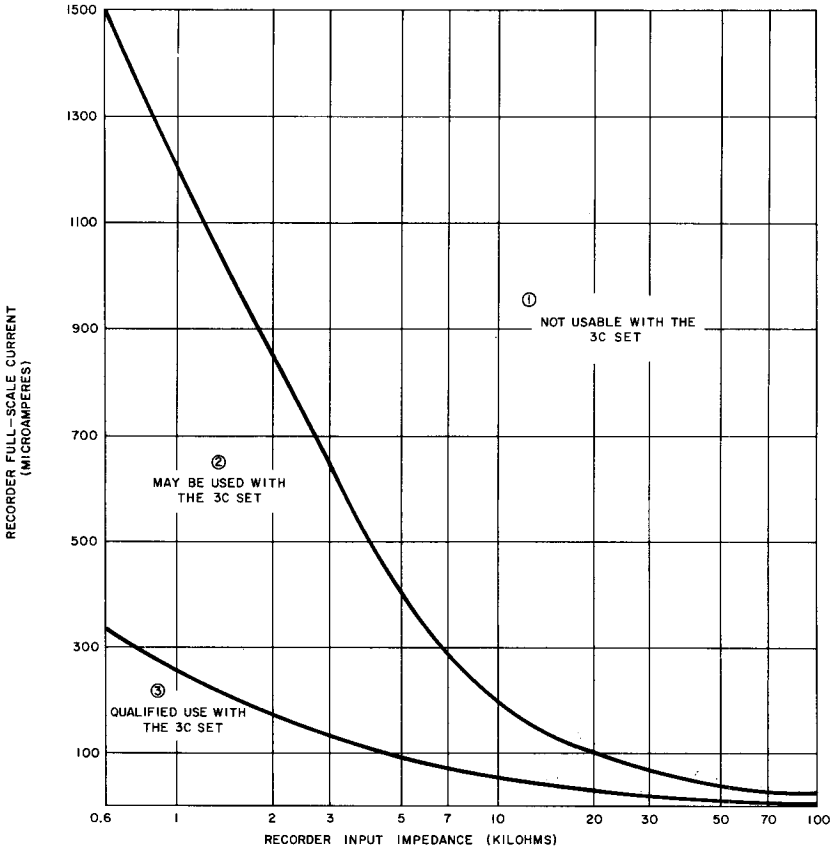

Fig. 13—Use of Recorder With 3C Noise Measuring Set

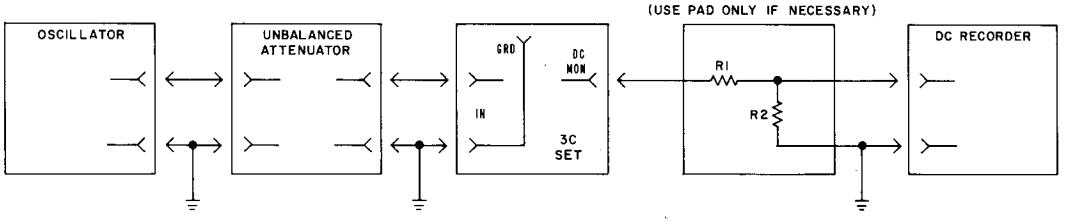

Fig. 14—Calibration Circuit For DC Recorder

10.04 The 3C set should be stored in a dry location with the cover on the set. Under these conditions, there should be no battery leakage problems.

10.05 The 3C NM set should be returned to the Western Electric distributing house for ***any*** repair. This is suggested because printed-circuit boards, transistors, and diodes, along with the associated circuitry, are incompatible with ordinary techniques of repair.

10.06 The 3C set should be returned to the Western Electric distributing house at least once a year for a complete check to ensure overall accuracy of the set.

11. REFERENCE (NOT ATTACHED)

11.01 The following drawing is related to this section:

SD-95276-02—Circuit Schematic.

11.02 The following sections contain noise measuring information:

660-403-300

660-403-301

660-403-302

660-403-500

660-403-501

660-403-503

J94027F P/AR TRANSMITTER/RECEIVER
DESCRIPTION, OPERATION, AND MAINTENANCE

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1. GENERAL INFORMATION

1.01 This section covers the description, operation, and maintenance of the J94027F P/AR transmitter/receiver. The J94027F (27F) replaces the J94027A, J94027C, J94027E P/AR generators and the J94027B P/AR receiver which are manufacture discontinued. The 27F transmitter/receiver is designed to provide a rating of some of the more important characteristics that affect the capability of a transmission facility to handle voiceband data signals. The P/AR rating is a measure of simultaneous effects caused by amplitude and/or envelope delay distortions, bandwidth reduction, and poor return loss present in the facility under test. Characteristics of the 27F transmitter/receiver are shown in Table A.

1.02 When this section is reissued, the reason for reissue will be given this paragraph.

A. General Description

1.03 The P/AR test system was developed to quickly identify data quality voice-frequency (VF) channels due to increased demand for data services on VF channels. As a single-weighted value, the P/AR unit rating can be used for the following functions.

(a) Characterize the combined effect of envelope delay distortion, bandwidth reduction, and low return loss evidenced by gain and phase ripples.

(b) Locate the L-multiplex trunks assigned to channels 1 and/or 12 by looking for the low P/AR reading caused by the envelope delay distortion (EDD) of the group filter on frequencies near the band edges.

(c) Screen private line facilities for approximate compliance to tariffed envelope delay distortion conditioning requirements. The P/AR spectrum and the tariffs give heaviest weighting to the envelope delay distortion in the center of the voiceband.

(d) Establish a benchmark type of measurement for a hardwire looped private line facility during circuit-order testing. P/AR test signal measurements made after the circuit has been turned up for service will determine the amount of parameter change and the general condition of the circuit.

1.04 The P/AR measurement requires a P/AR transmitter at one end of the VF channel under test and a P/AR receiver at the other end.

NOTICE
Not for use or disclosure outside the
Bell System except under written agreement

TABLE A

CHARACTERISTIC	27F P/AR TEST SET	
	TRANSMITTER	RECEIVER
Impedance (Balanced)	600 Ohms or 900 Ohms	600 Ohms or 900 Ohms
Number of Outputs	Two	Two (Input)
Pulse Repetition Freq	64 ms	
Pulse Polarity	Bilateral (Bipolar)	
True RMS Power Output Peak Power Output Average Power Output	True RMS Power Output Variable from 0 dBm to -41 dBm True RMS plus 10 dB RMS minus 5dB	
Input Attenuator Range		−2 dBm to −41 dBm
Power Supply	**(AC Line) 105 to 125 Vdc**	
Set Type	**Portable**	
Operating Temperature	0—50° C	
Overall Dimensions (Approximate, in inches)	17 Long 15 Wide 6 High	
Weight	18 Pounds	
Accuracy	±2 P/AR Units	
Resolution	1 P/AR Unit	
Measurement Ranges	0 to 199 P/AR Units	

The equipment may be used to test customer-to-customer connections, single trunks or loops, portions of trunks or loops (such as a channel of a carrier facility), or the voice transmission path through a signaling unit or other equipment.

1.05 While the primary purpose of the P/AR transmitter/receiver is to check for data-handling capability, it can also be useful in indicating the general transmission quality of a voiceband channel whether it is to be used for speech or for data.

1.06 The P/AR system will respond to a limited degree to other impairments such as noise, harmonic distortion, gain-slope distortion, phase jitter, repeater clipping, and compression. The 27F P/AR test system is superior to its predecessors because it is less sensitive to these impairments and unaffected by impulse noise and frequency shift.

1.07 On long-haul systems employing single sideband transmission, the 27F transmitter/receiver overcomes the problem of frequency shift by transmitting pulses made up of 16 frequency components from 125 + 15.625 Hz to 3875 + 15.625 Hz. [fn = (2n-1) 125 + 15.625 Hz, n = 1, 2, 3, ...16]. Without the 15.625-Hz offset, each spectral line is an odd harmonic of 125 Hz. Half-wave symmetry is produced by the absence of even harmonics, minimizing the influence of system intermodulation (nonlinear) distortion on the P/AR measurement.

1.08 The P/AR system responds to the ratio of the peak and full-wave rectified average values of a low duty-cycle test pulse transmitted over a trunk or circuit. This ratio is indicated on a zero-suppressed percentage basis relative to the undistorted test signal. That is, if the pulse is received undistorted, the P/AR meter receiver indicates 100. Distortion normally causes the peak-to-average ratio to be reduced, producing a reading lower than 100. For example, if the pulse is distorted so that the peak-to-average ratio is decreased 22 percent, the P/AR meter reading will be depressed 44 units from 100 to a P/AR reading of 56 since the actual P/AR indication decreases twice as fast as the percentage decrease in the ratio. A low value for this P/AR reading indicates that the test pulse has been dispersed or spread out in time as a result of the line distortion. These same effects cause intersymbol interference in a data signal.

1.09 A P/AR reading of 100 might be obtained on local facilities, but is not probable when testing over a carrier facility. Two main unavoidable impairments of a normal carrier channel are bandwidth restriction (due to the channel filters) and envelope delay distortion introduced at the band edges. However, the influence of strong echoes or high background noise can cause the P/AR reading to be above 100 and should be considered as carefully as the previously mentioned impairments that create very low P/AR readings.

1.10 Two common kinds of nonlinear distortion are clipping and compression. Clipping usually occurs as a nonsymmetrical distortion. That is, either the positive or the negative peaks of the transmitted signal are clipped. This kind of distortion frequently occurs in compandored carrier systems. When the 27F transmitter/receiver is used, clipping will be identical, independent of tip and ring, since the bilateral pulse alternates the sequence of polarity applied, and the peak-to-average ratios will be the same.

1.11 Symmetrical nonlinear distortions which affect the positive and negative portions of the test signal equally will not cause a polarity turnover effect. However, if the peaks of the P/AR test signal are compressed by the nonlinearity, the peak-to-average ratio will be reduced.

B. 27F P/AR Transmitter/Receiver Unit Description

1.12 The 27F P/AR transmitter/receiver is shown in Fig. 1. A block diagram of the 27F transmitter and receiver is shown in Fig. 2 and 3, respectively. The 27F equipment, unlike the other 27-type equipment, combines both the transmitter and receiver into a single unit.

> ***Note:*** The 27F test set is not compatible for use with any of the other 27-type units due to transmitter circuit changes and different signal processing methods used in the receiver of the 27F test set even though the envelope of the recovered test signal and the frequency spectrum are similar to those in the earlier P/AR units.

1.13 In addition to measuring P/AR values, the 27F test set measures the full-wave average and displays the rms level in dBm of the received P/AR line signal. Both the P/AR value and the rms level are displayed on a digital readout.

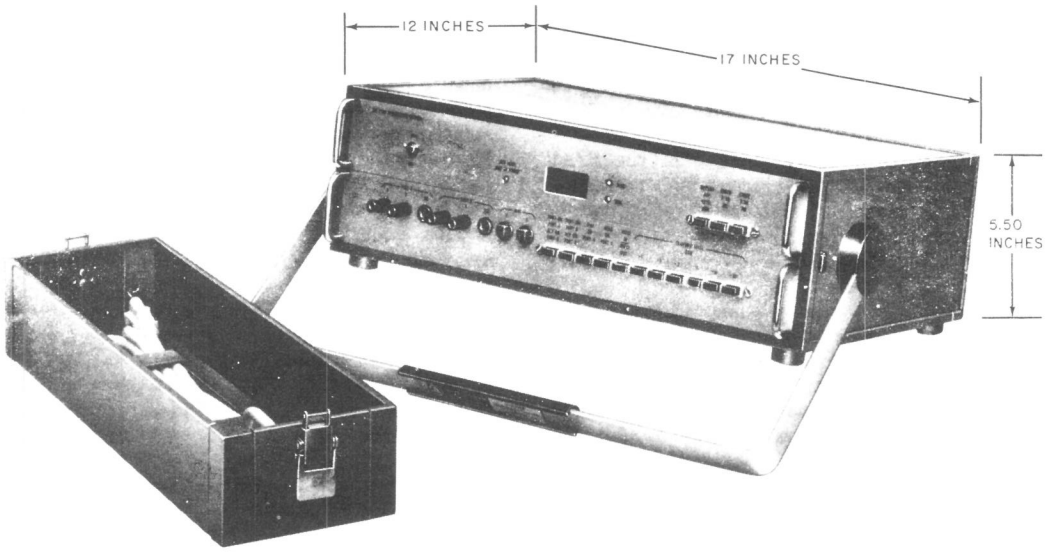


Fig. 1—J94027F P/AR Transmitter/Receiver

Indicator lights next to the readout indicate the measurement being displayed.

1.14 The 27F transmitter/receiver chassis is composed of two frame sections which are hinged together at the rear and opened at the front. The two frame sections are locked together in the close position using quarter turn fasteners. A large printed wiring board (PWB) and associated electronic components of the P/AR transmitter are contained by the lower frame, while a large PWB and associated electronic components of the P/AR receiver are contained by the upper frame. (See Fig. 4 and 5). This arrangement provides easy access and convenience during checking, adjusting, etc, and controls can be operated in the same manner as they are normally without any modification.

1.15 The 27F P/AR system is a portable transmitter/receiver that operates on a 105- to 125-volt, 60-Hz ac source. The ac power is converted to ±15 Vdc and +5 Vdc for use in both the transmitter and receiver circuits. Power is applied to the set through the male power cord receptacle located on the rear of the test set. The ac line is fused by a 1/2-ampere fuse located next to the power cord receptacle. A spare fuse is located next to the line fuse holder.

1.16 The 27F transmitter/receiver front panel and controls are shown in Fig. 6. Two pushbutton switches (TRMT ON PORT A RCV ON PORT B and TRMT ON PORT B RCV ON PORT A) are used for selection of PORT A and PORT B jack fields. The switches are interlocked to prevent simultaneous operations. When the TRMT ON PORT A RCV ON PORT B pushbutton is depressed, the tip (T) and ring (R) jacks of PORT A are used for transmission of the P/AR line signal and the T and R jacks of PORT B are used for receiving the line signal. When the TRMT ON PORT B RCV ON PORT A pushbutton is depressed, the T and R jacks of PORT B are used for transmission and the T and R jacks of PORT A, for receiving.

1.17 In addition to connections for routine P/AR testing, PORT A jacks should always be used when conducting P/AR tests on transmit and receive modes of a 2-wire wet connection. This type of connection requires a constant holding current for supervision which is supplied to the tip

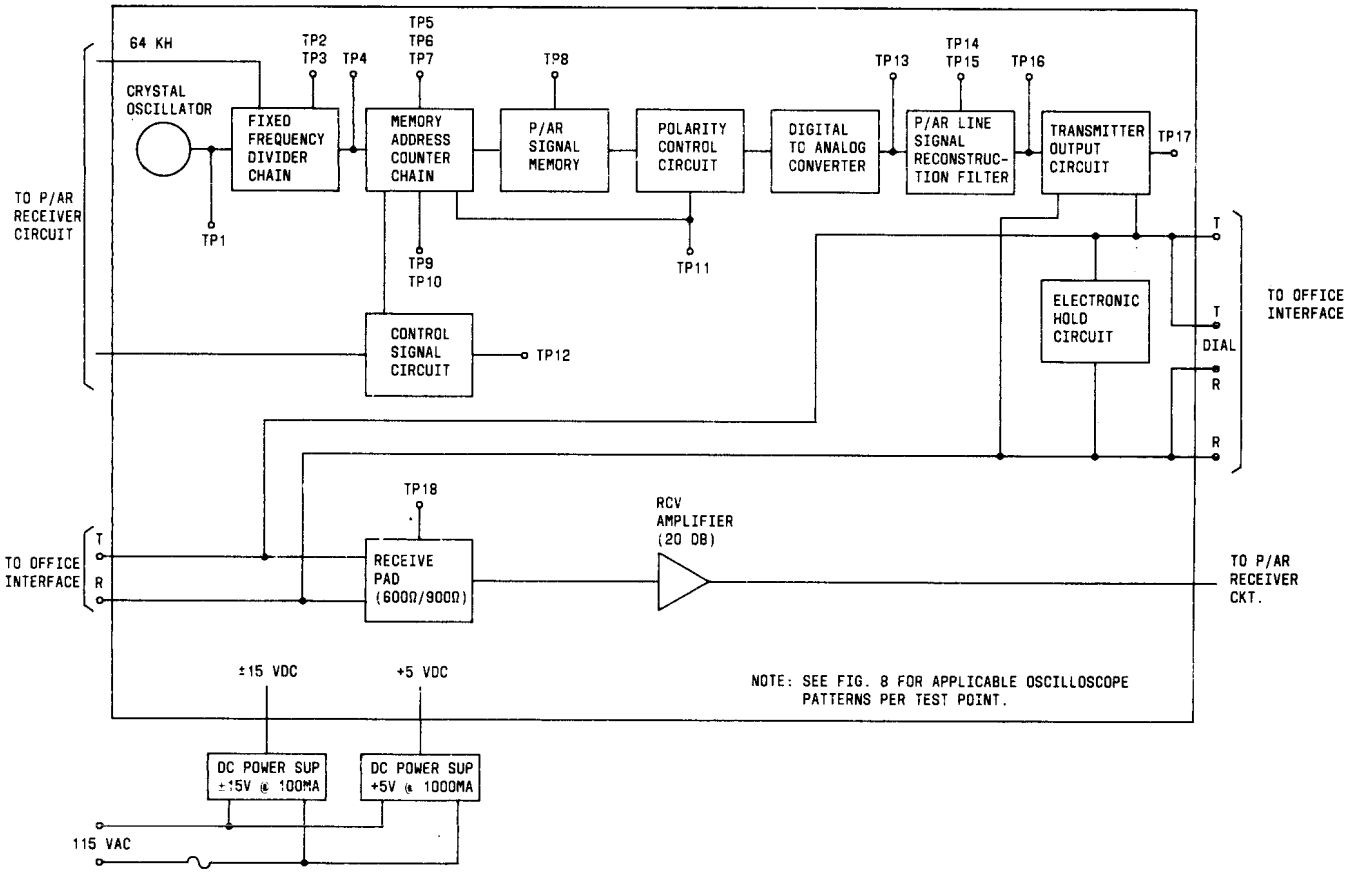
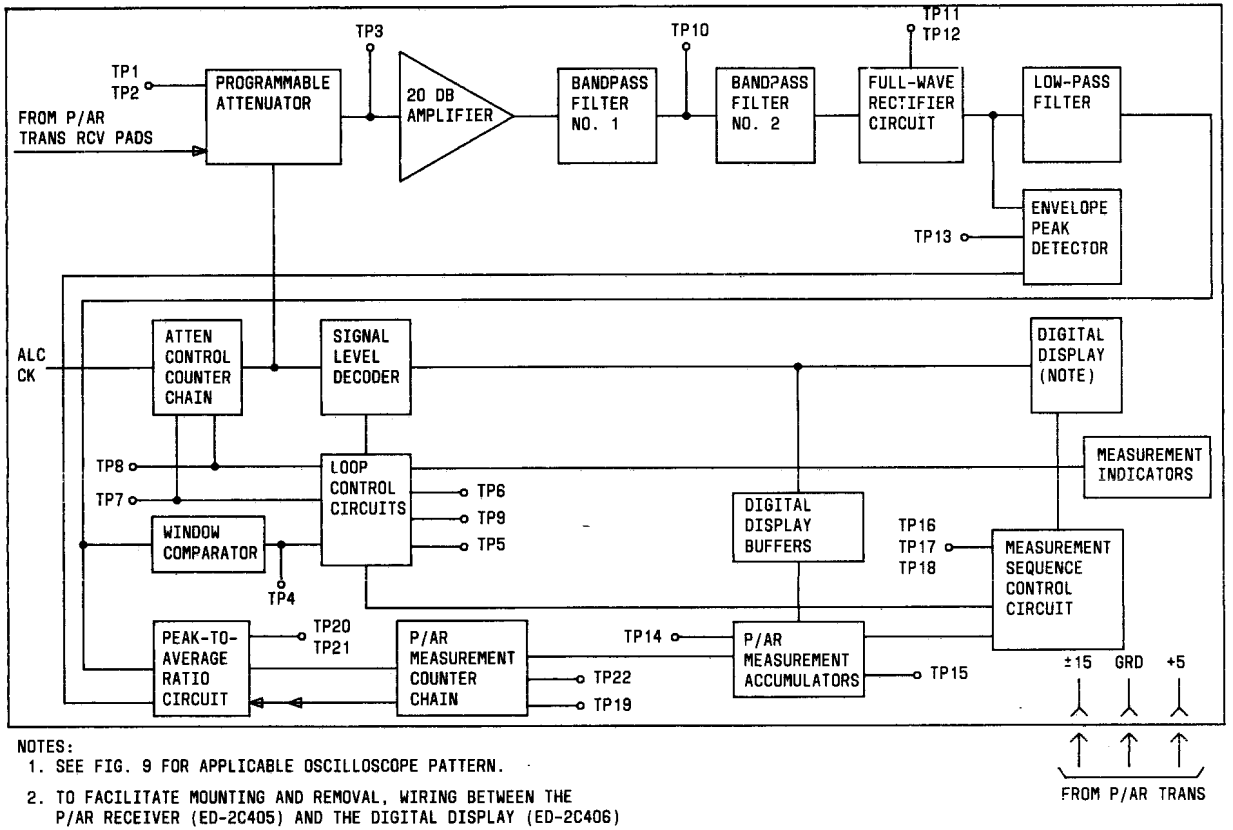


Fig. 2—27F P/AR Transmitter—Block Diagram



NOTES:
1. SEE FIG. 9 FOR APPLICABLE OSCILLOSCOPE PATTERN.
2. TO FACILITATE MOUNTING AND REMOVAL, WIRING BETWEEN THE P/AR RECEIVER (ED-2C405) AND THE DIGITAL DISPLAY (ED-2C406) HAS BEEN CONNECTORIZED.

Fig. 3—27F P/AR Receiver—Block Diagram

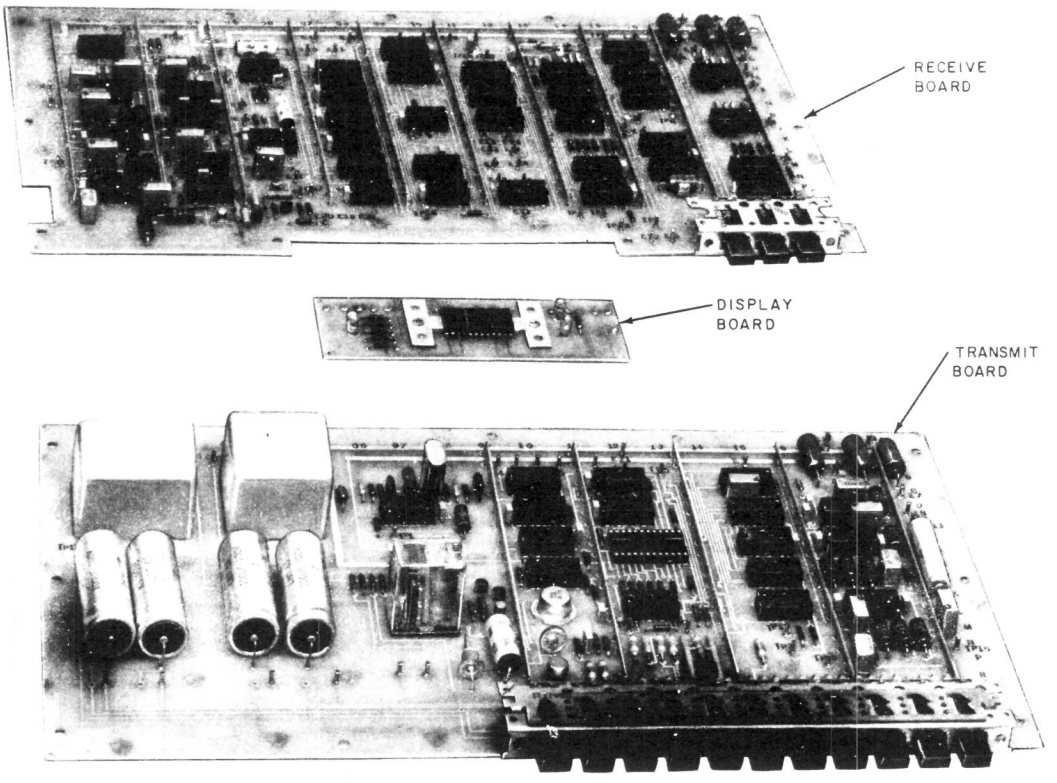


Fig. 5—27F Circuit Boards

When the pushbutton is released (out), a 600-ohm impedance is provided by a resistor pad within the 27F test set to match the impedance of the line under test during transmission and reception of the P/AR signal. When the pushbutton is depressed (in), a 900-ohm impedance is provided by a resistor pad for the transmission and reception of the P/AR signal input/output mode.

1.20 The TRANSMIT LEVEL DBM pushbutton switches select the output level of the P/AR signal in the transmit mode. The output level is selectable in 1-dB increments from 0 to -41 dBm (true rms) by depressing one or a combination of the six pushbuttons provided. The output level is equal to the sum of the values associated with each depressed pushbutton (eg, if -1, -3, -5, and -20 pushbuttons are depressed, the output level of the P/AR signal in the transmit mode is -29 dBm). When all six pushbuttons are released, the nominal transmit level is 0 dBm (true rms). Each switch operates independently, ie, push-to-actuate/push-to-release.

1.21 The 3-digit display and measurement indicator is used to display the P/AR rating of the received P/AR test signal over the range from 100 to 0 and the RMS value of the received signal from -2 dBm to -41 dBm. The display also indicates when the received signal level is either above or below the allowable range by displaying a plus (+) sign only for above range and a minus (-) sign only for below range in the P/AR rating measurement mode. In the RMS value measurement mode (range -2 dBm to -41 dBm), the digital disply will indicate -2 dBm for signal levels received above -2 dBm

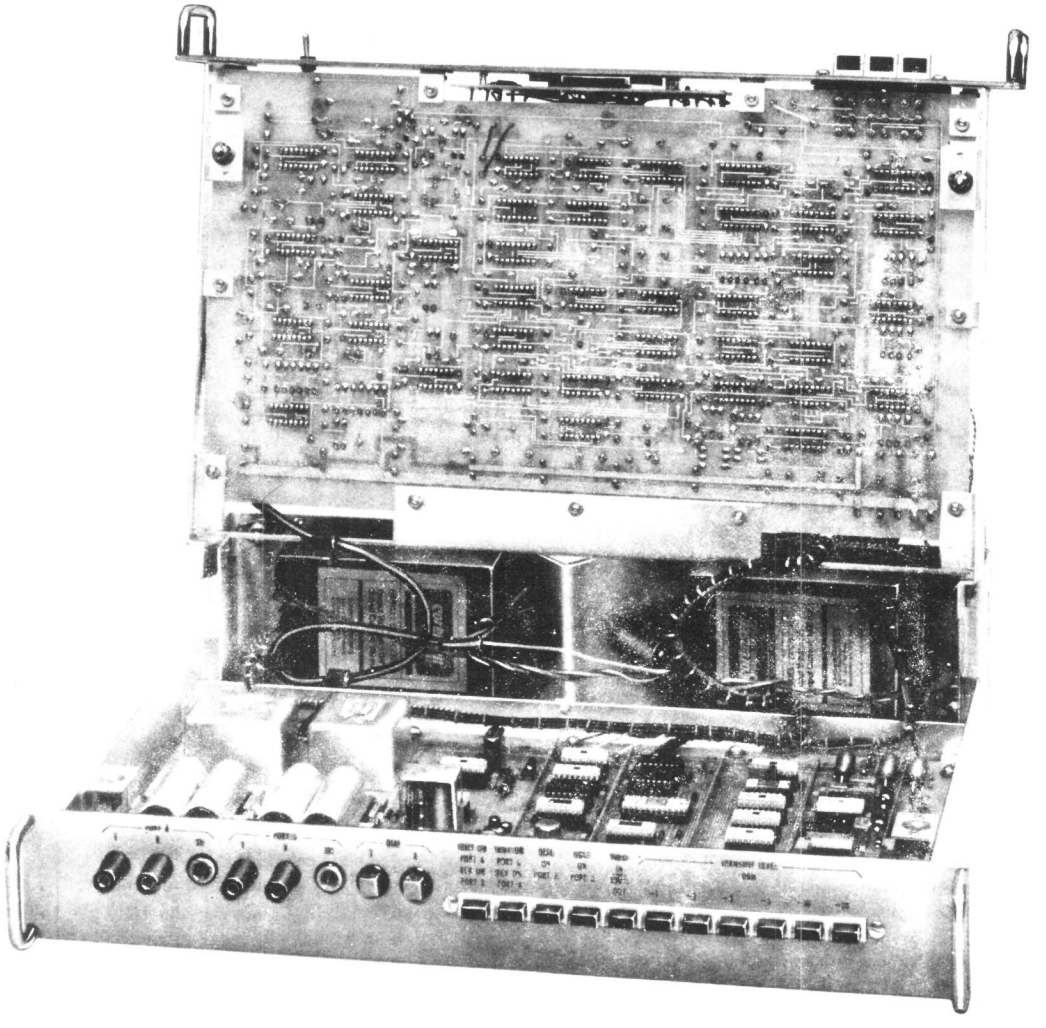


Fig. 4—27F Chassis Hinged Open for Service

and ring jacks of PORT A when the HOLD ON PORT A pushbutton is depressed.

1.18 The DIAL ON PORT A pushbutton, when depressed, connects the PORT A, T and R jacks to the DIAL T and R "cufflink" posts and disconnects the PORT A jacks from the internal transmission and receive circuits of the 27F test set. Dialing is accomplished through a maintenance handset connected to the DIAL T and R "cufflink" posts.

1.19 The 900Ω IN/600Ω OUT pushbutton serves a dual purpose by matching the 27F test set impedance to the characteristic impedance of the line under test in the transmit and receive modes.

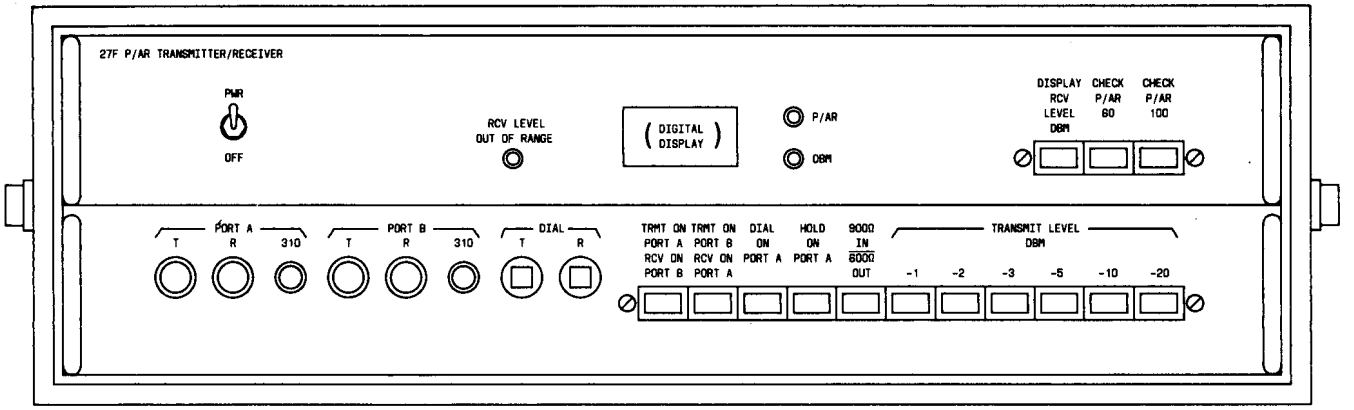


Fig. 6—27F P/AR Transmitter/Receiver Front Panel and Controls

and a -41 dBm for signal levels received below -41 dBm.

1.22 The three measurement indicators (P/AR, DBM, and RCV LEVEL OUT OF RANGE) are light-emitting diodes (LEDs) that are visible on the 27F test set front panel and indicate the status of the measurement shown on the digital display. When the P/AR rating is being measured, the P/AR LED is activated. When the RMS value in dBm of the received signal is being measured, the DBM LED is activated and, if the received signal level is not in the allowable range, the RCV LEVEL OUT OF RANGE LED is activated.

1.23 The DISPLAY RCV LEVEL DBM pushbutton switch, when depressed (in), causes the digital display and measurement indicator to show the received rms level of the P/AR test signal. Values ranging from -2 dBm to -41 dBm are displayed. Values greater than -2 dBm or less than -41 dBm are above or below range, respectively. When the pushbutton switch is released, the P/AR receiver reverts back to its normal measurement mode displaying P/AR rating units.

1.24 The 27F P/AR line signal transmission output can be checked by depressing (in) the CHECK P/AR 100 pushbutton which connects the transmitter circuit output internally to the receiver input and terminates PORT A and B jacks in 600 ohms. Result of the check is shown on the digital display in a P/AR rating unit. Releasing the pushbutton reestablishes the 27F transmitter/receiver to normal operation.

1.25 An operational check of the P/AR system is provided by operating the CHECK P/AR 60 pushbutton and observing the digital display for a P/AR rating of 60. When depressed, internal circuits simulating a VF channel with a P/AR rating of 60 shape a lower peak-to-average ratio signal output. Also, depressing the pushbutton connects the generator output internally to the receiver input and terminates the jacks of PORT A and PORT B in 600 ohms. Releasing the pushbutton reestablishes the 27F transmitter/receiver to normal operation.

1.26 The jacks of PORT A and PORT B accommodate 310-type plugs. The jacks are wired in parallel with binding-post-type terminals to accommodate spade clips. These access arrangements permit use of a variety of standard telephone test cords.

2. OPERATING INSTRUCTIONS

A. 27F Transmitter/Receiver—Calibration Check

2.01 The 27F transmitter/receiver calibration check should be performed periodically to verify the performance of the test set. The calibration check may be performed when the test set is connected or disconnected from on-line testing. The procedure is as follows.

STEP	PROCEDURE
1	Connect power cord to receptacle on rear of set to 115 volts, 60-Hz ac power line.
2	Operate PWR/OFF switch to PWR position.
3	Set the transmit level to -20 dBm by depressing the appropriate TRANSMIT LEVEL DBM pushbutton.
4	Depress and hold the CHECK P/AR 100 pushbutton.
5	Verify a P/AR reading on the digital display of 100±1 P/AR units.
	Note: When either the CHECK P/AR 100 or the CHECK P/AR 60 pushbutton is depressed, the digital readout (initially blank) will be displayed in approximately 4 seconds.

STEP	PROCEDURE
6	With the CHECK P/AR 100 pushbutton depressed, depress and hold the DISPLAY RCV LEVEL DBM pushbutton.
7	Verify that the receive level reading on the digital display is -20 dBm±1 dB.
8	Release the CHECK P/AR 100 and DISPLAY RCV LEVEL DBM pushbuttons.
9	Depress and hold the P/AR CHECK 60 pushbutton.
10	Verify a P/AR reading on the digital display of 60±1 P/AR units.
11	Release the P/AR CHECK 60 pushbutton.

B. 27F Transmitter/Receiver Setup and Measurement Procedures

2.02 In the following procedures, Procedure 1 is applicable to all facilities except P/AR tests conducted on 2-wire facilities requiring wet (battery and ground applied) off-hook connections for supervision. Procedure 2 lists the steps required for the setup and measurement of a 2-wire wet connection.

STEP	PROCEDURE 1
1	At the office testboard or equivalent, verify that circuit to be tested has been turned down from service.
2	Connect power cord to receptacle on rear of 27F test set to 115 volts, 60-Hz ac power line and operate PWR/OFF switch on front of test set to PWR position.
3	Select correct impedance to match impedance of line under test by operating the 900Ω IN/600Ω OUT pushbutton.
4	Select appropriate port (PORT A or PORT B) for transmitting (or receiving) by depressing TRMT ON PORT A RCV ON PORT B or TRMT ON PORT B RCV ON PORT A pushbutton.
5	Connect the 27F transmitter/receiver to line under test using appropriate test cords.
6	Verify that appropriate 27F test setup has been initiated at other end of line under test.
7	Read the P/AR measurement or the rms value of the received signal.

STEP	PROCEDURE 2
1	Perform Steps 1 through 3 of Procedure 1.

STEP	PROCEDURE
2	Depress TRMT ON PORT B RCV ON PORT A pushbutton.
3	Connect maintenance handset to T and R posts of DIAL function.
4	Depress DIAL ON PORT A pushbutton. ***Note:*** In the dial position (switch in), PORT A jacks are connected to the dial posts and disconnected from the internal circuitry.
5	Dial up the 107 test line. ***Note:*** The 107 test line transmits the P/AR signal along with other types of test signals. The 107 test line P/AR signal is compatible with the 27F P/AR transmitter/receiver. See Section 660-440-107 for additional 107 test line information including access procedures.
6	After 107 test line connection has been confirmed, depress HOLD ON PORT A pushbutton and release DIAL ON PORT A pushbutton. ***Note:*** Releasing the DIAL ON PORT A pushbutton sets the 27F in the measurement mode. The HOLD ON PORT A pushbutton must be fully locked in to prevent the dialup connection from being dropped.
7	Observe the P/AR measurement in P/AR rating units on the digital display. ***Note:*** The digital display will indicate the received level in dBm (true rms) when the DISPLAY RCV LEVEL DBM pushbutton is depressed.
8	To monitor test signals using a maintenance handset, depress DIAL ON PORT A pushbutton after test is in progress. Releasing the pushbutton reinstates the measurement mode on the test set.

3. CHECKS, ADJUSTMENTS, AND MAINTENANCE

A. General

3.01 It is recommended that all checks, adjustments, and/or maintenance be made as often as convenience permits and no less than once annually. In the event of a component failure or abnormal condition in the 27F P/AR test set, the test set should be sent to the appropriate service center for repair.

3.02 As an aid to checks, adjustments, and/or maintenance, typical 27F P/AR test set waveforms are shown in Fig. 7 through 9. The testpoints (TPs) correspond to those on the SD drawings and block diagrams.

3.03 The equipment required for checks, adjustments, or maintenance covering the 27F P/AR transmitter/receiver are as follows:

(a) 1 — RMS Voltmeter (Hewlett-Packard 3400A)

(b) 1 — DC Power Supply (Hewlett-Packard 6206B)

(c) 1 — Oscilloscope (Tektronix 549)

(d) 1 — Electronic Counter (Hewlett-Packard 5245L)

(e) 1 — Time Interval Unit (Hewlett-Packard 5262A)

(f) 1 — Multimeter (Triplett, KS-14510 L1)

(g) 1 — Digital Multimeter (Hewlett-Packard 3490A)

(h) 1 — Resistor, 600 ohms ±1% tolerance, 1/2 watt

(i) 1 — Resistor, 100 ohms ±1% tolerance, 1/2 watt

(j) 1 — Resistor, 900 ohms ±1% tolerance, 1/2 watt

(k) 1 — Attenuator (Daven, VT-795-G).

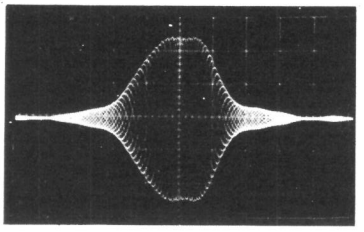
B. 27F Transmitter

3.04 The 27F line signal waveform check is as follows.

STEP	PROCEDURE
1	Connect external power (115 Vac, 60 Hz) to the 27F P/AR test set and operate PWR/OFF switch to PWR position.
2	Depress TRMT ON PORT A RCV ON PORT B pushbutton.
3	Set impedance to 600Ω by operating the 900Ω IN/600Ω OUT pushbutton.
4	Set TRANSMIT LEVEL DBM function to 0 dBm (all pushbuttons out).
5	Connect 600-ohm resistor between T and R jacks of PORT A.
6	Connect oscilloscope to T and R jacks of PORT A.
7	Set oscilloscope time base to 0.2 msec/cm.
8	Set the oscilloscope time base to the variable mode, and adjust control until the observed waveform has a single stationary lobe.
9	The observed waveform envelope should appear similar to Fig. 7A.
10	Disconnect oscilloscope and 600-ohm resistor from T and R jacks.

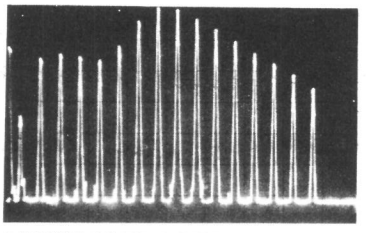
3.05 The 27F line signal spectrum check is as follows.

STEP	PROCEDURE
1	Perform Steps 1 through 5 of 3.04.
2	Connect spectrum analyzer to T and R jacks of PORT A.
3	Set analyzer controls as follows: FREQ SPAN — .5 kHz/DIV RESOLUTION BANDWIDTH — 10 Hz DISPLAY SMOOTHING — MIN SWEEP TIME — 10 SEC/DIV SWEEP MODE — REP AMPLITUDE MODE — 10 dB/DIV
4	At 1891-Hz frequency component of P/AR test signal (8th frequency component from 0 Hz, see 1.07), adjust input sensitivity and amplitude for peak value of 0 dB.
5	Adjust ADAPTIVE SWEEP to -55 dB level.
6	The observed spectrum should appear with 16 frequency components as shown in Fig. 7B. ***Note:*** All other spurious tones should be at least 50 dB below the 0-dB reference.
7	Verify that the 16 frequency components are separated by 250 Hz between each component.
8	See Table B for amplitude values of the 16 frequency components.
9	Disconnect spectrum analyzer and 600-ohm resistor from T and R jacks.



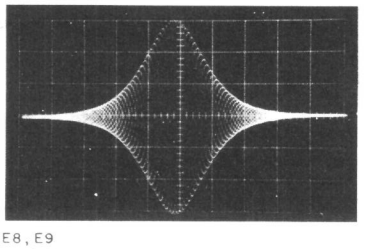
P/AR LINE SIGNAL ENVELOPE (T-R)
V = 1.0V
H = UNCALIBRATED
(TRANSMIT LEVEL = 0 DBM, AT 600 OHMS,
T-R TERMINATED WITH 600 OHMS)

A



P/AR LINE SIGNAL SPECTRUM (T-R)
V = 10 DB/DIV
H = 500 HZ/DIV
(REF: 1891 HZ COMPONENT = 0 DB)

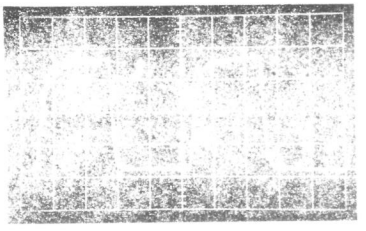
B



E8, E9
V = 0.5 V
H = UNCAL/.2 MS
(P/AR TEST SIGNAL
WITH P/AR = 100 — OUTPUT OF RECEIVER
SHAPING FILTER)

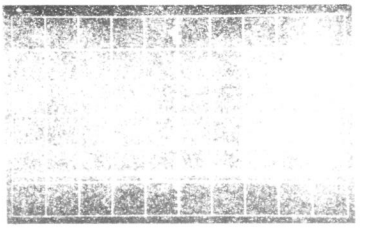
C

Fig. 7—Oscilloscope Patterns—27F Transmitter/Receiver



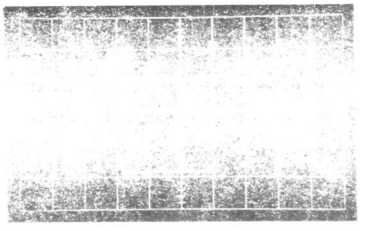
TP1
V = 1V
H = 0.2 μSEC
(CRYSTAL OSC OUTPUT – 1.024 MHZ)

A



TP7
V = 1V
H = 5 MSEC
(62.5-HZ PULSE WAVEFORM, 16 MSEC PERIOD,
PULSE WIDTH = 62.5 μSEC)

D

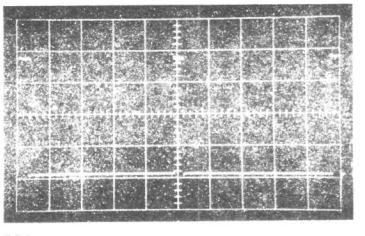


TP4
V = 1V
H = 10 μSEC
(SAMPLING FREQUENCY = 16.00 KHZ)

B

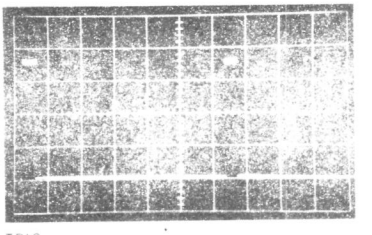
TP11
V = 1V
H = 10 MSEC
(15.625-HZ SQUARE WAVE
PERIOD = 64 MSEC)

E



TP5
V = 1V
H = 0.2 MSEC
(1.0-KHZ PULSE WAVEFORM,
PULSE WIDTH = 62.5 μSEC)

C



TP12
V = 1V
H = 10 MSEC
(15.625-HZ PULSE WAVEFORM,
PULSE WIDTH = 4.0 MSEC)

F

Fig. 8—Oscilloscope Patterns—27F Transmitter Circuits (Sheet 1 of 3)

TP13
V = 2V
H = UNCAL
(D/A CONVERTER OUTPUT)

G

TP16
V = 5V
H = UNCAL
(RECONSTRUCTION FILTER OUTPUT—
P/AR LINE SIGNAL)

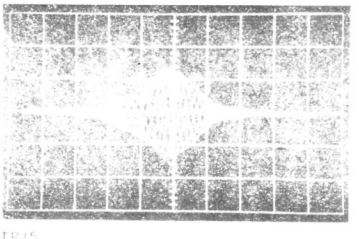
J

TP14
V = 5V
H = UNCAL
(OUTPUT OF FIRST-ORDER SECTION
OF P/AR RECONSTRUCTION FILTER)

H

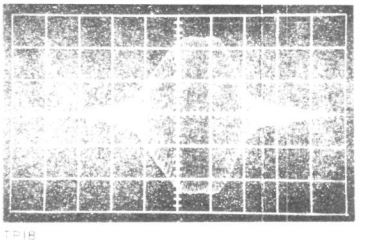
TP17
V = 1V
H = UNCAL
(UNBALANCED SIDE OF TRANSFORMER T1—
P/AR LINE SIGNAL, 0 DBM, 600 OHMS)

K



TP15
V = 5V
H = UNCAL

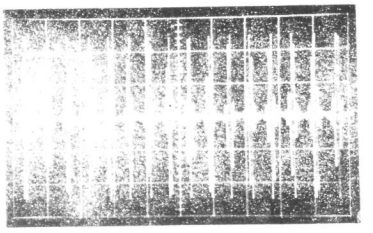
I



TP18
V = 1V
H = UNCAL
(UNBALANCED SIDE OF TRANSFORMER T2—
RECEIVED P/AR SIGNAL, PAR = 100,
0 DBM, 600-OHM TRANSMISSION)

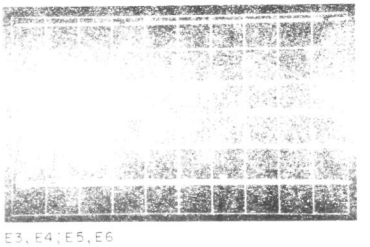
L

Fig. 8—Oscilloscope Patterns—27F Transmitter Circuits (Sheet 2 of 3)



P/AR LINE 1 (MA[illegible] 2
V=1.2V
H=6.4 MSEC
(TRANSMIT LEVEL = 0 DBM AT 600 OHMS,
T-R TERMINATED IN 600 OHMS)

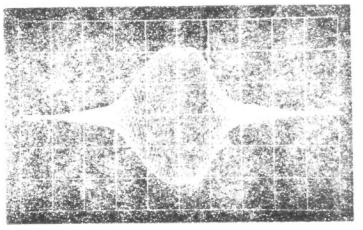
M



E3, E4 (E5, E6
V=5V
H=20 MSEC
(E3 (P/AR CLK) - SQUARE WAVE,
PERIOD = 1.28 MSEC)
(E4 (PK RESET) - RETANGULAR PULSE
PULSE WIDTH = 4 MSEC)
(E5 (CLEAR) - RECTANGULAR PULSE,
PULSE WIDTH = 4 MSEC)
(E6 (ALCCK) - PULSE WAVEFORM,
PULSE WIDTH = 62.5 μSEC)

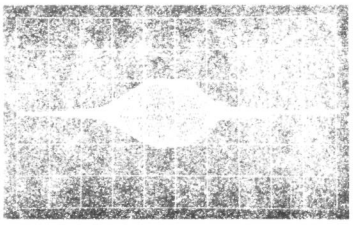
N

Fig. 8—Oscilloscope Patterns—27F Transmitter Circuits (Sheet 3 of 3)



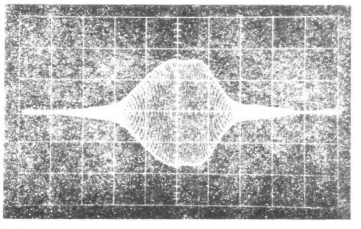
E1
V = 1.0V
H = UNCAL / .2 MS
(INPUT TO AUTOMATIC LEVEL CONTROL)

A



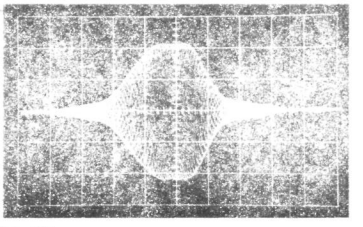
TP3
V = 0.1 V
H = UNCAL / .2 MS
(OUTPUT OF STAGE 3 OF PROGRAMMABLE ATTENUATOR)

D



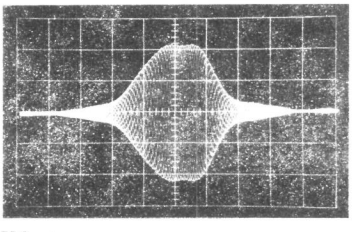
TP1
V = 1V
H = UNCAL / .2 MS
(OUTPUT OF STAGE 1 OF PROGRAMMABLE ATTENUATOR)

B



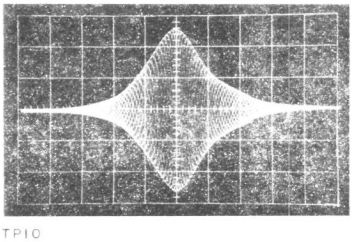
E6, E7
V = 0.5V
H = UNCAL / .2 MS
(INPUT TO RECEIVER SHAPING FILTER)

E



TP2
V = 0.5V
H = UNCAL / .2 MS
(OUTPUT OF STAGE 2 OF PROGRAMMABLE ATTENUATOR)

C



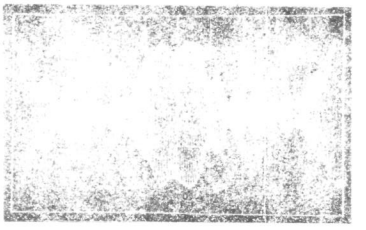
TP10
V = 0.5V
H = UNCAL / .2 MS
(OUTPUT OF BANDPASS FILTER NO. 1)

F

Fig. 9—Oscilloscope Patterns—27F Receiver Circuits (Sheet 1 of 3)

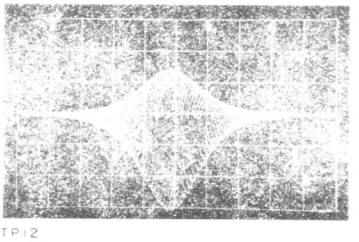
TP11
V = 2V
H = UNCAL/.2 MS
(OUTPUT SIGNAL OF INVERTING HALF-WAVE RECTIFIER)

G



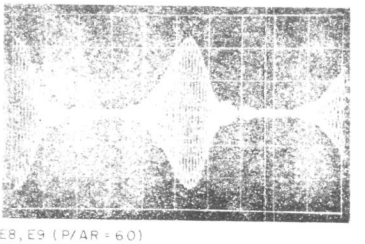
E1 (PAR = 60)
V = 1.0V
H = UNCAL/0.5 MS
(RECIVED P/AR SIGNAL AT INPUT TO AUTOMATIC LEVEL CONTROL)

J (NOTE 2)



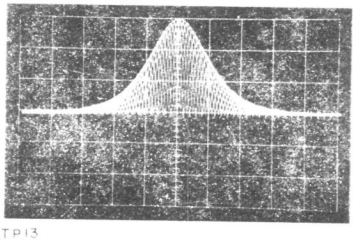
TP12
V = 1.0V
H = UNCAL/.2 MS
(OUTPUT SIGNAL OF NON-INVERTING RECTIFIER)

H



E8, E9 (P/AR = 60)
V = 0.5V
H = UNCAL/.5 MS
(P/AR TEST SIGNAL FOR SELF-TEST PAR = 60)

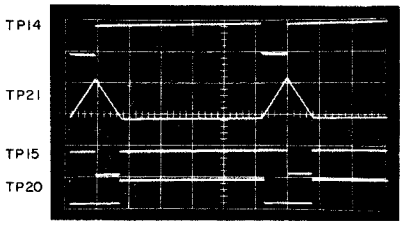
K (NOTE 2)



TP13
V = 1.0V
H = UNCAL/.2 MS
(FULL-WAVE RECTIFIED P/AR TEST SIGNAL)

I

Fig. 9—Oscilloscope Patterns—27F Receiver Circuits (Sheet 2 of 3)



TP14, 15, 20, 21
V = 5.0V
H = 20 MS
(TP14 PULSE SIGNAL THAT DRIVES RATIO CIRCUIT FET SWITCH, PERIOD = 128 MSEC, PULSE WIDTH = 16 MSEC)
(TP15 ENABLE SIGNAL FOR P/AR ACCUMULATOR, PERIOD = 128 MSEC, PULSE WIDTH = 16 MSEC)
(TP20 OUTPUT OF A RATIO CIRCUIT THRESHOLD COMPARATOR, PERIOD = 128 MSEC, PULSE WIDTH = 32 MSEC)
(TP21 OUTPUT OF RATIO CIRCUIT INTEGRATOR, PERIOD = 128 MSEC, PULSE WIDTH = 32 MSEC)

L

NOTES:
1. ALL CPS 2 OSCILLOSCOPE PATTERNS SHOWN WERE OBTAINED WITH TRANSMITTER AND RECEIVER CONNECTED BACK-TO-BACK (P/AR = 100). TRANSMIT LEVEL = −15 DBM AT 600 OHMS.
2. THE P/AR 60 SELF TEST SIGNAL MAY BE GENERATED CONTINUOUSLY BY GROUNDING TERMINAL E1 ON CP1.

Fig. 9—Oscilloscope Patterns—27F Receiver Circuits (Sheet 3 of 3)

NOTES

TABLE B

COMPONENT NO.	FREQUENCY (Hz)	AMPLITUDE (dB)
1	141	−34.0 ± 2.0
2	391	−16.0 ± 0.5
3	641	−14.6 ± 0.4
4	891	−15.2 ± 0.4
5	1141	−16.3 ± 0.3
6	1391	−11.9 ± 0.2
7	1641	−4.1 ± 0.2
8	1891	0.0 ± 0.05
9	2141	−0.43 ± 0.2
10	2391	−3.2 ± 0.2
11	2641	−6.7 ± 0.3
12	2891	−10.0 ± 0.3
13	3141	−13.7 ± 0.4
14	3391	−17.3 ± 0.5
15	3641	−21.0 ± 0.5
16	3891	−24.9 ± 0.8

3.06 The 27F output level and impedance check is as follows.

STEP	PROCEDURE
1	Perform Steps 1 through 5 of 3.04.
2	Connect the rms voltmeter between the T and R jacks of PORT A.
3	Verify rms voltmeter reading of 0.0±1.0 dBm.

STEP	PROCEDURE

4 Verify the following rms voltmeter values when the appropriate TRANSMIT LEVEL DBM pushbuttons are depressed to obtain the listed output level for the 27F:

OUTPUT TRANSMIT LEVEL SETTING (dBm) OF 27F TRANSMITTER	RMS VOLTMETER MEASUREMENT (dBm)
0	0.0 ± 1.0 = REF LEV*
−1	−1.0 ± 0.2 + REF LEV
−2	−2.0 ± 0.2 + REF LEV
−3	−3.0 ± 0.2 + REF LEV
−5	−5.0 ± 0.2 + REF LEV
−10	−10.0 ± 0.2 + REF LEV
−20	−20.0 ± 0.2 + REF LEV

* REF LEV is actual value shown on the RMS VM at TRANSMIT LEVEL 0 which may be a small deviation from the 0 value up to ±1.0 dBm. To obtain a true measurement with the RMS VM, meter readings must be adjusted to include the deviation.

5 Readjust TRANSMIT LEVEL DBM function to 0 dBm (all pushbuttons out).

6 Disconnect 600-ohm resistor from T and R jacks of PORT A of the 27F transmitter.

7 Set impedance to 900Ω by operating the 900Ω IN/600Ω OUT pushbutton.

8 Connect a 900-ohm resistor between the T and R jacks of PORT A.

9 Connect the rms voltmeter between the T and R jacks of PORT A.

10 A reading of REF LEV + 1.8±0.2 dBm should be indicated on the rms voltmeter.

Note: Readings for the 27F output signal in the 900-ohm mode will be 1.8±0.2 dBm higher on the rms voltmeter due to an impedance mismatch. The rms voltmeter input impedance is 600 ohms.

11 Repeat Step 4. The rms voltmeter will reflect the listed measurement result plus 1.8±0.2 dBm setting for each output level setting.

12 Disconnect the rms voltmeter and 900-ohm resistor from T and R jacks of PORT A.

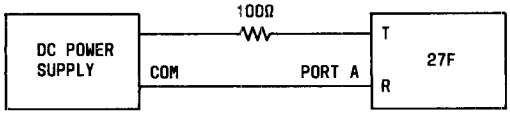
STEP	PROCEDURE
13	Readjust TRANSMIT LEVEL DBM function to 0 dBm.
14	Depress TRMT ON PORT B RCV ON PORT A pushbutton.
15	Set impedance to 600Ω by operating the 900Ω IN/600Ω OUT pushbutton.
16	Connect 600-ohm resistor between T and R jacks of PORT B.
17	Connect the rms voltmeter between T and R jacks of PORT B.
18	Repeat Steps 3 through 12 using T and R jacks of PORT B for P/AR signal transmission check.

3.07 The 27F dial control check is as follows.

STEP	PROCEDURE
1	Set PWR/OFF switch to OFF position and release DIAL ON PORT A pushbutton.
2	Set the multimeter (Triplett, KS-14510, L1) to test for continuity.
3	Connect the multimeter between tip jack (T) of PORT A and tip jack (T) of DIAL.
4	An "open" (no continuity) reading should be indicated.
5	Depress DIAL ON PORT A pushbutton and observe multimeter reading.
6	Meter should indicate continuity.
7	Release DIAL ON PORT A pushbutton and connect the multimeter between ring (R) jack of PORT A and ring (R) jack of DIAL.
8	The multimeter should indicate an "open" circuit.
9	Depress DIAL ON PORT A pushbutton and observe multimeter.
10	The multimeter should indicate continuity.
11	Release DIAL ON PORT A pushbutton and disconnect test equipment from the P/AR unit.

3.08 The 27F holding function check is as follows.

STEP	PROCEDURE
1	Set PWR/OFF switch to OFF position.
2	Prepare the following test setup:



3	Depress HOLD ON PORT A pushbutton.
4	Connect the dc voltmeter (H-P 3490A) between T and R jacks of PORT A.
5	Adjust the dc power supply to obtain the voltages indicated in Table C (V_{TR}) for the T and R jacks of PORT A.

TABLE C

VOLTAGE MEASURED BETWEEN T AND R JACKS OF PORT A (V_{TR})	$V_{PS} - V_{TR}$
50.0 ± 0.1	2.6 ± 0.3
40.0 ± 0.1	2.6 ± 0.3
30.0 ± 0.1	2.6 ± 0.3
20.0 ± 0.1	2.5 ± 0.3
10.0 ± 0.1	2.4 ± 0.3

6	Measure the corresponding power supply voltage and subtract the T and R voltage (V_{TR}) from the power supply voltage (V_{PS}).
7	The difference voltage (V_{PS}-V_{TR}) should be as specified in Table C.
8	Reverse connections shown in Step 2 to T and R jacks of PORT A and repeat Steps 4 through 7.
9	Release HOLD ON PORT A pushbutton and disconnect test setup.

C. 27F Receiver

3.09 The 27F receiver detector null adjustment is as follows.

STEP	PROCEDURE
	Note: SD-1C167-01 will be required for reference in the following steps.
1	Perform Steps 1 through 3 of 3.04.
2	Depress TRANSMIT LEVEL DBM -10 pushbutton.
3	Remove 27F cover for circuit access of CP2 (see 1.14 and Fig. 4 and 5).
4	Connect E7 on CP2 to circuit ground using clip leads.
5	Connect the digital multimeter (H-P 3490A) to terminal E14 on CP2 and adjust multimeter to read dc volts.
6	Adjust variable resistor R67 on CP2 until meter indication is 0.000±0.002 volts.
7	Disconnect multimeter.
8	Connect E19 on CP2 to circuit ground using clip leads.
9	Connect digital multimeter to terminal E12 on CP2.
10	Adjust variable resistor R72 on CP2 until meter indication is 0.000±0.002 volts.
11	Disconnect multimeter.
12	Remove clip leads connecting E7 and E19 to circuit ground and replace cover.

3.10 The 27F receiver P/AR ratio circuit adjustment is as follows.

STEP	PROCEDURE
1	Perform Steps 1 through 3 of 3.04.
2	Depress TRANSMIT LEVEL DBM -10 pushbutton.
3	Depress CHECK P/AR 100 pushbutton and observe digital display.

STEP	PROCEDURE
4	Display indication should be in the range from 90 to 110.
5	Adjust electronic counter (H-P 5245L) to measure time interval using time interval unit (H-P 5262A).
6	Adjust controls on time interval unit as follows: START, STOP TRIGGER LEVELS to +2 START, STOP MULT to 1 MODE function set to COM START SLOPE to "-" STOP SLOPE to "+"
7	Remove 27F cover necessary for circuit access of CP2 (see 1.14 and Fig. 4 and 5).
8	Connect START input of time interval unit between TP15 on CP2 and circuit ground (E38).
9	Adjust variable resistor R85 on CP2 until counter indicates 15.600±0.02 msec.
10	The 27F digital display should indicate a P/AR rating of 100.
11	Disconnect time interval unit.
12	Connect oscilloscope to terminal E8 on CP2 and set time base to 0.2 msec/cm.
13	Place time base generator on oscilloscope in variable mode and vary time base control until the observed waveform appears stationary.
14	The observed waveform should appear similar to Fig. 7C.

3.11 The 27F receiver autoranging and level measurement check is as follows.

STEP	PROCEDURE
1	Perform Steps 1 through 4 of 3.04.
2	Connect T and R jacks of PORT A to attenuator (Daven, VT-795-G or equivalent) input and T and R jacks of PORT B to attenuator output.

STEP	PROCEDURE
3	Set the attenuator controls and the 27F DISPLAY RCV LEVEL DBM pushbutton as indicated in Table D.
4	Verify that the corresponding 27F digital display reading and measurement indicators (LED) are as shown in Table D for each setting.
5	Disconnect the attenuator.

TABLE D

ATTENUATOR SETTING (dB)	27F DISPLAY RCV LEVEL DBM PUSHBUTTON POSITION	27F DIGITAL DISPLAY READOUT	MEASUREMENT INDICATORS (LED)		
			RCV LEVEL OUT OF RANGE	P/AR	DBM
43	OUT	—	ON	ON	OFF
	IN	−41	ON	OFF	ON
40	OUT	100 ± 1	OFF	ON	OFF
	IN	−40 ± 1	OFF	OFF	ON
30	OUT	100 ± 1	OFF	ON	OFF
	IN	−30 ± 1	OFF	OFF	ON
20	OUT	100 ± 1	OFF	ON	OFF
	IN	−20 ± 1	OFF	OFF	ON
10	OUT	100 ± 1	OFF	ON	OFF
	IN	−10 ± 1	OFF	OFF	ON
3	OUT	100 ± 1	OFF	ON	OFF
	IN	−3 ± 1	OFF	OFF	ON
0	OUT	+	ON	ON	OFF
	IN	−2	ON	OFF	ON

4. REFERENCES

4.01 The following references contain additional information.

NUMBER	TITLE
660-440-107	107-Type Test Line for Data Transmission Description
SD-1C167-01	27F P/AR Transmitter/Receiver
CD-1C167-01	27F P/AR Transmitter/Receiver Circuit
801-250-162	J94027-Type P/AR Meter Equipment Design Requirements—Common Systems

WESTERN ELECTRIC COMPANY MODEL KS-20501
RETURN LOSS MEASURING SET
DESCRIPTION AND OPERATION

CONTENTS PAGE

1. GENERAL 1
2. EQUIPMENT DESCRIPTION 1
3. OPERATION 4

1. GENERAL

1.01 This section describes the KS-20501 List 3 and 4 return loss measuring sets (RLMS).

1.02 This section is reissued to include detailed operating and calibration instructions. Due to the extensive revision, arrows ordinarily used to denote changes are not shown.

1.03 More detailed information and circuit descriptions not covered by this section may be found in the instruction manual. Manuals may be purchased from:

Bowmar/ALI, Incorporated
531 Main Street
Acton, Massachusetts 01720

1.04 Defective sets should be returned to the nearest Western Electric Service Center for repair.

2. EQUIPMENT DESCRIPTION

2.01 The KS-20501 RLMS is available in two configurations. The KS-20501 List 3 (Fig. 1) is a portable unit designed to measure either 2-wire or 4-wire return loss and requires 115 volt, 60-Hz power. The KS-20501 List 4, (Fig. 2) is a rack mounted unit for 4-wire return loss measurements only and requires −48 volt battery for operation.

2.02 The KS-20501, List 3 unit measures 8-3/4 inches high, 12 inches wide and 7-5/8 inches deep. With the cover, it weighs approximately 15 pounds. The KS-20501, List 4 unit measures 10 inches high, 11 inches wide, 6-1/4 inches deep and weighs approximately 12 pounds.

2.03 The control functions, except where noted, are identical for both units. The controls and their functions are listed below.

TEST TYPE—Allows selection of three internal filters for measuring return loss in three frequency bands or an external oscillator for measuring the unweighted return loss at a single frequency. The positions are designated ERL (Echo Return Loss for measurements between 560 Hz and 1965 Hz); SRL (Singing Return Loss for measurements between 260 and 500 Hz); SRL-HI (Singing Return Loss—High Frequency for measurements between 2200 Hz and 3400 Hz); and EXT OSC (External Oscillator for using an external signal source between 200 and 15 kHz).

TEST LOCATION—Configures the set for type of circuit being tested (2-wire or 4-wire) and permits compensation for level differences (transmit and receive) and line losses. Positions are: +23 dB, for voice frequency patch bays

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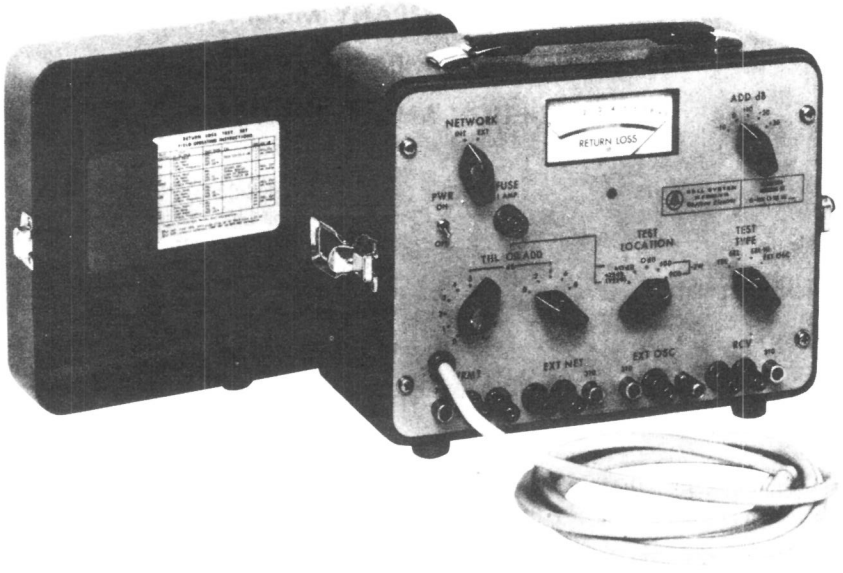

Fig. 1—KS-20501, List 3 Return Loss Measuring Set

(VFPB); +0 dB, for testing 4-wire terminating sets when line loss and transhybrid loss compensation is required; 0 dB, for testing 4-wire circuits when loss compensation is not required (4-type crossbar test frames); 600/900 2-WIRE for measuring return loss on 2-wire circuits with either 600 or 900 ohm impedance. The 2-WIRE positions are ***not*** available on the List 4 model.

NETWORK—This switch is on the List 3 model only and is used in conjunction with the 2-WIRE positions of the TEST LOCATION switch. Allows selection of an internal balance network or the use of an external network while testing 2-wire circuits.

THL OR ADD—Two rotary switches which are used to compensate for up to 10.8 dB of line or transhybrid loss when the TEST LOCATION switch is in the +23 dB or +0 dB positions only.

ADD dB—Five-position rotary switch designated −10, 0, +10, +20, and +30 to allow on-scale meter readings. The switch setting is added to the meter reading for return loss measurements. Negative values indicate return gain.

PWR—Two-position toggle switch for connecting power to the set. Designated ON/OFF.

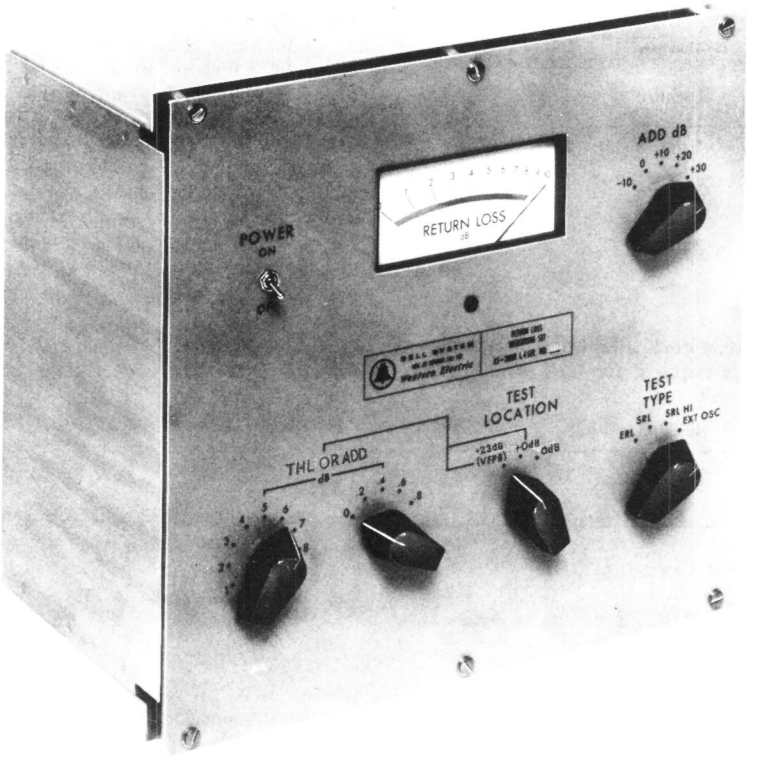

Fig. 2—KS-20501, List 4 Return Loss Measuring Set

2.04 Circuits are connected to the KS-20501, List 3 set for tests through jacks or binding posts on the front panel. The jacks accept 310-type plugs and the binding posts accept General Radio 938-type plugs or equivalent or spade lugs. The jack groups are designated as follows:

TRMT—Output signal for 4-wire tests and the only connection required for 2-wire tests.

RCV—Receives the test signal on 4-wire circuits.

EXT OSC—Used to connect an external signal source for return loss measurements when the TEST TYPE switch is in the EXT OSC position. Input level of the source should be approximately −3 dBm with an impedance of 600 ohms.

EXT NET—Permits substitution of an external network in place of the internal network for 2-wire measurements. NETWORK switch must be in the EXT position.

2.05 All connections to the rack-mounted KS-20501, List 4 RLMS are made via an Amphenol connector on the back panel. The connections serve the same functions as in the List 3 model

except 2-wire functions are not provided. Pin connections are as follows:

Function	Pin Numbers
RCV	1 and 5
TRMT	4 and 8
Ground	6 and 7
−48 volts	2
EXT OSC input	3

2.06 A bay framework adapter assembly per ED-99987 is required for rack mounting the KS-20501, List 4 unit.

3. OPERATION

3.01 Operation of the KS-20501 RLMS is straight forward. Fig. 3 is a block diagram of the List 3 or 4 unit set up for 4-wire measurements. Fig. 4 is a block diagram of the List 3 unit set up for 2-wire measurements. Three procedures are described for return loss tests. The first describes testing 4-wire circuits; the second is for testing 2-wire circuits; and the third is for tests using an external signal source. Procedures for the List 3 and List 4 models are identical. (2-wire tests cannot be made with the List 4 RLMS).

3.02 The procedure for testing 4-wire circuits is as follows:

STEP	PROCEDURE
1	Set PWR switch to ON.
2	Set TEST TYPE switch to desired test (ERL, SRL, SRL-HI, or EXT OSC); for EXT OSC position see procedure in 3.06.
3	Set TEST LOCATION switch to proper position (+23 dB for VFPB; +0 dB for hybrid tests; or 0 dB when testing from 4-type crossbar test frames).
4	Set ADD dB switch to 0.
5	Connect TRMT jack to transmit side of circuit to be tested (see Fig. 5).
6	Connect RCV jack to receive side of circuit to be tested (see Fig. 5).
7	When using the +23 dB or +0 dB position on the TEST LOCATION switch: (a) Short the tip and ring on the 2-wire side of the hybrid. (b) Adjust the THL OR ADD controls for a 0 dB indication on the meter. (c) If a 0 dB indication cannot be obtained in (b), set the ADD dB switch to the −10 position and readjust THL OR ADD controls. Return loss measurements must be reduced by 10 dB for correct readings. (d) Remove short from 2-wire side.
8	Terminate the distant end of the circuit in the proper impedance.
9	Adjust the ADD dB switch for an on-scale meter indication.

STEP	PROCEDURE

10 Read the corrected return loss by adding the meter reading to the ADD dB switch setting.

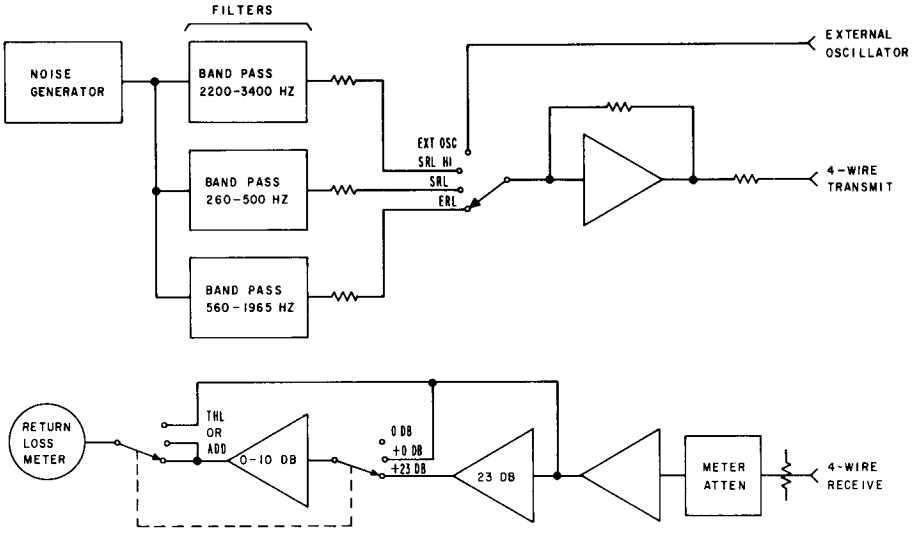

Fig. 3—Block Diagram of KS-20501 List 3 or 4 Setup for 4-Wire Measurements

3.03 This completes the procedures for measuring the return loss on 4-wire circuits. If other tests are required in addition to the original selection in Step 2, select the next test desired and read the return loss as described in Steps 9 and 10.

3.04 The following procedure is used when making 2-wire return loss tests with the KS-20501 List 3 RLMS.

STEP	PROCEDURE
1	Set PWR switch to ON.
2	Set TEST LOCATION switch to 2W/600 or 900 depending on impedance of the circuit being tested.
3	Set TEST TYPE switch to test desired. (ERL, SRL, SRL-HI, or EXT OSC).

STEP	PROCEDURE

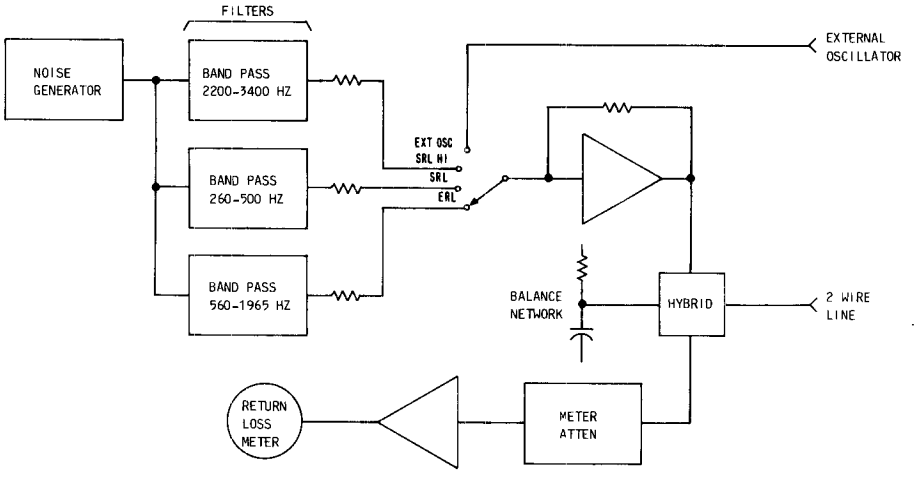

Fig. 4—Block Diagram of the KS-20501 List 3 RLMS Setup for 2-Wire Measurements

Note: If the EXT OSC position is selected, follow procedures in 3.06.

4 Set the NETWORK switch to the INT position to use the internal balance network for measurements. If an external network is to be used set the NETWORK switch to EXT and connect the network to be used to the EXT NET jacks with the appropriate cords.

5 Connect the 2-wire circuit to be tested to the TRMT jacks with the appropriate cord.

6 Adjust the ADD dB switch for an on-scale meter reading.

7 Read the return loss by adding the setting of the ADD dB switch to the meter reading.

3.05 This completes the procedures for 2-wire return loss measurements. If tests other than the one originally selected in Step 3 are required, select the test desired with the TEST TYPE switch and read the result as in Step 7.

3.06 The following procedure is to be used any time an external signal source is used for return loss tests. It is necessary to calibrate the KS-20501 RLMS for the signal source used to prevent inaccurate measurements.

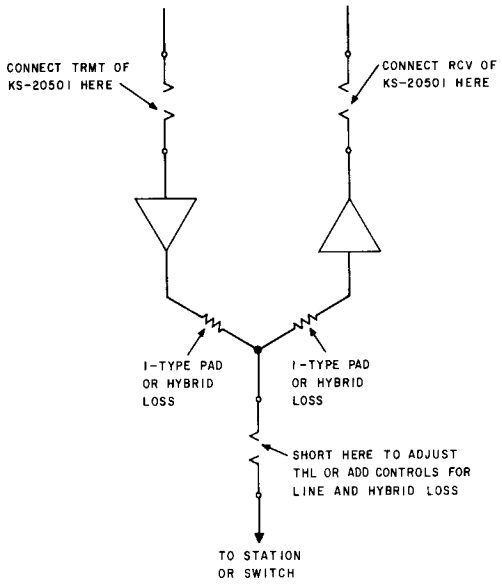

Fig. 5—Test Configuration for 4-Wire Circuits

STEP	PROCEDURE
1	Set PWR switch to ON.
2	Set TEST TYPE switch to EXT OSC.
3	Set ADD dB switch to 0.
4	Go to Step 5 for 4-wire tests; for 2-wire tests, go to Step 10.
5	Set the TEST LOCATION switch to the 0 dB position.
6	Connect the TRMT jack to the RCV jack with the appropriate cord.
7	Connect the external signal source (600 ohm impedance) to the EXT OSC jack with the appropriate cord (approximately −3 dBm level).
8	Adjust the signal source output level for a 0 dB meter indication.
9	The KS-20501 RLMS is now calibrated for 4-wire tests using an external signaling source. Remove the connection between the TRMT and RCV jacks and perform the tests as described in 3.02.

STEP	PROCEDURE
10	Set the NETWORK switch to the INT position or if an external network is to be used, set the switch to EXT and connect the network to the EXT NET jack with the appropriate cord.
11	Set the TEST LOCATION switch to the 600 or 900 position depending on the circuit impedance.
12	Connect the external source to the EXT OSC jacks with the appropriate cords (600-ohm impedance and approximately −3 dBm level).
13	Adjust the external source output level for a 0 dB meter indication.
14	The KS-20501, List 3 RLMS has now been calibrated for 2-wire tests using an external signal source. Perform tests as described in 3.04.

107-TYPE TEST LINE FOR DATA TRANSMISSION MAINTENANCE DESCRIPTION

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1. GENERAL

1.01 This section describes the 107-type test line and its application. Due to present and future demands for data transmission on voice-frequency (VF) circuits, the 107-type test line was developed to obtain an accurate, standard, widely available dial accessed test line for testing VF circuit parameters that affect voiceband data signals. Upon seizure, the 107-type test line transmits a programmed sequence of signals one-way on a far-to-near basis. These test signals permit testing by one person using appropriate test receivers on the near end for measurement of all parameters affecting data transmission. The 107-type test line equipment is shown in Fig. 1. See Table A for the 107-type test line signal specifications.

1.02 This section is reissued to include compatibility with No. 1 ESS and No. 2 ESS switching equipment and addition of a STOP SEQUENCE switch.

1.03 The 107-type test line can be installed in any electromechanical, No. 1 ESS, or No. 2 ESS telephone office and can be used with appropriate receiving equipment to measure the characteristics of a single trunk link, customer loop, etc, on a one-way basis. Measurements may involve a multiplicity of telephone links including several offices, VF paths, and carrier systems. The transmission measurements may be made at access points within the central office or on trunk, loop, and station equipment outside central offices where appropriate test equipment and access are provided.

1.04 The programmed sequence of 107-type test line signals shown in Fig. 2 consists of a peak-to-average ratio (P/AR) signal, 1004-Hz tone, 404-Hz tone, 2804-Hz tone, quiet termination, intermodulation distortion signal, and a long-term 1004-Hz tone. Voice-frequency parameters that can be measured using the 107-type test signal include envelope delay distortion (P/AR), gain slope, noise without tone, return loss, intermodulation distortion, noise (C-notched), impulse noise with tone, phase jitter, gain hits, phase hits, dropouts, and frequency shift. Cross reference of individual

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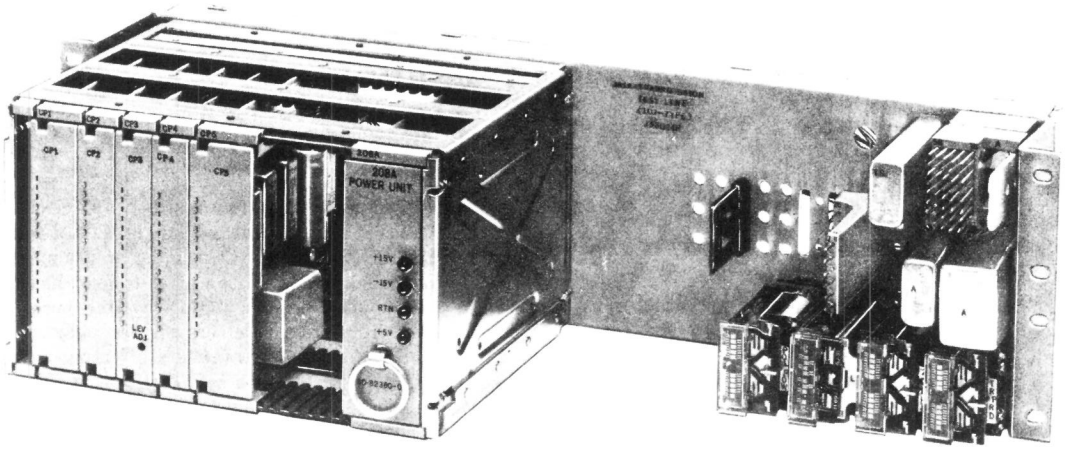


Fig. 1—Typical 107-Type Test Line Equipment

test signals to VF parameters measured is shown in Table B.

1.05 While the primary purpose of the 107-type test line is to test a VF channel for its data handling capability, the test line can also be useful in indicating the general transmission quality of a voiceband channel whether it is to be used for speech or for data.

2. 107-TYPE TEST SIGNAL ACCESS INFORMATION

2.01 In class 5 offices, the 107-type test line is accessed on a Direct Distance Dialing (DDD) basis by dialing an "office" code and station number comprising a total of seven digits or, if the 107 line is to be accessed from another area code, by dialing an "area" code, an "office" code, and a station number comprising a total of ten digits. In class 4 or higher offices, the 107-type test line is accessed by dialing 107 over the trunk to be tested. After a 107-type test line connection has been seized at the far end, the test line will transmit the sequence of test signals shown in Fig. 2 to the near-end office. Test signal transmission may be terminated at any time by the originator returning to the on-hook condition.

2.02 In a typical office (far end) containing a 107-type test line, DDD access from the near-end office is through the test board or test frame as shown in Fig. 3. Appropriate transmission measuring equipment is required on the near end of the 107 test connection for test measurements. In the event transmission measurements are to be made from the near end to the far end and a 107-type test line is available at the near end with none at the far end, a separate line of communication must be established with a person at the far end. The person at the far end makes the appropriate transmission measurements, using the 107 line at the near-end, and relays the results to the near end.

3. 107-TYPE TEST SIGNAL DESCRIPTION

A. P/AR Signal

3.01 On VF transmission paths, the P/AR line signal, composed of a complex series of transmitted pulses, is used to measure the simultaneous effects of envelope delay distortion, bandwidth reduction, and poor return loss (evidenced by gain and phase ripples). These transmission impairments cause intersymbol interference of data signals during transmission. The P/AR test signal is insensitive to steady interferences or impairments on a channel such as harmonic distortion, noise (unless it exceeds current standards), or phase jitter, and is completely unaffected by frequency shift and impulse noise.

TABLE A

107-TYPE TEST LINE CHARACTERISTICS

ACCURACY OF TIME INTERVALS	±1%
LENGTH OF ON-HOOK FLASH	3 sec.
CURRENT DRAIN	0.4 amp from −48 Vdc office battery
OUTPUT LEVELS	−16 dBm (TP0) true rms
	−18 dBm (TP2)
OUTPUT IMPEDANCE	600 or 900 ohms, return loss >40 dB

	P/AR (Hz)	SINUSOIDAL TONES (Hz)	INTERMODULATION DISTORTION TONES (Hz)
Output Frequencies	fn* = (2n − 1) 125 Hz + 15.625 Hz	1004.0, 404.0, 2804.0	856.75, 862.77, 1372.0, 1388.0
Signal Purity. All Harmonics	—	56 dB below fundamental	35 dB below fundamental
Frequency Accuracy	±0.005% of nominal	±0.005% of nominal	±0.005% of nominal
Output Level Adjustment	—	±0.4 dB	—
Output Level Stability	±0.1 dB	±0.03 dB	±0.25 dB
Level Difference Between Tones	—	±0.1 dB	±0.25 dB

* n = 1, 2, ... 16 — (See Section 103-110-110.)

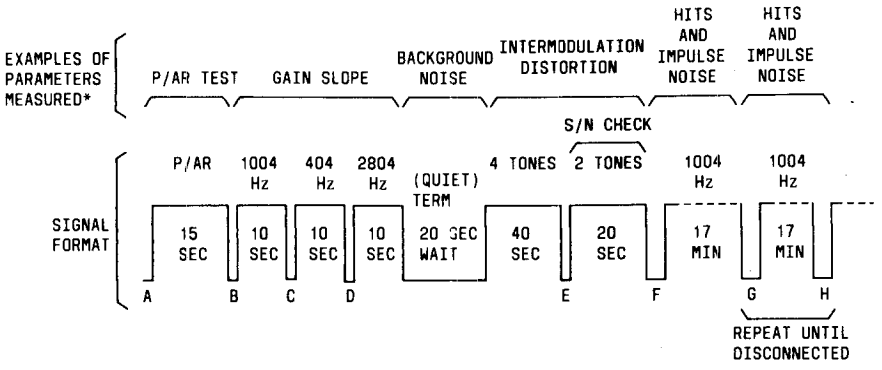
3.02 The P/AR test signal has a known peak-to-full wave average ratio with a value of 10 dB. If the P/AR line signal encounters distortions in the VF path during transmission, the pulses are altered resulting in a different P/AR test signal received. Using the appropriate test receivers for measuring, the known P/AR signal is compared to the received P/AR signal resulting in a percentage ratio relative to the undistorted P/AR test signal. This ratio serves as the basis for the P/AR weighted measurement or rating for channel adaptability to data transmission.

3.03 The envelope delay distortion for a hardwired, looped private line facility tends to remain invariant or change slowly with time. The parameters for envelope delay distortion which the P/AR test signal measures may be used as a benchmark type of measurement when recorded during circuit-order testing for a new circuit. Subsequent P/AR measurements could determine if there were changes in the facilities provided on the circuit.

Note: For further information concerning P/AR signals, see Section 103-110-110.

B. 1004-Hz, 404-Hz, and 2804-Hz Tones

3.04 The sinusoidal test tones of 1004 Hz, 404 Hz, and 2804 Hz permit measurements of harmonic distortion, frequency shift, noise with



* SEE TABLE B FOR COMPLETE BREAKDOWN.

NOTES:
A - 300 MSEC OFF-HOOK WAIT (QUIET) TO ALLOW SINGLE FREQUENCY SIGNALING SYSTEM TO STABILIZE.
B, C, D, E - 1 SEC OFF-HOOK WAIT (QUIET) TO INDICATE WHEN THE TEST SIGNAL HAS CHANGED.
F, G, H - 3 SEC ON-HOOK FOLLOWED BY 300 MSEC OFF-HOOK WAIT FOR SUPERVISION.
ALL TEST SIGNALS ARE TRANSMITTED AT -16 DBM (TP0) LEVEL OR -18 DBM (TP2) LEVEL.

Fig. 2—107-Type Test Line Signal Format

TABLE B

107-TYPE TEST LINE INTERVAL OF TRANSMISSION AND VF MEASUREMENT CAPABILITIES (USING APPROPRIATE RECEIVING EQUIPMENT FOR MEASURING) FOR EACH TEST SIGNAL

TRANSMITTED SIGNAL	INTERVAL OF TRANSMISSION	VF PARAMETER MEASURED
P/AR	15 sec.	Envelope Delay Distortion
1004 Hz	10 sec.	Signal-to-C-Notched Noise, Harmonic Distortion, Frequency Shift, Noise-with-Tone, and Gain Slope
404 Hz	10 sec.	Gain Slope
2804 Hz	10 sec.	Gain Slope
Quiet Termination	20 sec.	Background Noise and Return Loss
4-Tone	40 sec.	Intermodulation Distortion
2-Tone	20 sec.	Signal-to-Noise Check on the Intermodulation Distortion Measurement
On-Hook	3 sec.	Supervisory Test
1004 Hz (Long-Term)	17 min.	Impulse Noise with Tone, Gain Hits, Phase Hits, Dropouts, Phase Jitter, and Harmonic Distortion

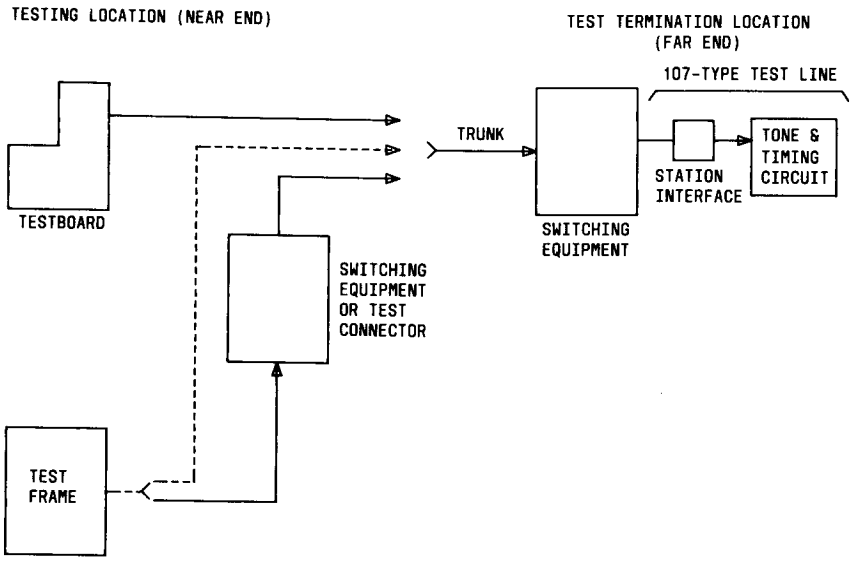


Fig. 3—Arrangement for 107-Type Test Line

tone, gain slope, and signal-to-C-notched noise in excess of 50 dB. All frequencies are offset by 4 Hz to permit accurate level measurements on T1 carrier which uses a sampling rate of 8 kHz. A test tone at any integral submultiple of the 8-kHz sampling rate can cause a relatively small number of harmonically related tones to fall back in the voiceband causing variations, or "beats," in the measured parameters. For example, at 1000 Hz, the level varies or "beats" by ±0.25 dB and the C-notch noise "beats" by ±5 dB.

3.05 Although the 107-type test line basic unit signal level output has been adjusted by the manufacturer at -16 dBm or -18 dBm (depending on the type of office), the output level may be readjusted to compensate for office wiring loss by adjusting the LEV ADJ accessible through the faceplate of CP3.

C. 20-Second Quiet Termination

3.06 The 20-second quiet termination permits measurement of background noise or return loss. During the 20-second quiet interval, the test line output impedance of 600 or 900 ohms is modified by reducing the series capacitance to 2.16 μF which gives the standard compromise network termination for return loss measurements.

D. 4-Tone Intermodulation Distortion Test Signal

3.07 The 4-tone intermodulation distortion test signal permits measurement of intermodulation distortion, sometimes referred to as harmonic distortion, or nonlinear distortion. The intermodulation distortion of concern is distortion within an individual voice channel. It should not be confused with the intermodulation noise which crosstalks into the channel as a result of nonlinearities in multiplex equipment and line amplifiers of a frequency division multiplex system. Although these nonlinearities can contribute to nonlinear distortion, at voice frequencies their contribution is usually negligible.

3.08 The 4-tone method uses two sets of tones, all of which have the same amplitude. One set of tones consists of frequencies at 857 and 863 Hz (a 6-Hz spacing). The second set of tones consists of frequencies of 1372 and 1388 Hz (a 16-Hz spacing). The power level of the combined tones is a nominal -16 dBm0. Intermodulation products of these tones will be created within a nonlinear voice channel. The resulting intermodulation

distortion is determined by measuring the second- and third-order intermodulation products using narrow-band filters in a receiver.

E. 2-Tone Signal-to-Noise (S/N) Check

3.09 The 40-second transmission of the 4-tone test signal is followed by a 20-second transmission of 1372-Hz and 1388-Hz test tones to check the contribution of noise to the 4-tone intermodulation distortion measurement. These two test tones are the same high-frequency tones used in the 4-tone transmission test. In order to keep compandors or quantizers in the facilities at the same operating point, the two test tones are transmitted at a 3-dB higher level. As a result, the only power in the narrow-band second- and third-order intermodulation distortion slots will be due to background noise.

F. Long-Term 1004-Hz Tone Interval

3.10 The long-term 1004-Hz tone interval of 17 minutes allows enough time to perform the standard 15-minute impulse noise measurement. The 17-minute interval also permits a reasonable setup time in order to perform simultaneous measurements of gain and phase hits and impulse noise. Impulse noise, gain hit, or phase hit measurement consists of counting the number of hits exceeding predetermined thresholds during a predetermined time interval. Because of the sporadic nature of these phenomena, relatively long time periods are required for measurement.

4. CONTINUOUS OUTPUT OF INDIVIDUAL 107-TYPE TEST SIGNAL MODE

4.01 The 107-type test line has incorporated into CP1 a manually operated internal switch with positions STOP and GO. The function of the switch in the STOP position is to halt the 107 test signal sequence in any mode, supplying a continuous output of any one of the test signals for troubleshooting purposes or for a concentrated study of the mode selected.

4.02 In addition to the STOP switch, a STOP SEQUENCE switch also has been provided. The STOP SEQUENCE switch locks the 107 test signal in any mode of operation in its automatic sequence. This is an improved means of stopping the tone generator. Previously, to lock the test signal in one of the modes of operation, a short had to be placed between terminals 53 (SEQ 1) and 54 (SEQ 2). This shorting procedure is now rated MD and replaced by the STOP SEQUENCE switch.

CAUTION: The 107 test signal should not be left locked in a continuous mode of operation when the preceding tests are completed. It is important to remember to return the STOP switch to the GO position or to return the STOP SEQUENCE switch to normal operation. This is because the 107-type test line cannot be accessed properly if left in the continuous mode of operation after the original seizure has been terminated.

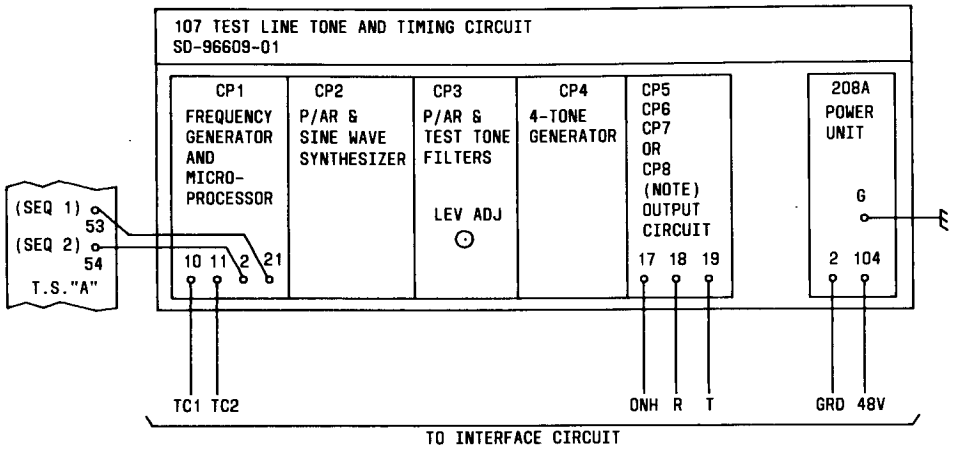
5. EQUIPMENT DESCRIPTION

5.01 The equipment for a 107-type data transmission test line basic unit consists of plug-in circuit packs of which five constitute the tone-generating and tone-sequencing circuitry and one, a dc-to-dc power converter. (See Fig. 1.) The basic unit is 10 inches wide and 6 inches high. It is arranged to be mounted on a 23-inch miscellaneous relay rack. Space is available on the 23-inch rack to accommodate additional interface circuitry. The basic unit and additional interface circuitry make up the functional circuitry required to place the 107 test signal "on-line." Signal level adjustment of sinusoidal tones may be made through holes in the faceplate of CP3 which allow screwdriver access.

6. GENERAL DESCRIPTION OF OPERATION

6.01 The tone and timing circuit is made up of the six circuit packs shown in Fig. 4, including the power supply. Start of the 107-type test line signal is through leads TC1 and TC2 (CP1) of the tone and timing circuit as shown in Fig. 5. The heart of the tone and timing circuit is a 4-bit microprocessor system located in CP1. The microprocessor, together with crystal oscillator clocks, performs all the timing and tone control functions.

6.02 The train of clock pulses from CP1 is applied to the P/AR and sine-wave synthesizers on CP2. The P/AR line signal and sinusoidal tones are synthesized digitally from encoded quantized amplitude samples of the desired signals in read-only memory (ROM) devices. The analog signal is



NOTE:

CP NO. & REF	OUTPUT LEVEL	OUTPUT IMPEDANCE
CP5-REF. J93024H, LIST 18	-16 dBm0	600
CP6-REF. J93024H, LIST 17	-18 dBm0	600
CP7-REF. J93024H, LIST 16	-16 dBm0	900
CP8-REF. J93024H, LIST 15	-18 dBm0	900

Fig. 4—107-Type Test Line Basic Unit

recovered from the digital information by sequentially scanning the ROM with a signal from the crystal-controlled memory address counters and then converting these digital samples to analog voltages in the digital-to-analog (D/A) converter.

6.03 The output of the D/A converter is a quantized representation of the desired signal. This analog signal is fed to the P/AR and test tone filters (CP3). These filters are low-pass reconstruction filters which reduce the level of unwanted sidebands produced by the harmonics of the memory scanning frequency. The filtered P/AR signal is applied directly to the output circuit pack (CP5, CP6, CP7, or CP8). The filtered sine wave is applied to the output circuit pack through a switching relay in the 4-tone generator (CP4).

6.04 Circuit pack CP4 provides a test signal for making intermodulation (nonlinear) distortion measurements. The test signal consisting of four tones is generated from crystal oscillators in pairs (high- and low-frequency pairs). The two pairs of tones are added together in the output circuit. For a signal-to-noise (S/N) check (2-tone transmission), an inverter disables the low-frequency pair of tones and operates a transistor switch which causes the output amplifier to increase the level of the high-frequency pair by 3 dB. The output is fed to the output circuit pack (CP5, CP6, CP7, or CP8). When the 2-tone or high-frequency pair is transmitted, it has the same power as the 4-tone signal.

6.05 The four output circuit packs (CP5, CP6, CP7, and CP8) shown in Fig. 4 have identical characteristics except for the output impedance (600 or 900 ohms) and output level (-16 dBm or -18 dBm). The output impedance and output level are selected depending on the type of central office in which the 107-type test line is to be located. Supervisory on-hook information and a tip (T) and ring (R) balanced signal output are also provided by the output circuit.

6.06 The 208A power unit converts the -48 Vdc office battery to ±15 Vdc and +5 Vdc to supply power to the circuit packs.

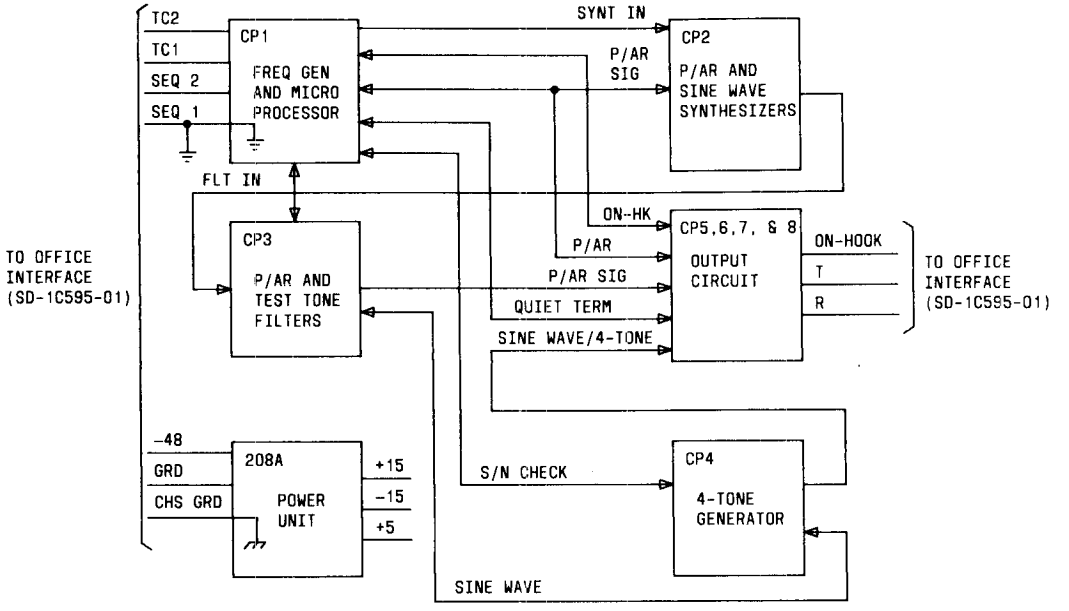


Fig. 5—107-Type Test Line Tone and Timing Circuit Block Diagram

6.07 The tone and timing circuit is compatible with all electromechanical switching equipment and with some electronic switching systems. The test line tone and timing circuit can be used with the following terminations.

- Step-by-Step Tandem Completion, 900 ohms, TP0 or TP2
- Crossbar Tandem Completion, 900 ohms, TP0 or TP2
- Step-by-Step Toll Completion, 600 ohms, TP0 or TP2
- Crossbar No. 5 (2-Wire) Tandem Completion, 900 ohms, TP0 or TP2
- Crossbar No. 5 (2-Wire) Toll Completion, 600 ohms, TP0 or TP2
- Crossbar No. 5 (4-Wire) Toll Completion, 600 ohms, TP0 or TP2
- Crossbar No. 4A or 4M (4-Wire) Toll Completion, 600 ohms, TP0 or TP2
- Crossbar No. 5 (4-Wire) Local Completion, 600 ohms, TP0 or TP2

- Panel Local Completion Battery Cutoff (BOC) Intermediate or First Line, 900 ohms, TP0 or TP2
- Panel Local Completion (BCO) Single or Last Line, 900 ohms, TP0 or TP2
- Panel Local Completion Ground Cutoff (GCO) Intermediate or First Line, 900 ohms, TP0 or TP2
- Panel Local Completion (GCO) Single or Last Line, 900 ohms, TP0 or TP2
- Non-PBX Step-by-Step Local Completion, 900 ohms, TP0 or TP2
- Crossbar No. 5 (2-Wire) Local Completion, 900 ohms, TP0 or TP2
- Crossbar No. 1 Local Completion, 900 ohms, TP0 or TP2
- ESS No. 1 (2-Wire), 900 ohms, TP0 or TP2
- ESS No. 2 (2-Wire), 900 ohms, TP0 or TP2
- ESS No. 1 (4-Wire), HILO (4-Wire), 600 ohms, TP0 or TP2.

7. INTERFACE CIRCUITRY

7.01 Interface circuits providing switch access to the 107-type test line are available for all classes and types of electromechanical offices (see SD-1C595-01).

7.02 Information concerning interface circuits may be found in Section 801-250-168. This section contains, in addition to ordering information, data regarding office impedance, transmission levels, etc, for various types and classes of central offices.

8. REFERENCES

8.01 The following references contain additional information.

NUMBER	TITLE
103-110-110	J94027A, C, and E P/AR Meter Generators and J94027B P/AR Meter Receiver Description, Operation, and Maintenance
801-250-168	Equipment Design Requirements
SD-1C595-01	Common Systems—107-Type Test Line Circuit
SD-96609-01	Common Systems—Transmission Measuring Data Transmission Test Line (107-Type) Tone and Timing Circuit
314-410-500	Voice Bandwidth Private Line Data Circuits Tests and Requirements
314-205-500	Data Systems—DATAPHONE® Service and Data Access Arrangements on Direct Distance Dialing Network—Overall Data Transmission Test Requirements

NOTES

178A TEST SET

DESCRIPTION AND OPERATION

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1. GENERAL

1.01 This section covers the description and operation of the 178A test set. The 178A is a portable test set designed for use in DATAPHONE® Select-A-Station service. The overall system and service description is covered in Section 314-410-550.

1.02 Whenever this section is reissued, the reason for reissue will be given in this paragraph.

1.03 The 178A test set is designed to functionally test the system in response to a trouble report or to perform preservice testing prior to turning up the system for service. The test set can functionally test the four options of data station selectors (DSSs) used in the two service offerings and any of the allowed tandem arrangements of primary and secondary DSSs. This portable test set can be used at the various work locations such as the central office DSS location or the test center.

A. Service Characteristics

1.04 There are two service offerings and three DSS options available as follows:

(a) Sequential Offering

- Auto-step DSS option
- Auto-step DSS option with reset
- Controlled-step DSS option

(b) Addressable Offering.

In the sequential offering the connection sequence to remote stations is determined by the customer and specified on the service order (SO). Limited control over the order of connections is provided only with the auto-step DSS option with reset. The addressable offering provides message codes that allow for varying the order of station selection and connection time on an in-service basis.

1.05 Tandem connection of DSSs is permitted in the controlled-step DSS option of the sequential offering and in the addressable offering. This type of connection enables a large geographic concentration of remote stations to be served economically. Two DSSs, denoted as a primary and a secondary, may

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be connected in tandem. The number of secondary DSSs that can connect to a primary DSS is limited only by the number of output ports on the primary. The maximum number of ports available is 128 in the sequential offering and 125 in the addressable offering.

2. PHYSICAL DESCRIPTION

2.01 The 178A test set, Fig. 1, is contained in a portable carrying case and can be operated in an upright or horizontal position. The cover is used to hold and store the accessory cords. The test set cover is hinged and may be removed for convenience.

2.02 The test set in the carrying case is approximately 17 inches wide, 13 inches high, 7 inches deep and weighs approximately 22 pounds.

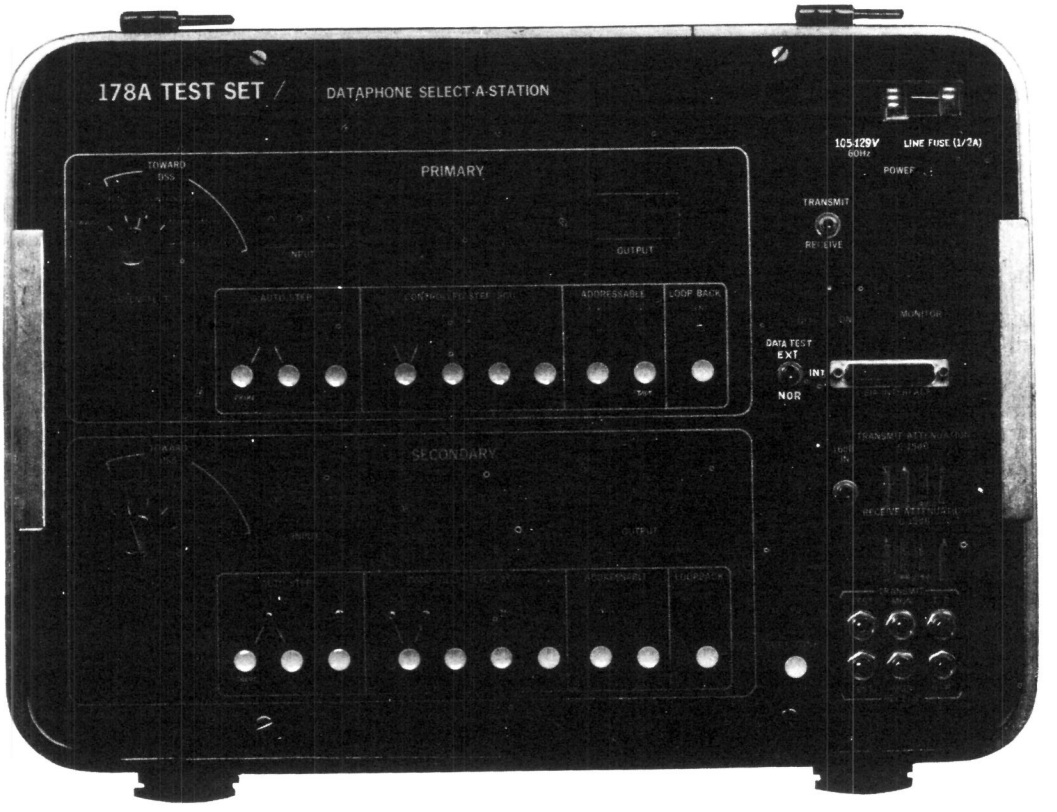

Fig. 1—178A Test Set-Front Panel View

Front Panel Controls and Displays

2.03 The test set controls are divided into two sections, PRIMARY and SECONDARY. A primary DSS is tested by the primary section and a secondary DSS is tested by the secondary section. The selector control unit (SCU) at the master station is tested using both the primary and secondary sections. Each section on the front panel contains the following controls:

- A rotary switch used to select the type of system
- A 3-digit thumb-wheel switch used to control the decimal point location or enter port addresses
- A 3-digit display for indicating test results
- Numerous pushbuttons to start various tests
- Light emitting diodes (LEDs) to display results of various tests.

Note: The TEST TONE pushbutton and LED are used in conjunction with testing both primary and secondary DSSs. Therefore, they are located outside the sectioned portions on the front panel.

2.04 The various pushbuttons and LEDs used in testing a particular type of DSS (either primary or secondary) are found within the same sectional area.

2.05 The 178A test set is powered from a 110 Vac source (usually a wall outlet). A 1/2-amp fuse is contained in the input POWER receptacle. The ON-OFF switch is a pushbutton (labeled POWER) that is lighted when power is applied and the button is depressed. The test set has a built-in LED test that is made each time power is applied to the set. During each initial application of power, all 15 LEDs and the display indicators light for a brief period and then turn off.

Loudspeaker

2.06 A loudspeaker is provided to monitor the signals into and out of the test set circuits. A toggle switch is provided to select the transmit or receive sides and an ON-OFF volume control is provided. If external transmission test equipment is plugged into the TEST jacks, the 178A test set circuits, including the loudspeaker, are isolated from the line.

3. FUNCTIONAL DESCRIPTION

3.01 The test set is designed to interface with a 4-wire circuit at an analog signal level. This will normally be, but is not restricted to, the primary link at test jacks available on the DSS or at a testboard. Two coil patch cords, equipped with 310-type plugs at each end, are supplied with the set. These cords have a usable length of 12 feet and plug into the T/R jacks located on the lower right corner of the front panel.

Note: Tip-sleeve type plugs must not be used since they have a larger diameter and will cause the jacks to fail mechanically.

3.02 Six jacks are located on the lower right corner of the set. Three jacks are on the TRANSMIT side and three are on the RECEIVE side. The transmit jack labeled T/R is used to connect the set to a circuit for sending signals from the test set. The receive T/R jack is used to connect the set to a circuit for receiving signals from a circuit. The various 4-wire circuit access points for the 178A test set are shown in Fig. 2. This figure also shows the expected 1004-Hz levels at these access points.

3.03 After the 178A test set has been connected to a circuit or DSS, other transmission test equipment can be connected and used to perform transmission tests. The TEST and MON jacks on the transmit and receive side are provided for connecting transmission test equipment to the network. Whenever the TRANSMIT TEST or RECEIVE TEST jacks are used, the connection from the circuit to the 178A test set is broken and the transmission test equipment has full access to the circuit. The MON jacks are used to permit test equipment to bridge onto the tip and ring leads of each circuit pair. Bridging should only be made on a high impedance basis.

3.04 Figure 2 shows the 178A test set can connect directly to a DSS using the DSS IN and DSS OUT jacks on the RL5 circuit pack. The test set can also connect to the primary circuit at a test center that has access. Test access to the selector control unit (SCU) at the master station is made using the TRANS TST and RCV TST jacks on data auxiliary set (DAS) 829-type L1A.

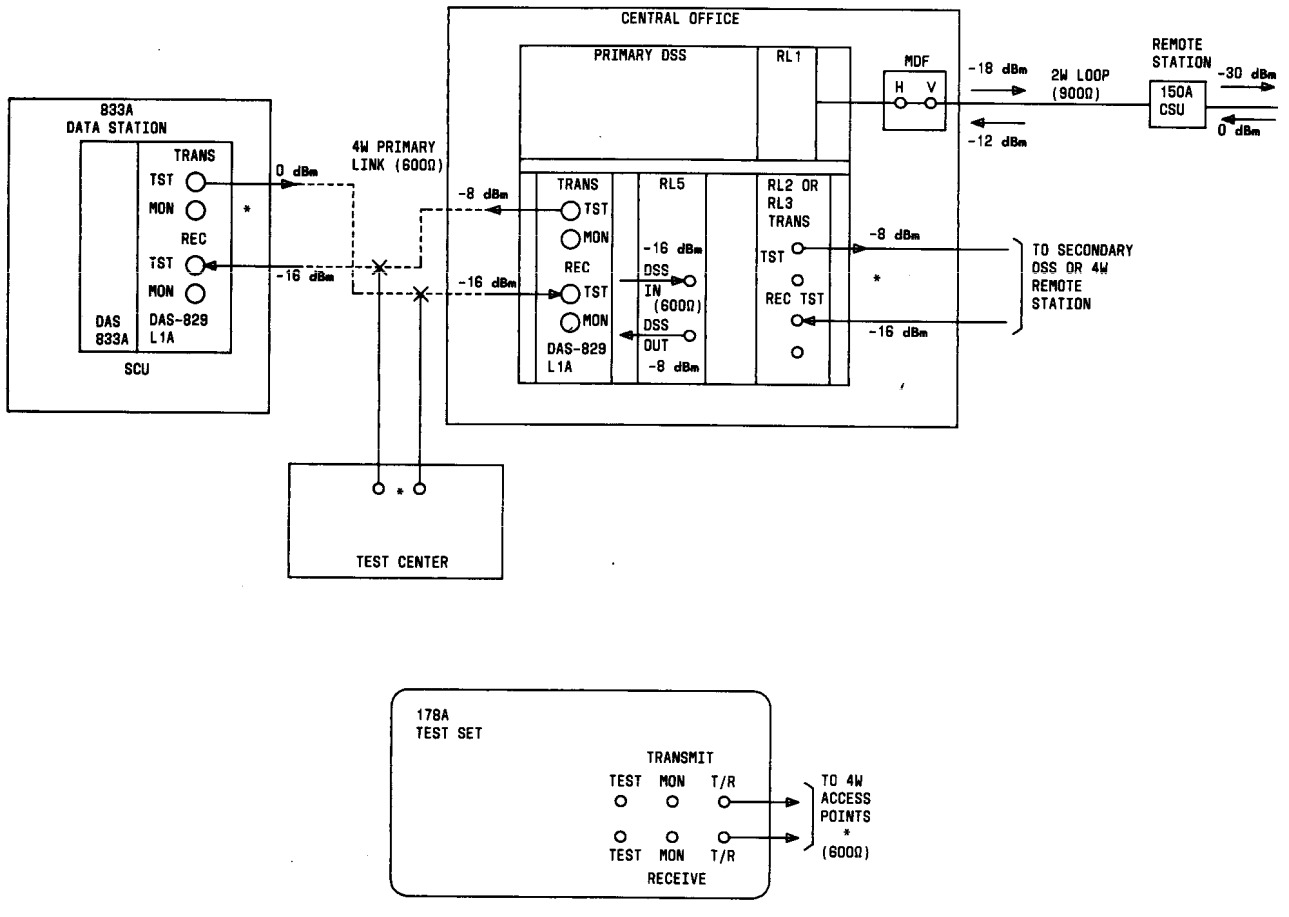

Fig. 2—Diagram Showing Test Access Points for 178A and Expected 1004-Hz Levels

Signal Level Adjustment

3.05 A set of attenuators is provided in the test set for both the receive and transmit circuit pairs. These attenuators provide signal level adjustment capability for the range of the test set. The transmit attenuator is made up of a fixed 16-dB attenuator controlled by a toggle switch and a 15-dB attenuator variable from 0 to 15 dB in steps of 1 dB. The total range of this attenuator is from 0 to 31 dB. With the toggle switch set to the 16-dB OUT position and all the slide switches set so that the number under each slide cannot be seen, the test set transmits a signal at a level of 0 dBm. For an application requiring a lower level, the transmit attenuator toggle switch and pad are set accordingly.

3.06 The receive attenuator consists of an attenuator pad variable from 0 to 15 dB in steps of 1 dB. The test set requires a receive level of -16 dBm. Any receive level greater than -16 dBm must be padded down using the receive attenuator pad.

> ***Note:*** Signal levels below -16 dBm are not provided at the standard access points in the DSS or SCU for normal operation when all equipment and circuits are properly aligned and working.

Electronic Industries Association (EIA) Interface Connector

3.07 An EIA interface connector is provided for connecting an external data test set, such as a 914-type DTS or 921A DTS, for use in making data tests. This connector will normally be used for tests from a test center to either the SCU or DSS when the addressable offering of the service is used. The adjacent toggle switch is called the DATA TEST switch. This switch has three operating positions labeled EXT, INT, and NOR which designate the external, internal, and normal switch positions, respectively. When the switch is in the EXT position, the receive data (BB) and the send data (BA) leads of the test sets internal data set 202T are brought out to the EIA connector. This provides an access point for a data test set such as the 914-type or 921A to the transmitted data signals on the circuit. When the switch is in the INT position, a data test on an addressable system can be made. This test is described in 6.21 of this section. When the switch is in the NOR position, the BB and the BA leads of the test sets internal data set 202T are connected to appropriate internal control circuits.

4. INITIAL SETUP

4.01 After the test set has been connected to a circuit, the receive and transmit attenuators are then set to their proper levels. The SYSTEM TEST switch is set to the appropriate test position on both the PRIMARY and SECONDARY sides of the front panel.

> ***Note:*** If only a primary DSS is to be tested, the secondary system test switch can be on any position. For addressable testing, both primary and secondary system test switches must be in the same position even if only a primary DSS is tested.

4.02 If a functional test of the SCU is to be performed, place both the primary and secondary SYSTEM TEST switches in the TOWARD SCU position. If a DSS or DSSs are to be tested, place the primary switch in the position that describes the primary DSS mode, and place the secondary switch in the position that describes the secondary DSS mode.

> ***Note:*** The ADDRESSABLE-1 position is used for an addressable system with the single character addressing option, and the ADDRESSABLE-2 position is used for an addressable system with the double character addressing option (error control option).

5. DESCRIPTION OF TESTS TOWARD THE SELECTOR CONTROL UNIT (SCU)

A. Testing Toward The SCU

5.01 The tests toward the SCU given in this part are usually made at the DSS or test center location. The procedures for making a more complete interface and functional test at the SCU are given in Section 598-083-106—TOP using the 914-type data test set.

Functional Test of SCU

5.02 The 178A test set can functionally test the tone receivers and tone generators in the

SCU. The buttons and LEDs that are used are located in the CONTROLLED STEP/SCU section of both the PRIMARY and SECONDARY sections on the front panel. First, an attendant at the master station must manually place the SCU in the functional test mode by depressing the FT switch on the DAS 833A of the SCU to be tested. Then, at the 178A test set, set the SYSTEM TEST switch on the PRIMARY and SECONDARY sections to the TOWARD SCU position. A primary tone (2975-Hz) is sent toward the SCU by depressing and holding the primary MANUAL STEP button on the test set. In response, the SCU will send back a secondary tone (2800-Hz) causing the secondary FT LED to light. When the MANUAL STEP button is released, the secondary FT LED will go off. Similarly, a secondary tone is sent toward the SCU by depressing and holding the secondary MANUAL STEP button. In response, the SCU will send back a primary tone, causing the primary FT LED to light. When the MANUAL STEP button is released, the primary FT LED will go off. At the completion of the test, the attendant at the master station must release the FT switch on the DAS 833A to return the SCU to the normal operating mode.

B. Channel Loopback Test

5.03 Another test that can be performed in conjunction with the SCU is a channel loopback test. The attendant at the master station is instructed to manually enable the channel loopback mode by depressing the LB switch on the DAS 833A of the SCU. A test tone can be transmitted from the 178A test set by depressing and holding the TEST TONE TRANSMIT button located on the lower right-hand corner. This tone is looped around by the DAS 829-type L1A in the SCU and is received at the 178A test set causing the TEST TONE RECEIVED LED to light. When the TEST TONE TRANSMIT button is released, the TEST TONE RECEIVED LED will go off. To restore the SCU to the normal operating mode, the attendant at the master station must release the LB switch on the DAS 833A. To verify that this has been done, again depress and hold the TEST TONE TRANSMIT button on the 178A test set. The TEST TONE RECEIVED LED will not light if loopback has been released.

Further transmission tests toward the SCU using transmission test sets can be used when the channel is looped back. These tests typically are used to verify benchmark readings of 1004-Hz loss, frequency response, and envelope delay distortion (EDD). These test sets can gain access to the circuit through the 178A test set jacks as given in 3.03.

6. DESCRIPTION OF TESTS TOWARD DATA STATION SELECTOR (DSS)

6.01 The tests toward the DSS in this part are usually made at the test center location. The more detailed test procedures are given in Section 666-617-101—TOP. The test procedures are also given in Section 590-105-101—TOP when tests are to be made at the DSS location.

A. Auto-Step DSS Option

6.02 A DSS operating with the auto-step option cycles through its port assignments without any control from the SCU at the master station. There are two appropriate operating parameters set at initial installation of the DSS. These are the number of ports per cycle and the connection time per port. A frame tone is transmitted by the DSS at the beginning of each cycle. Therefore, the tests applicable to this option consist of measuring the time duration of the frame tone and measuring the time interval between successive detections of the frame tone. The first test is called the frame time test while the second test is called the cycle time test. These tests can be performed on both a primary or a secondary DSS.

Frame Time Test

6.03 To perform the frame time test, depress the FRAME TIME button on the appropriate section of the test set. The output display will light showing all zeros and then start counting. There is normally a delay before the display starts counting. This delay is dependent upon the hold time of the system and the number of ports in the cycle. The delay is related to the time required to go through a complete cycle of the ports in the DSS under test. For systems with long hold times and long cycle lengths, this time delay can be

considerable. The waiting period or delay occurs since the FRAME TIME button can be depressed at any time relative to the appearance of the frame tone. To ensure an accurate measurement of the frame tone duration, the first appearance of the frame tone sets the measuring circuit and then the next appearance is measured. This reading on the display can be related to the actual port connect time setting in the DSS using Table A. This table shows, for example, that if the DSS has been optioned to provide a connect time of 100 milliseconds (ms), the display reading would show .129 seconds. When the counting stops, the reading on the 3-digit display is the actual time interval of the frame tone less the detection time.

TABLE A

FRAME TIME INTERVAL READING IN SECONDS	HOLD TIME OPTION (Ms)	FRAME TIME INTERVAL READING IN SECONDS	HOLD TIME OPTION (Ms)
		.879	600
.009	20	.939	640
.024	30	1.18	800
.039	40	1.42	960
.054	50	1.66	1120
.069	60	1.90	1280
.084	70	2.14	1440
.099	80	2.38	1600
.114	90	2.62	1760
.129	100	2.86	1920
.144	110	3.10	2080
.159	120	3.34	2240
.174	130	3.58	2400
.189	140	3.82	2560
.204	150	4.76	3200
.219	160	5.20	3480
.279	200	6.70	4480
.339	240	7.66	5120
.399	280	8.62	5760
.459	320	9.58	6400
.519	360	10.5	7040
.579	400	11.5	7680
.639	440	12.4	8320
.699	480	13.4	8960
.759	520	14.4	9600
.819	560	15.3	10240

6.04 If the count exceeds the capacity of the interval counter, the OVERFLOW LED will light. For example, if the input thumb-wheel switch is set to 000 allowing readings up to 0.999 seconds and the OVERFLOW LED lights, the overflow condition will cause the display to go blank. If this occurs, set the thumb-wheel switches to 001, 002, or 003. Each increment causes the decimal point to move one position to the right. In the setting of 003, the decimal point disappears allowing readings up to 999 seconds. The setting of 003 should only be required in the cycle time test.

Cycle Time Test

6.05 This test measures the ports per cycle or time for one complete cycle of the DSS, including the two frame ports. The INPUT thumb-wheel switches should be set between 000 and 003, depending upon the expected time interval result indicated in Table B. If the DSS is optioned for a long connect time and has a large number of ports, the cycle time can exceed 999 seconds. If this occurs, the OVERFLOW LED will light but the count will not stop until the interval of 1999 seconds is exceeded. For cycle time intervals greater than 999 seconds but less than 1999 seconds, the OVERFLOW LED will light and the 3-digit display will indicate the least three significant figures of the measured time interval. For example, if the number of seconds expected is 1200, the INPUT thumb-wheel switches would be set to 003. The display will indicate 200 when the OVERFLOW LED lights. As expected, time intervals in excess of 1999 seconds will cause the display to go blank when the OVERFLOW condition is reached.

6.06 To perform the cycle time test, the CYCLE TIME button on the test set is depressed. The output display will light with all zeros and then start counting. When the counting on the display indicator stops, observe and record the OUTPUT DISPLAY reading; then, locate and compare this reading and the Hold Time Option of the DSS with Table B. Locate the ports per cycle of the DSS by moving to the far left Ports Per Cycle column of Table B on the same horizontal line as the Cycle Time in Seconds reading. For example, the connect time (Hold time option) per port of the DSS is 240 ms and the Output Display of Cycle Time in Seconds reading is 21.6 seconds.

On Table B locate the Hold Time of 240 ms at the top portion of the table, then drop down on the same vertical column under 240 ms to the display reading of 21.6 seconds. Now move to the far left Ports Per Cycle column on the same horizontal line as the reading of 21.6 seconds. The result should be 88 ports per cycle and agree with the service record on that particular DSS.

> ***Note:*** As in the frame time test, the time before the display begins counting will vary depending on the hold time of the system and number of ports in the polling cycle. For systems with long hold times and long cycle lengths, the waiting period could be several minutes. If the CYCLE TIME button is depressed just after the DSS has moved off the frame port, an entire polling cycle must be completed before the frame tone reappears.

B. Auto-Step DSS Option With Reset

Frame Time and Cycle Time Test

6.07 If the DSS is equipped with the automatic step with reset option, the waiting time for the previous two tests can be shortened before the display begins counting. The reset option allows the DSS to be remotely returned to the frame port. After the FRAME TIME or CYCLE TIME button is depressed, the RESET OPTION button is depressed. This action causes the cycle to reset to the frame port and the FRAME LED will light. If the display is still not counting, wait until the FRAME LED goes off, then depress the RESET OPTION button again. The display will start counting if the DSS is operating properly.

C. Controlled-Step DSS Option

6.08 In the controlled-step option mode, the DSS steps from one port to another in a fixed sequence controlled by the SCU in the master station. In the following tests, the 178A test set replaces the master station and the SCU, and controls the DSS. The SYSTEM TEST switch in the appropriate section must be set to the CONTROLLED STEP position for these tests.

Hunt Frame Test

6.09 In this test the 178A test set transmits a tone burst to the DSS and waits for a time duration of 110 ms. Within that period, the 178A test set expects to receive a frame tone from the DSS. If the 178A test set does not detect a frame tone, another tone burst is transmitted followed by an additional waiting time of 110 ms. If the 178A test set detects the frame tone (on two successive ports), the FRAME LED will light indicating a successful completion of the hunt frame test. If the frame port is not found (frame tone is not detected), the test set will continue to transmit up to 200 tone bursts to the DSS. If the 178A test set reaches this count without detecting the frame tone, the test fails as indicated by the lighting of the FAIL LED.

> ***Note:*** Detection of the frame port as indicated by the FRAME LED requires frame tone on two successive ports. This differs from the FT LED which lights anytime the frame tone is detected and does not require detection of the frame tone on two successive ports.

6.10 The hunt frame test is made by depressing the HUNT FRAME button on the test set. The OUTPUT display is then lighted and counts as the test progresses. The numbers displayed on the OUTPUT display indicator are used only to indicate that the test is progressing normally. When the test has been completed, either passing or failing, the OUTPUT display indicators are turned off.

Cycle Length Test

6.11 This test verifies that the number of ports in a polling cycle corresponds to the number assigned to the DSS on the service records. The test can only be performed after the frame port has been detected as indicated by the lighting of the FRAME LED on the test set.

6.12 The cycle length test is made by depressing the CYCLE LENGTH button on the test set. This causes the 178A test set to transmit a

series of tone bursts, approximately 110 ms apart, to the DSS. These tone bursts advance the DSS one port at a time until the frame port signal is again detected. During the cycle length test, the OUTPUT display remains lighted and indicates the number of the port as it is polled. The number that is displayed when the frame port is detected indicates the actual number of ports in the cycle. However, it does not include the two frame ports.

MANUAL STEP Button

6.13 The MANUAL STEP button provides the means to advance or step the DSS one port at a time. This feature can be used to manually step the DSS through all the assigned ports from the test set location. It also provides the capability to stop on one or more specific ports for an extended period of time.

START Button

6.14 Another feature in the controlled-step portion of the 178A test set is provided by the START button. This feature is used whenever a particular port address on the DSS is required at the test set. The process of providing this specific address is begun by first entering the port number on the INPUT thumb-wheel switches. The START button is then depressed. The 178A test set will transmit a series of tone bursts to the DSS, approximately 110 ms apart, and stop when the port number as designated on the INPUT thumb-wheel switches is accessed. The OUTPUT display will count as the DSS cycles through the polling sequence and will stop when the test set stops transmitting tone bursts. The port number, as indicated on the OUTPUT display, should be the same number as designated on the INPUT thumb-wheel switches. This procedure can only be performed following a successful hunt frame test.

> ***Note:*** It is not necessary to repeat the hunt frame test each time a specific port address is required.

D. Addressable DSS Offering

6.15 Previous tests have been directed at testing the sequential offering service. In the addressable offering, the DSS ports can be polled or selected in a random sequence. The 178A test set transmits programmed addresses and accesses a specific port on the DSS. This type of DSS operation also features an addressable/auto-step mode of operation. With this type of operation, the DSS can operate in the addressable mode for some time and be placed in the auto-step DSS option mode by sending an appropriate control port address plus output port address from the 178A test set to the DSS.

6.16 To send an address to the DSS in the addressable mode set both SYSTEM TEST switches to the ADDRESSABLE 1 or ADDRESSABLE 2 position, then depress the RELEASE button on the 178A test set. This causes the test set to transmit a tone burst to the DSS and release it from its present port connection. When the DSS is released, an acknowledgement tone is transmitted to the 178A test set and causes the ACK LED to light. This indication confirms that the DSS has been released and the address procedure can continue.

6.17 The decimal address of the desired port must be entered using the INPUT thumb-wheel switches. The START button on the 178A test set is then depressed and the test set sends the desired address. This action also causes the ACK LED to go off which indicates that the DSS is in a connected state.

Special Addresses

6.18 There are a number of special port addresses than can be used in testing the 178A test set. These are listed as follows:

(a) 127—This address causes the DSS to send a 1 kHz test tone. After this address has been transmitted, the TEST TONE RECEIVED LED will light on the 178A test set.

(b) 513—When 513 is entered using the INPUT thumb-wheel switches, the 178A test set will transmit address 126 followed immediately by address 113. This is interpreted by the DSS as the share load command. The DSS will then send back a 2-character status report. (For dualized operation only).

(c) 425—When 425 is entered using the INPUT thumb-wheel switches, the 178A test set will transmit address 126 followed immediately by the address 25. The DSS interprets this as the swap links command. (For dualized operation only).

(d) 414—The 178A test set transmits address 126 followed by address 14. The DSS interprets this as the shut down dual command. The DSS will then send back a 2-character status report. (For dualized operation only).

(e) 502—The 178A test set transmits address 126 followed by address 102. In response, the DSS goes into the digital loopback mode which loops the data signal back toward the 178A test set. An external data test set can be connected to the 178A test set for data performance measurements. The 178A test set can also perform a functional data test as given in 6.21.

(f) 490—The 178A test set transmits address 126 followed by address 90. In response, the DSS sends back a 2-character status report.

(g) 200 to 324—The 178A test set transmits the address 125 followed by the address entered using the INPUT thumb-wheel switches minus 200. The DSS interprets this as a command to go from the addressable mode to the auto-step mode and to start at the address entered minus 200. For example, if the address 225 is entered using the INPUT thumb-wheel switches, the 178A test set will send address 125 followed by address 25.

Display of Status Words

6.19 When the DSS sends back a status report (after receiving 490, 513, or 414), it transmits a 2-character status report. In order to display these two characters with one display, the following method is used. The display on the test set first shows all 8s, goes blank, shows the first character, goes blank, shows the second, goes blank again, and then repeats the cycle. Using this method the two characters are shown in sequence.

6.20 Table C shows the possible first and second words and their meanings. There are several first words that are impossible to obtain unless there is an error in transmission.

Data Test Using the 178A Test Set

6.21 The 178A test set can be used to perform a functional data test with a DSS in the addressable mode. This is only a qualitative test as no measure is made of distortion. The DSS is first conditioned to the digital loopback mode using port address 502. The SYSTEM TEST switches are set to the ADDRESSABLE 1 position and the DATA TEST switch is set to the INT position. Without first depressing the RELEASE button, send any address from 000 to 124 by depressing the START button twice. The OUTPUT display shows all 8s, goes blank, shows the address sent, goes blank, shows the address sent, goes blank, and then repeats the cycle. If the address shown on the OUTPUT display is different from the address sent, an error was made somewhere in the channel or DSS. After the test is completed, the DATA TEST switch must be returned to the NOR position.

E. Channel Loopback Tests

6.22 The DAS 829-type L1A in a DSS can be looped back under certain conditions. An auto-step or auto-step with reset DSS can be looped back at any time. A controlled-step DSS can only be looped back when it is on the frame port. An addressable DSS can only be looped back when it is in the released state. To accomplish loopback once the DSS is properly conditioned, the SEND LOOPBACK button on the test set is depressed momentarily. This will cause a 2713-Hz tone of approximately 5 to 7 seconds to be sent toward the DSS. After the tone has been sent, the LOOPBACK SENT LED will light indicating the loopback tone has been sent.

Note: The lighting of the LOOPBACK SENT LED does not indicate that the DSS is in the loopback mode.

6.23 The DAS 829-type L1A in the DSS receives and detects the loopback tone and goes into the loopback mode ***after*** the tone is removed. To verify that the DSS is in loopback, the TEST TONE TRANSMIT button in the lower right-hand portion of the front panel is depressed and held. A test tone of 1013 Hz is transmitted toward the DSS. If loopback has been achieved, the test tone is looped back and causes the RECEIVED TEST TONE LED to light. The LED will be lighted as long as the TEST TONE TRANSMIT button is held. To release loopback at the DSS, another 2713-Hz, loopback tone is sent by depressing the SEND LOOPBACK button momentarily. To verify that the DSS has released from the loopback mode, depress and hold the TEST TONE TRANSMIT BUTTON. The TEST TONE RECEIVED LED will not light if loopback has been released.

TABLE B
DETERMINATION OF PORTS PER CYCLE FROM CYCLE TIME READING

PORTS PER CYCLE	HOLD TIME OPTION IN MILLISECONDS												
	20	30	40	50	60	70	80	90	100	110	120	130	
8	.20	.30	.40	.50	.60	.70	.80	.90	1.00	1.10	1.20	1.30	OUTPUT DISPLAY CYCLE TIME IN SECONDS
16	.36	.54	.72	.90	1.08	1.26	1.44	1.62	1.80	1.98	2.16	2.34	
24	.520	.780	1.04	1.30	1.56	1.82	2.08	2.34	2.60	2.86	3.12	3.38	
32	.680	1.20	1.36	1.70	2.04	2.38	2.72	3.06	3.40	3.74	4.08	4.42	
40	.840	1.26	1.68	2.10	2.52	2.94	3.36	3.78	4.20	4.62	5.04	5.46	
48	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	
56	1.16	1.74	2.32	2.90	3.48	4.06	4.64	5.22	5.80	6.38	6.96	7.54	
64	1.32	1.98	2.64	3.30	3.96	4.62	5.28	5.94	6.60	7.26	7.92	8.58	
72	1.48	2.22	2.96	3.70	4.44	5.18	5.92	6.66	7.40	8.14	8.88	9.62	
80	1.64	2.46	3.28	4.10	4.92	5.74	6.56	7.38	8.20	9.02	9.84	10.7	
88	1.80	2.70	3.60	4.50	5.40	6.30	7.20	8.10	9.00	9.90	10.8	11.7	
96	1.96	2.94	3.92	4.90	5.88	6.86	7.84	8.82	9.80	10.8	11.8	12.7	
104	2.12	3.18	4.24	5.30	6.36	7.42	8.48	9.54	10.6	11.7	12.7	13.8	
112	2.28	3.42	4.56	5.70	6.84	7.98	9.12	10.3	11.4	12.5	13.7	14.8	
120	2.44	3.66	4.88	6.10	7.32	8.54	9.76	11.0	12.2	13.4	14.6	15.9	
128	2.60	3.90	5.20	6.50	7.80	9.10	10.4	11.7	13.0	14.3	15.6	16.9	

TABLE B (Cont)

PORTS PER CYCLE	HOLD TIME OPTION IN MILLISECONDS										
	140	150	160	200	240	280	320	360	400	440	
8	1.40	1.50	1.60	2.00	2.40	2.80	3.20	3.60	4.00	4.40	OUTPUT DISPLAY CYCLE TIME IN SECONDS
16	2.52	2.70	2.88	3.60	4.32	5.04	5.80	6.50	7.20	8.00	
24	3.64	3.90	4.16	5.20	6.24	7.30	8.32	9.40	10.4	11.4	
32	4.76	5.10	5.44	6.80	8.16	9.52	10.9	12.2	13.6	15.0	
40	5.88	6.30	6.72	8.40	10.1	11.8	13.4	15.1	16.8	18.5	
48	7.00	7.50	8.00	10.0	12.0	14.0	16.0	18.0	20.0	22.0	
56	8.12	8.70	9.28	11.6	13.9	16.2	18.6	21.0	23.2	25.5	
64	9.24	9.90	10.6	13.2	15.8	18.5	21.1	23.8	26.4	29.0	
72	10.4	11.1	11.8	14.8	17.8	20.7	23.7	26.6	29.6	32.6	
80	11.5	12.3	13.1	16.4	19.7	23.0	26.2	29.5	32.8	36.1	
88	12.6	13.5	14.4	18.0	21.6	25.2	29.0	32.4	36.0	39.6	
96	13.7	14.7	15.7	20.0	23.5	27.4	31.4	35.3	39.2	43.1	
104	14.8	15.9	17.0	21.2	25.4	29.7	34.0	38.2	42.4	46.6	
112	16.0	17.1	18.2	23.0	27.4	31.9	36.5	41.0	45.6	50.2	
120	17.1	18.3	20.0	24.4	29.3	34.2	39.0	43.9	48.8	53.7	
128	18.2	19.5	21.0	26.0	31.2	36.4	42.0	46.8	52.0	57.2	

TABLE B (Cont)

PORTS PER CYCLE	HOLD TIME OPTION IN MILLISECONDS																		
	480	520	560	600	640	800	960	1120	1280	1440	1600	1760	1920	2080	2240	2400	2560	3200	
8	4.80	5.20	5.60	6.00	6.40	8.00	9.60	11.2	12.8	14.4	16.0	17.6	19.2	20.8	22.4	24.0	25.6	32.0	
16	8.64	9.40	10.1	11.0	11.5	14.4	17.3	20.2	23.0	25.9	28.8	31.7	34.6	37.4	40.3	43.2	46.1	57.6	
24	12.5	13.5	14.6	15.6	16.6	20.8	25.0	29.1	33.3	37.4	41.6	45.8	50.0	54.1	58.2	62.4	66.6	83.2	OUTPUT DISPLAY
32	16.3	17.7	19.0	20.4	21.8	27.2	32.7	38.1	43.5	49.0	54.4	59.8	65.3	70.7	76.2	81.6	87.0	109	
40	20.2	21.8	23.5	25.2	26.9	33.6	40.3	47.0	53.8	60.5	67.2	73.9	80.6	87.4	94.1	101	108	134	
48	24.0	26.0	28.0	30.0	32.0	40.0	48.8	56.0	64.0	72.0	80.0	88.0	96.0	104	112	120	128	160	
56	27.8	30.2	32.5	34.8	37.1	46.4	55.7	65.0	74.2	83.5	92.8	102	111	120	130	139	148	186	CYCLE TIME IN SECONDS
64	31.7	34.3	37.0	39.6	42.2	52.8	63.4	73.9	84.5	95.0	105	116	126	137	147	158	169	211	
72	35.5	38.5	41.4	44.4	47.4	59.2	71.0	82.9	94.7	106	118	130	142	153	165	177	189	236	
80	39.4	42.7	45.9	49.2	52.5	65.6	78.7	91.8	105	118	131	144	157	170	183	197	210	262	
88	43.2	46.8	50.4	54.0	57.6	72.0	86.4	100	115	130	144	158	172	187	202	216	230	288	
96	47.0	51.0	54.9	58.8	62.7	78.4	94.0	109	125	141	156	172	188	203	219	235	251	314	
104	50.9	55.1	59.4	63.6	67.8	84.8	102	118	135	152	169	186	203	220	237	254	271	339	
112	54.7	59.3	63.8	68.4	73.0	91.2	109	127	145	164	182	200	219	237	255	274	292	365	
120	58.6	63.4	68.3	73.2	78.1	97.6	117	136	156	175	195	214	234	253	273	292	312	390	
128	62.4	67.6	72.8	78.0	83.2	104	125	146	166	187	208	229	250	270	291	312	333	416	

TABLE B (Cont)

PORTS PER CYCLE	HOLD TIME OPTION IN MILLISECONDS											
	3480	4480	5120	5760	6400	7040	7680	8320	8960	9600	10240	
8	34.8	44.8	51.2	57.6	64.0	70.4	76.8	83.2	89.6	96.0	102	OUTPUT DISPLAY
16	62.6	80.6	92.1	103	115	126	138	149	161	172	184	
24	90.5	116	133	149	166	183	199	216	233	249	266	
32	118	152	174	195	217	239	261	283	304	326	348	
40	146	188	215	242	268	295	322	349	376	403	430	
48	174	224	256	288	320	352	384	416	448	480	512	
56	202	259	297	334	371	408	445	482	519	556	593	CYCLE TIME IN SECONDS
64	229	295	338	380	422	464	507	549	591	633	675	
72	257	331	378	426	473	521	568	615	663	710	757	
80	285	367	419	472	524	577	629	682	734	787	839	
88	313	403	461	518	576	633	691	748	806	864	921	
96	341	439	501	564	627	690	752	815	878	941	1003	**OVERFLOW** lamp is on for these times
104	368	474	542	610	678	746	814	882	949	1017	1085	
112	396	510	583	656	729	802	875	948	1021	1094	1167	
120	424	546	624	702	780	858	937	1015	1093	1171	1249	
128	452	582	665	749	332	915	998	1081	1165	1248	1331	

TABLE C
SPECIAL STATUS WORDS FOR ADDRESSABLE OFFERING

WORD 1			WORD 2			
DECIMAL READOUT	HOLD TIME (MS)	SHELF	DECIMAL READOUT	PORTS PER CYCLE	STATUS	SHELF
000*	10	A	000	8	OPNS	A
001	20	A	001	16	OPNS	A
002	30	A	002	24	OPNS	A
003	40	A	003	32	OPNS	A
004	50	A	004	40	OPNS	A
005	60	A	005	48	OPNS	A
006	70	A	006	56	OPNS	A
007	80	A	007	64	OPNS	A
008	90	A	008	72	OPNS	A
009	100	A	009	80	OPNS	A
010	110	A	010	88	OPNS	A
011	120	A	011	96	OPNS	A
012	130	A	012	104	OPNS	A
013	140	A	013	112	OPNS	A
014	150	A	014	120	OPNS	A
015	160	A	015	125	OPNS	A
016*	40	A	016	8	SD	A
017*	80	A	017	16	SD	A
018*	120	A	018	24	SD	A
019*	160	A	019	32	SD	A
020	200	A	020	40	SD	A
021	240	A	021	48	SD	A
022	280	A	022	56	SD	A
023	320	A	023	64	SD	A
024	360	A	024	72	SD	A
025	400	A	025	80	SD	A
026	440	A	026	88	SD	A
027	480	A	027	96	SD	A
028	520	A	028	104	SD	A
029	560	A	029	112	SD	A
030	600	A	030	120	SD	A
031	640	A	031	125	SD	A

* - Invalid Condition
SD - Shut Down
OPNS - Operational, Not Sharing Load
OPSL - Operational, Sharing Load

TABLE C (Cont)

WORD 1			WORD 2			
DECIMAL READOUT	HOLD TIME (MS)	SHELF	DECIMAL READOUT	PORTS PER CYCLE	STATUS	SHELF
032*	160	A	032	8	OPSL	A
033*	320	A	033	16	OPSL	A
034*	480	A	034	24	OPSL	A
035*	640	A	035	32	OPSL	A
036	800	A	036	40	OPSL	A
037	960	A	037	48	OPSL	A
038	1120	A	038	56	OPSL	A
039	1280	A	039	64	OPSL	A
040	1440	A	040	72	OPSL	A
041	1600	A	041	80	OPSL	A
042	1760	A	042	88	OPSL	A
043	1920	A	043	96	OPSL	A
044	2080	A	044	104	OPSL	A
045	2240	A	045	112	OPSL	A
046	2400	A	046	120	OPSL	A
047	2560	A	047	125	OPSL	A
048*	640	A	048*	8	SD	A
049*	1280	A	049*	16	SD	A
050*	1920	A	050*	24	SD	A
051*	2560	A	051*	32	SD	A
052	3200	A	052*	40	SD	A
053	3840	A	053*	48	SD	A
054	4480	A	054*	56	SD	A
055	5120	A	055*	64	SD	A
056	5760	A	056*	72	SD	A
057	6400	A	057*	80	SD	A
058	7040	A	058*	88	SD	A
059	7680	A	059*	96	SD	A
060	8320	A	060*	104	SD	A
061	8960	A	061*	112	SD	A
062	9600	A	062*	120	SD	A
063	10240	A	063*	125	SD	A

* - Invalid Condition
SD - Shut Down
OPNS - Operational, Not Sharing Load
OPSL - Operational, Sharing Load

TABLE C (Cont)

WORD 1			WORD 2			
DECIMAL READOUT	HOLD TIME (MS)	SHELF	DECIMAL READOUT	PORTS PER CYCLE	STATUS	SHELF
064*	10	B	064	8	OPNS	B
065	20	B	065	16	OPNS	B
066	30	B	066	24	OPNS	B
067	40	B	067	32	OPNS	B
068	50	B	068	40	OPNS	B
069	60	B	069	48	OPNS	B
070	70	B	070	56	OPNS	B
071	80	B	071	64	OPNS	B
072	90	B	072	72	OPNS	B
073	100	B	073	80	OPNS	B
074	110	B	074	88	OPNS	B
075	120	B	075	96	OPNS	B
076	130	B	076	104	OPNS	B
077	140	B	077	112	OPNS	B
078	150	B	078	120	OPNS	B
079	160	B	079	125	OPNS	B
080*	40	B	080	8	SD	B
081*	80	B	081	16	SD	B
082*	120	B	082	24	SD	B
083*	160	B	083	32	SD	B
084	200	B	084	40	SD	B
085	240	B	085	48	SD	B
086	280	B	086	56	SD	B
087	320	B	087	64	SD	B
088	360	B	088	72	SD	B
089	400	B	089	80	SD	B
090	440	B	090	88	SD	B
091	480	B	091	96	SD	B
092	520	B	092	104	SD	B
093	560	B	093	112	SD	B
094	600	B	094	120	SD	B
095	640	B	095	125	SD	B

* - Invalid Condition
SD - Shut Down
OPNS - Operational, Not Sharing Load
OPSL - Operational, Sharing Load

TABLE C (Cont)

WORD 1			WORD 2			
DECIMAL READOUT	HOLD TIME (MS)	SHELF	DECIMAL READOUT	PORTS PER CYCLE	STATUS	SHELF
096*	160	B	096	8	OPSL	B
097*	320	B	097	16	OPSL	B
098*	480	B	098	24	OPSL	B
099*	640	B	099	32	OPSL	B
100	800	B	100	40	OPSL	B
101	960	B	101	48	OPSL	B
102	1120	B	102	56	OPSL	B
103	1280	B	103	64	OPSL	B
104	1440	B	104	72	OPSL	B
105	1600	B	105	80	OPSL	B
106	1760	B	106	88	OPSL	B
107	1920	B	107	96	OPSL	B
108	2080	B	108	104	OPSL	B
109	2240	B	109	112	OPSL	B
110	2400	B	110	120	OPSL	B
111	2560	B	111	125	OPSL	B
112*	640	B	112*	8	SD	B
113*	1280	B	113*	16	SD	B
114*	1920	B	114*	24	SD	B
115*	2560	B	115*	32	SD	B
116	3200	B	116*	40	SD	B
117	3840	B	117*	48	SD	B
118	4480	B	118*	56	SD	B
119	5120	B	119*	64	SD	B
120	5760	B	120*	72	SD	B
121	6400	B	121*	80	SD	B
122	7040	B	122*	88	SD	B
123	7680	B	123*	96	SD	B
124	8320	B	124*	104	SD	B
125	8960	B	125*	112	SD	B
126	9600	B	126*	120	SD	B
127	10240	B	127*	125	SD	B

* - Invalid Condition
SD - Shut Down
OPNS - Operational, Not Sharing Load
OPSL - Operational, Sharing Load

7. REFERENCES

7.01 The following documents provide additional information on the 178A test set.

NUMBER	TITLE
CD & SD 73129-01	178A Test Set—Description

SECTION	TITLE
314-410-550	DATAPHONE® Select-A-Station—Overall System Description
590-105-100	Data Station Selector J70180AA—Description and Operation
590-105-101	Data Station Selector J70180AA—TOP
666-617-100	DATAPHONE® Select-A-Station Service—Test Centers—Administrative Procedures
666-617-101	Test Center Procedures—TOP

8. GLOSSARY

8.01 A list of unique terms and their definitions used in this section are as follows:

Addressable—A service offering in which the customer has in-service control of both the duration and order of connections to a number of remote stations.

Automatic Step—A DSS option of the sequential offering in which the duration and order of connections are fixed.

Automatic Step with Reset—A DSS option of the sequential offering in which the duration and order of connections are fixed, but the DSS will reset to the beginning of the connection cycle upon command from the master station.

Channel Service Unit (CSU)—A standard termination device located at the remote station.

Control Step—A DSS option of the sequential offering which allows the customer to have in-service control over the duration of the connection. However, the connection sequence is fixed.

Data Auxiliary Set 829-Type—Circuit packs used to provide 4-wire terminations for 4-wire facilities.

Data Auxiliary Set 833A—A circuit pack that provides control signaling functions in the SCU at the master station.

Data Station Selector (DSS)—A switching device located in central offices and having the capability of making connections between a 4-wire input and up to 128 outputs, 2-wire or 4-wire, one at a time, under the control of a master station.

Frame Signal—A signal from the DSS in the central office to the SCU at the master station to indicate the beginning of a connection cycle.

Hold Time—The time during which a circuit remains connected.

Master Station—The one station of a multistation circuit that communicates with each remote station and has control of the connections.

Primary Link—The 4-wire transmission facility between the master station and SCU and a primary DSS.

Remote Office Link—A polled link from a DSS to a remote station using interoffice facilities.

Remote Station—One of many stations on a multistation circuit that is connected to the master station by DSSs.

Secondary Link—The 4-wire transmission facility between a primary DSS and a secondary DSS.

Selector Control Unit (SCU)—The equipment associated with one circuit located at the master station and used by the customer to transmit control signals to DSSs and receive supervisory signals from DSSs.

Sequential—A service offering to a customer in which the order of connections from the master station to the remote stations is fixed by that initial assignment to the DSS output ports.

Special Service Center (SSC)—A test center with responsibility for coordination and control of customer service within a specific serving territory.

NOTES

Loop-Around Data Test Facility

User Instructions

General

The user of the Loop-Around service will require two telephone sets and lines at his test position. Each Loop-Around Facility has two telephone numbers associated with it; one user telephone is used to dial each number of a specific Loop-Around Facility (see Table A). After an electrical security check assures that the Facility was addressed from telephone sets at the same location, the Loop-Around circuitry will complete the looped around connection.

TABLE A

City	Line 1	Line 2
Boston	617-434-9901	617-434-9902
New York	212-969-9930	212-969-9931
Washington	202-484-1427	202-484-1428
Atlanta	404-681-1253	404-681-1254
Chicago	312-341-0670	312-341-0671
Dallas	214-827-8670	214-827-8671
Los Angeles	213-620-9998	213-620-9999
Seattle	206-622-0041	206-622-0042

Establishing a Connection

The proper calling procedure involves placing a call (local or toll) to Line 1 of the selected Loop-Around Facility. As this call is completed the user will hear one ring-back followed by silence. A second call (local or toll) is then placed by the user using his second telephone set and line to Line 2 of the desired Loop-Around Facility. As this connection is completed the user will hear one ring-back followed by a five-second 1000-Hz tone. At the end of this tone the user must, within five seconds, distinctly repeat a one-syllable word three times, such as "five-five-five" into the transmitters of both of his telephone lines. At this point the looped connection will be made and appropriate charges (local or toll) initiated on each of the originating telephones. The words must be simultaneously transmitted over the two lines. This simultaneity of the words received at the Loop-Around point is used by the circuitry to insure that the two telephones are at the same location.

Rejection of a Connection

There are three basic ways the Loop-Around circuit will reject a connection. First, the circuit allows the customer only five seconds in which to complete his three simultaneous words. If connection is not complete by the end of that interval, a steady 1000-Hz tone will be placed on Line #2.

Second, the circuit detects non-simultaneous signals on the channels during both the five-second tone interval and the five-second silent interval. If sufficient non-simultaneous signals are received, the customer will be rejected and an immediate indication will be given by a 1000-Hz tone on Line #2.

Finally, a customer is not allowed to seize either channel for an indefinite time without completing loop around. If either, or both, channel is seized and loop around not completed, after approximately 2-1/2 minutes, the customer will be charged for a minimum toll call and subsequently returned to control by his local central office.

Busy Conditions

If the desired Loop-Around Facility is already in use, the user will encounter a normal busy signal as he attempts to complete a call to Line 1.

Transmission

It must be stressed that a customer's test connection established via the Loop-Around Data Test Facility will, at best, only approximate a typical DDD connection.

Bell System Technical References may be consulted for additional information related to transmission performance.

Notice

The Loop-Around Data Test Facility is being provided by American Telephone and Telegraph Company as an aid for the designers, manufacturers, consultants and suppliers of customer-provided systems and equipment which connect with Bell System communications systems or equipment. American Telephone and Telegraph Company reserves the right to revise this service for any reason, including, but not limited to, conformity with standard promulgated by ANSI, EIA, CCITT, or similar agencies, utilization of new advances in the state of the technical arts, or to reflect changes in the design of equipment or services described therein. The limits of responsibility and liability of the Bell System with respect to the use of customer-provided systems or equipment are set forth in the appropriate tariff regulations.

NOTICE

The two following manuals are included because of multifunction and widespread use. Others that can be used are not included here because of space limitations.

NOTICE

This manual is reproduced with permission of the Bradley Telcom Corp.

Certain parts have been omitted because of space limitation. Refer to the Bradley Telcom Corp. manual supplied with the equipment for complete details.

HEWLETT hp PACKARD

OPERATING AND SERVICE MANUAL

SUPPLEMENT

HP Part Number 04940-90037

4940A
Service Manual
HP Model 4940A
Option 004
Transmission Impairment
Measuring Set

HP Model 4940A Option 004 is standard instrument modified to provide for low frequency phase jitter measurement capability from 4 Hz to 20 Hz in addition to the standard phase jitter capability.

Operation of the instrument remains unchanged except that when MEASUREMENT Switch is set to PHASE JITTER and the NORMAL TEST Switch is pressed, low frequency phase jitter is displayed in left display.

Specifications changes or additions are as follows:

PHASE JITTER, RECEIVER:

Low Frequency Phase Jitter:

Frequency Range: 990 Hz to 1030 Hz

Range: 0 - 30 degrees

Resolution: 0.1 degree

Accuracy: ±5% ±0.2 degrees

Detector: peak-to-peak

Bandwidth: (3 dB points) Nominal 4 Hz to 20 Hz

A13 LOW FREQUENCY PHASE FILTER ASSEMBLY

Principles of Operation

A brief, general discussion of the A13 Assembly follows. Three figures are included: Figure 1, a simplified block diagram, Figure 2 is a component locator, and Figure 3, a detailed schematic diagram. Table 1 is a parts list for A13 Assembly.

In phase jitter measurement, a 1004 Hz test signal is sent through the line under test. The receiving unit then measures the incidental phase modulation impressed on the test signal by the line under test.

The A13 Assembly recovers low frequency phase jitter information from the 1004 Hz input signal and presents this information to the display processor.

Four basic blocks make up the A13 Assembly. These are:

Phase Demodulator
Peak-to-Peak Detector
Analog-to-Digital Connector
Control State Flip-Flop

PHASE DEMODULATOR

The phase demodulator consists of circuits identified in Figure *X* Simplified Block Diagram and detailed in Figure *Y*. The phase detector, 2 Hz low pass filter (Lock Acquisition) and VCO combine to form the phase-lock-loop. The Out-of-Lock Detector and Lock Acquisition circuit enable the Phase-Lock-Loop to quickly obtain lock. Once lock is achieved, the Lock Acquisition circuit is disabled.

The signal applied to the 20 Hz Low Pass Filter is a rectangular wave train with a duty-cycle which varies exponentially with the amount of phase jitter. The base-band phase jitter signal is recovered by this circuit and applies the signal to the peak-to-peak detector.

PEAK-TO-PEAK DETECTOR

The peak-to-peak detector consists of the p-to-p detector and the detector discharge circuit. The two peak detectors detect the positive peak and the negative peak signal voltages. Following each cycle the detector discharge circuit resets the peak-to-peak detector through the control and sync logic circuits and the one-shot M.V.

ANALOG-TO-DIGITAL CONNECTOR

The analog-to-digital connector generates an output pulse whose width is proportional to the input analog voltage. The output pulse from this circuit is logic ANDed with the 400 kHz Clock Signal and inputted to the multiplexer. The multiplexer output pulses are counted by a counter on the A10 Assembly.

CONTROL STATE FLIP-FLOP

Logic control and timing is performed by the control and sync-logic circuits connected as a flip-flop. The RFD signal from A19, through the control state circuit, triggers the one-shot M.V. to discharge the peak-to-peak detector and also controls the analog-to-digital converter circuit.

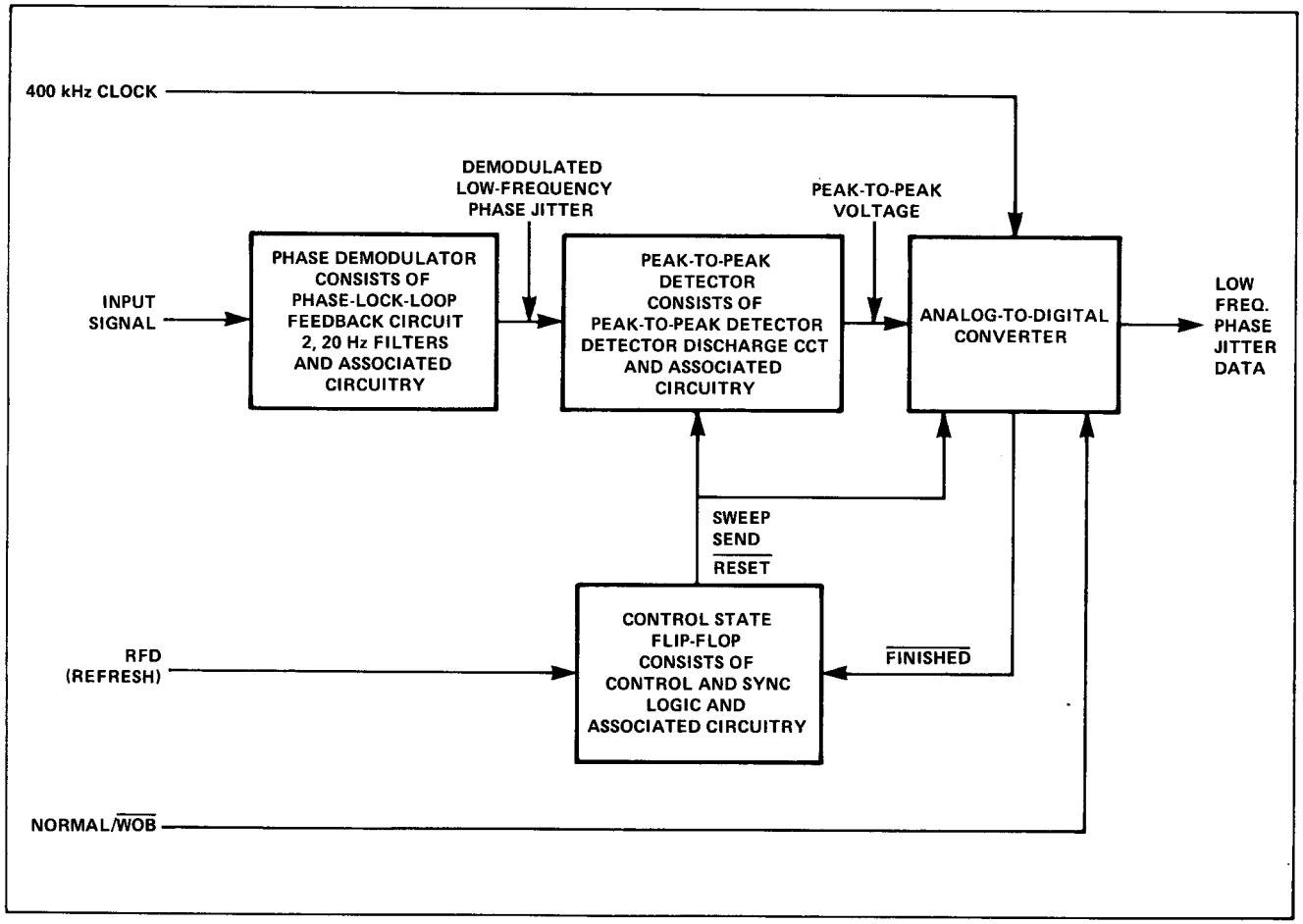

Figure 1. Simplified Block Diagram A13 L.F. Phase Jitter

HEWLETT PACKARD

OPERATING MANUAL

4940A

TRANSMISSION IMPAIRMENT MEASURING SET

All Serial Numbers

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04940-90010

690 E. Middlefield Road, Mountain View, California 94042

PRINTED: JULY 1976

WARNING

SAFETY

If this instrument is to be energized via an autotransformer for voltage reduction, make sure the common terminal is connected to the earthed pole of the power source.

BEFORE SWITCHING ON THIS INSTRUMENT, the protective earth terminals of this instrument must be connected to the protective conductor of the (mains) power cord. The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. The protective action must not be negated by use of an extension cord (power cable) without a protective conductor (grounding).

Make sure that only fuses with the required rated current and of the specified type (normal blow, time delay, etc.) are used for replacement. The use of repaired fuses and the short-circuiting of fuse holders must be avoided.

Whenever it is likely that the protection offered by fuses has been impaired, the instrument must be made inoperative and be secured against any unintended operation.

GROUNDING

Any interruption of the protective (grounding) conductor (inside or outside the instrument) or disconnecting the protective earth terminal can make this instrument dangerous. Intentional interruption is prohibited.

HIGH VOLTAGE

Any adjustment, maintenance, and repair of the opened instrument under voltage should be avoided as much as possible and, when inevitable, should be carried out only by a skilled person who is aware of the hazard involved.

Capacitors inside the instrument may still be charged even if the instrument has been disconnected from its source of supply.

Adjustments and service described herein are performed with power supplied to the instrument while protective covers are removed. Energy available at many points, if contacted, result in personal injury.

CAUTION

LINE VOLTAGE

BEFORE SWITCHING ON THIS INSTRUMENT, make sure instrument requirements match the voltage of the power source.

GROUNDING

BEFORE SWITCHING ON THIS INSTRUMENT, ensure that all devices connected to this instrument are connected to the protective (earth) ground.

BEFORE SWITCHING ON THIS INSTRUMENT, ensure that the line power (mains) plug is connected to a three-conductor line power outlet that has a protective (earth) ground. (Grounding one conductor of a two-conductor outlet is not sufficient.)

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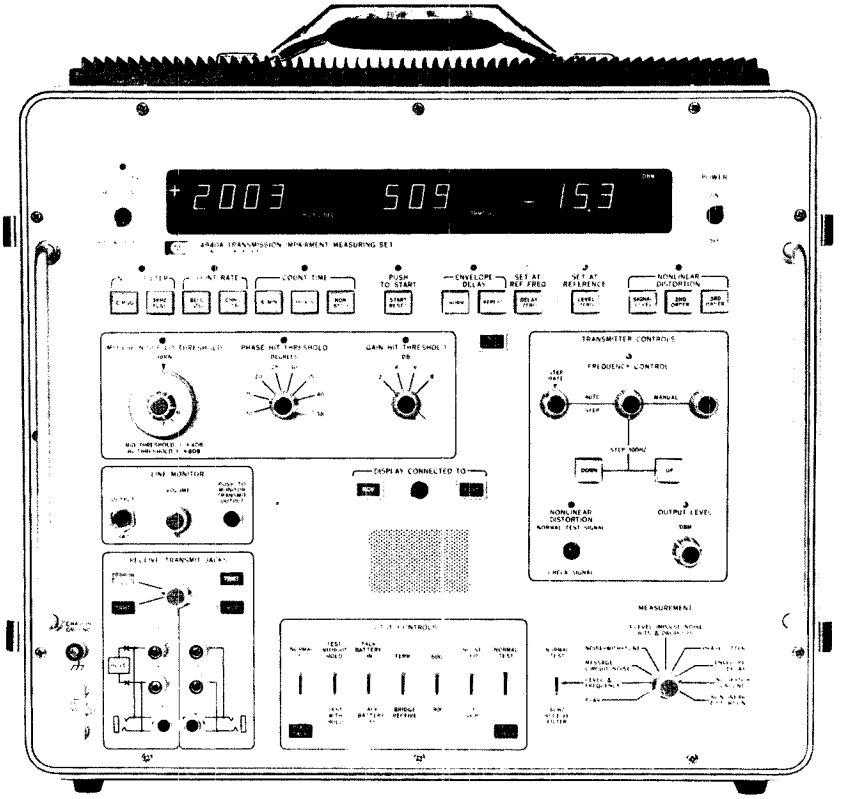


Figure 1-1. Hewlett-Packard 4940A Transmission Impairment Measuring Set

GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. This manual contains the information required to install and operate the Hewlett-Packard Model 4940A Transmission Impairment Measuring Set (TIMS). This section covers a general description, identification, specifications, options, accessories, related manuals, and other basic information. Figure 1-1 shows the test set with its cover removed.

1-3. The various sections in this manual provide information as follows:

a. SECTION II, INSTALLATION. Provides information relative to unpacking and inspection, power requirements, mounting, checkout, packing and shipping, etc.

b. SECTION III, OPERATION. Provides information relative to operating controls and indicators and the operating instructions for the test set.

c. SECTION IV, MEASUREMENT PRINCIPLES. Provides functional description of all measurements.

1-4. GENERAL DESCRIPTION.

1-5. TIMS is a multifunction test set which measures the data handling capability of a voice communications channel. The voice channel parameters which TIMS measures are (1) loss, (2) dropouts, (3) gain hits, (4) phase hits, (5) phase jitter, (6) noise-with-tone, (7) noise-to-ground, (8) frequency shift, (9) nonlinear distortion, (10) message circuit noise, (11) 3-level impulse noise, (12) attenuation distortion, (13) envelope delay distortion, (14) peak-to-average ratio (P/AR), and (15) single frequency interference. TIMS also includes a comprehensive self-check capability.

1-6. IDENTIFICATION.

1-7. Hewlett-Packard identification can be made by reviewing the identification plate on the bottom of the test set case (see figure 1-2). Hewlett-Packard products carry a model number, an option listing, and a ten-digit serial number. The model number corresponds to the placarding on the front panel and the option number(s) indicates those options which the customer has specified, if any.

1-8. Hewlett-Packard identifies each unit with a two-section serial number (0000A-00000). The first four digits are a serial number prefix used to identify a particular unit configuration. The letter code identifies the country in which the unit was manufactured (e.g., the letter "A" indicates manufactured in U.S.A.). The last five digits identify each specific unit. If the serial number prefix on the unit does not agree with the prefix on the title page of this manual, there are differences between that unit and the unit described in this manual. These differences are described in manual supplements available at the nearest HP Sales and Service Office or in Appendix A of this manual.

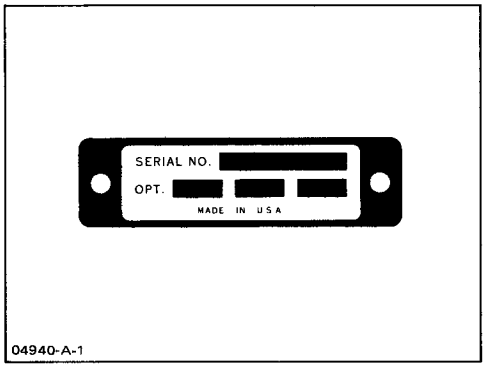


Figure 1-2. Identification Plate

1-9. SPECIFICATIONS.

1-10. Specifications for TIMS are listed in table 1-1.

1-11. OPTIONS.

1-12. Options are factory modifications of a standard TIMS that are requested by the customer. Available options are (1) Option 001 allowing P/AR measurement, (2) Option 002 allowing nonlinear distortion measurement, (3) Option 003 allowing both P/AR and nonlinear distortion measurement, (4) Option 019 allowing mounting in a 19 in. relay rack, and (5) Option 023 allowing mounting in a 23 in. relay rack.

1-13. ACCESSORIES.

1-14. Available as an accessory for the 4940A TIMS is the Model 18047A Fiberglass Transit Case (Option 010). This case is used to provide additional protection for the test set when it is shipped from location to location. This accessory may be ordered with TIMS or separately from your local Hewlett-Packard Sales and Service Office (refer to the list at the back of this manual for addresses).

1-15. RELATED MANUALS.

1-16. Summarized operating instructions for the test set are provided in the 4940A Operating Instructions booklet, HP P/N 04940-90014. Complete service information for the test set is provided in the 4940A Service Manual, HP P/N 04940-90012, which may be obtained by returning the card enclosed in this manual.

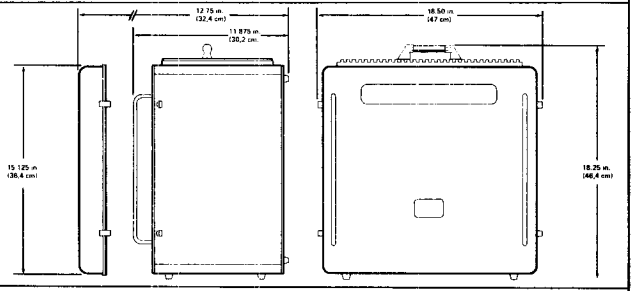
1-17. TIMS REPAIR.

1-18. User repairs should be limited to replacement of fuses, annuciator lamps, and power cords. Repairs and adjustments of electronic circuits should not be attempted. These repairs require special equipment and procedures and should be performed only by authorized repair shops. For any needed assistance contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

Table 1-1. HP 4940A TIMS Specifications

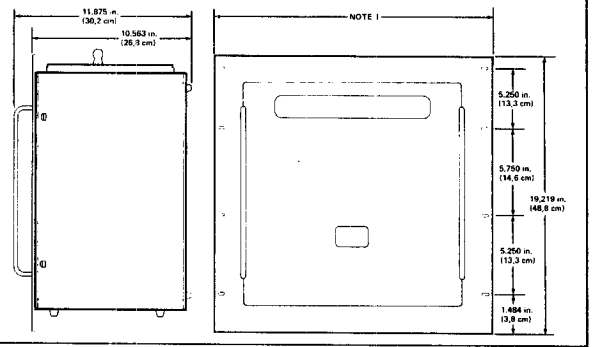
DIMENSIONS AND WEIGHTS

Standard Model
Net: 39 lbs. (18kg)
Shipping: 50 lbs. (22,7kg)



Rack Mount Option Models
Net: 40 lbs (18,1kg)
Shipping: 50 lbs. (22,7kg)

Note 1. Option 019: 19.00 in. (48,3 cm)
Option 023: 23.00 in. (58,4 cm)



Model 18047A Fiberglass
Transit Case
Net: 18 lbs. (8kg)

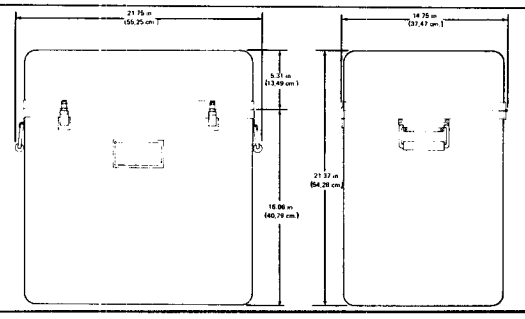


Table 1-1. HP 4940A TIMS Specifications (Continued)

TRANSMITTER	RECEIVER
LEVEL AND FREQUENCY Frequency Range: 200 Hz to 3904 Hz Resolution: 1 Hz Accuracy: ±0.5 Hz in Step Modes Manual Mode: Continuously adjustable; 200 Hz to 3900 Hz Step 100 Hz Mode: 204 Hz to 3904 Hz in 100 Hz increments Auto Step Mode: Repeatedly steps up and then back (in 100 Hz increments) from 204 Hz to 3904 Hz Level Range: +10 dBm to −40 dBm Resolution: 0.1 dBm Accuracy: ±0.1 dB Frequency Response: ±0.1 dB from 200 Hz to 3904 Hz Harmonic and Spurious Signals: Total Harmonic Distortion to 10 kHz: Greater than 50 dB below fundamental Spurious Signals to 10 kHz: Greater than 50 dB below fundamental Background Noise to 10 kHz: Less than −90 dBm	Frequency Range: 200 Hz to 4100 Hz Resolution: 1 Hz Accuracy: ±0.5 Hz Level Range: +10 dBm to −40 dBm Resolution: 0.1 dBm Accuracy: ±0.1 dB at 1 kHz from 0 to −15 dBm; ±0.2 dB over full frequency and level range Detector: Full wave average Bandwidth (3 dB points): Nominal 20 Hz to 10 kHz 60 Hz Input Filter (switch selectable): Nominal 25 dB loss at 60 Hz; 4 dB loss at 180 Hz
PHASE JITTER Frequency: 1004 Hz fixed Level Range: +10 dBm to −40 dBm Resolution: 1 dBm Background Noise, Harmonics and Spurious Signals: Refer to LEVEL AND FREQUENCY	Frequency Range: 990 Hz to 1030 Hz Level Range: +10 dBm to −40 dBm Resolution: 1 dBm Jitter Range: 0.2 to 25 degrees Resolution: 0.1 degree Accuracy: ±5% of reading ±0.2 degrees Detector: Peak to peak Bandwidth (3 dB points): Nominal 20 Hz to 300 Hz
MESSAGE CIRCUIT NOISE Quiet Termination	Weighting Filters: C-Message and 3 kHz flat Detector: Quasi RMS Range: +10 dBrn to +100 dBrn Resolution: 1 dBrn Accuracy: ±1 dB
3-LEVEL IMPULSE NOISE, HITS AND DROPOUTS Frequency: 1004 Hz fixed Level Range: +10 dBm to −40 dBm Resolution: 1 dBm Background Noise, Harmonics and Spurious Signals: Refer to LEVEL AND FREQUENCY	Received Tone Level: 0 dBm to −40 dBm Notch Filter: Greater than 50 dB rejection from 995 Hz to 1025 Hz Count Interval: 5 min., 15 min. or continuous Impulse Noise Threshold Range: Lo: 30 dBrn to 109 dBrn Mid: 4 dB above Lo (Max 109 dBrn) Hi: 8 dB above Lo (Max 109 dBrn) Impulse Noise Threshold Accuracy: ±1 dB Impulse Noise Count Range: Lo: 0 to 19,999 Mid: 0 to 9,999 Hi: 0 to 1,999 Count Rate: 7 counts per second max. ±5% or channel limited Gain Hit Thresholds: 2, 4, 6, and 8 dB Phase Hit Thresholds: 10 to 45 degrees in 5 degree increments Hit Guard Interval: Nominal 4 ms Dropout-Level Threshold: Fixed; greater than 12 dB decrease in level Dropout Duration: Nominal 4 ms (±10%) or greater Phase Hit Counts: 0 to 19,999 Dropout Counts: 0 to 9,999 Gain Hit Counts: 0 to 1,999 Display: All six phenomena are counted simultaneously and stored. A switch selection displays either the Impulse Noise counts or the Hits and Dropout counts during or after the measurement period.
NOISE-TO-GROUND Quiet Termination	Range: 40 dBrn to 130 dBrn Input Circuit: 600Ω or 900Ω across the line; 100 kΩ to ground For other specifications refer to MESSAGE CIRCUIT NOISE

Table 1-1. HP 4940A TIMS Specifications (Continued)

TRANSMITTER	RECEIVER
ENVELOPE DELAY Frequency Range: 300 Hz to 3904 Hz For other Frequency specifications see LEVEL AND FREQUENCY Modulation Frequency: 83⅓ Hz Level Range: +10 dBm to −40 dBm For other Level specifications see LEVEL AND FREQUENCY Harmonic and Spurious Signals to 10 kHz: Greater than 46 dB below main signal power. Background Noise to 10 kHz: Less than −90 dBm	Frequency Range: 300 Hz to 3904 Hz For other Frequency specifications see LEVEL AND FREQUENCY Level Range: +10 dBm to −40 dBm Carrier Level Accuracy: ±.25 dB For other Level specifications see LEVEL AND FREQUENCY Delay Range: 3,000μs to +9,000μs Resolution: 1μs Accuracy (back to back): ±10μs from 600 Hz to 3904 Hz; ±30μs from 300 Hz to 600 Hz Minimum Signal to Noise Ratio (for stated accuracy): 20 dB, 3 kHz flat weighting
NOISE-WITH-TONE Frequency: 1004 Hz fixed Level Range: +10 dBm to −40 dBm Resolution: 1 dBm Background Noise, Harmonics and Spurious Signals: Refer to LEVEL AND FREQUENCY	Notch Filter: Greater than 50 dB rejection from 995 Hz to 1025 Hz For other specifications refer to MESSAGE CIRCUIT NOISE
NONLINEAR DISTORTION Test Signal Type: Two pairs of tones centered at 860 Hz and 1380 Hz Level Range: 0 dBm to −40 dBm Resolution: 1 dBm	Level Range: +10 dBm to −35 dBm Resolution: 1 dBm Accuracy: ±1 dBm 2nd Order Receive Filters: Centered at 520 Hz and 2240 Hz 3rd Order Receive Filter: Centered at 1900 Hz 2nd Order Products Range: To 50 dB below received level Accuracy: ±1 dB 3rd Order Products Range: To 60 dB below received level Accuracy: ±1 dB
P/AR Level Range: 0 dBm to −40 dBm Resolution: 1 dBm	Level Range: +10 dBm to −30 dBm Resolution: 1 dBm P/AR Range: 0 P/AR Units to 120 P/AR Units Resolution: 1 P/AR Unit Accuracy: ±2 P/AR Units
GENERAL Longitudinal Balance: 60 dB to 6 kHz, decreasing 6 dB per octave above 6 kHz Impedances: 600Ω and 900Ω Return Loss: Greater than 40 dB SF Skip: 2450 Hz to 2750 Hz	Longitudinal Balance: 60 dB to 6 kHz, decreasing 6 dB per octave above 6 kHz Terminating Impedances: 600Ω and 900Ω Bridging Impedance: Greater than 50 kΩ Bridging Loss: Less than 0.3 dB at 1 kHz Return Loss: Greater than 40 dB High Frequency Protection: Greater than 60 dB attenuation above 500 kHz

MONITOR AMPLIFIER OUTPUT Output Range: 0 volts to 7 volts Bandwidth (3 dB points). 200 Hz to 6200 Hz Frequency Response: ±1 dB from 300 Hz to 3900 Hz (Nominal values into loads of 150Ω or greater) Output Impedance: 5Ω Output Connector: 347 jack	**AUXILIARY OUTPUTS-BNC** Carrier: Square wave output of received frequency VCO. Nominal 10 kΩ source impedance. PM: AC signal proportional to band limited phase jitter. Nominal 10 kΩ source impedance.
MISCELLANEOUS Test Jacks: 310 jack multiplied with 5 way binding posts for both transmitter and receiver DC Blocking (with no holding). 200 volts Power Requirements: 105 to 129 volts AC, 60 Hz	Operating Temperature: 32°F to 122°F (0°C to 50°C) Storage Temperature: −40°F to 167°F (−40°C to 75°C) Warm-up Time for stated accuracy: 5 minutes

2-1. INTRODUCTION.

2-2. This section contains information on unpacking and incoming inspection, input power requirements, mounting, checkout, and packing and shipping for the Transmission Impairment Measuring Set (TIMS).

2-3. UNPACKING AND INSPECTION.

2-4. Inspect the shipping container for damage. If the shipping container or cushioning material is damaged, it should be kept until the contents of the shipment have been checked for completeness and the unit has been checked mechanically and electrically. Procedures for checking electrical performance are given in paragraph 2-12. If the contents are incomplete, if there is mechanical damage or defect, or if the unit does not pass the electrical performance test, notify the nearest Hewlett-Packard office (listed in the back of this manual). If the shipping container is damaged, or the cushioning material shows signs of stress, notify the carrier as well as the Hewlett-Packard office. Keep the shipping materials for carrier's inspection. The HP office will arrange for repair or replacement without waiting for claim settlement.

2-5. POWER REQUIREMENTS.

2-6. The test set operates on standard commercial 60 Hz power of between 105 and 129 volts.

2-7. POWER CORD.

2-8. To protect operating personnel, the test set panel and chassis must be grounded. This test set is equipped with a detachable three-conductor power cable (HP P/N 8120-1983) which, when connected to a properly grounded power receptacle, grounds the unit.

WARNING

Any interruption of the protective (grounding) conductor (inside or outside the instrument) or disconnecting the protective earth terminal can make this instrument dangerous. Intentional interruption is prohibited.

2-9. MOUNTING.

2-10. The standard TIMS is provided with plastic feet on the bottom and back to allow placement on any flat surface. If it is desired to rack mount the test set, then either option 019 (standard 19 in. rack mounting model) or option 023 (standard 23 in. rack mounting model) may be ordered at the time of initial purchase. Dimensions of both the standard model and the two rack mount models are given in the specifications table in the General Information section of this manual. To mount the test set in a 19 inch or 23 inch rack, proceed as follows:

a. Place the test set on a flat surface and lay it on its back so that the front panel is facing up. Remove the twelve existing screws holding the front panel to the test set case, located around the edge of the front panel.

b. Lay the rack mount adapter over the face of the front panel, being careful to align the four notches in the adapter with the front panel "roll bar" handles.

c. Secure the rack mount adapter and front panel to the case (see figure 2-1) using the twelve screws provided (6-32, 0.625 in., pan head, Pozi drive).

d. Lift the test set into its rack position, and install with eight screws (10-32, 0.625 in., flat head), brass washers (0.578 in. OD, 0.250 in. ID) and nylon washers (0.555 in. OD, 0.095 in. ID) (see figure 2-2).

2-11. The test set is air cooled by an exhaust fan mounted in the top cover of the case. The top cover also has cooling fins cast into it to provide convection cooling for the heat dissipating elements in the power supply circuitry.

CAUTION

Do not place any object, such as manuals, clipboards, etc., on top of the test set. Restriction of air from the fan or cooling fins can cause overheating and damage to the test set.

2-12. BEFORE-USE CHECKOUT.

2-13. To determine that the test set is electrically operational, perform the Self Check procedures as described in the Operation section of this manual. The self check procedures will determine if the test set is operating properly.

2-14. SHIPPING INSTRUCTIONS.

2-15. USING ORIGINAL PACKAGING.

2-16. The same container and packing material used in factory packaging can be obtained through Hewlett-Packard Sales and Service Offices listed at the back of this manual. If the test set is being returned to Hewlett-Packard for servicing, attach a tag indicating the type of service or repair required, return address, model number, option numbers, and full serial number. Also mark the container FRAGILE to assure careful handling. In any correspondence, refer to the test set by model number, option numbers, and full serial number.

2-17. USING OTHER PACKAGING.

2-18. The following general instructions should be used for repackaging with commercially available materials:

a. Wrap the test set in heavy paper or plastic. (If shipping to a Hewlett-Packard Sales and Service Office, attach a tag indicating the type of service required, return address, model number, option numbers, and full serial number.)

b. Use a strong shipping container. A double-wall carton made of 275 pound test material is adequate.

c. Use enough shock-absorbing material (3- to 4-inch layer) around all sides of the test set to provide firm cushioning and prevent movement inside the container.

d. Seal the shipping container securely and mark it FRAGILE to assure careful handling.

e. In any correspondence, refer to the test set by model number, option numbers, and full serial number.

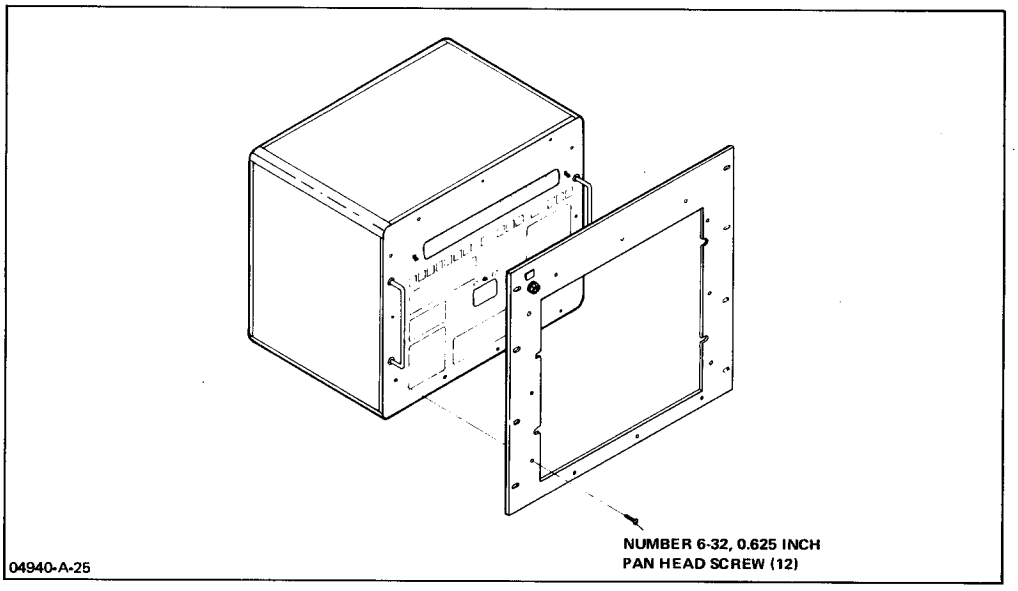


Figure 2-1. Installing Rack Mount Adapter

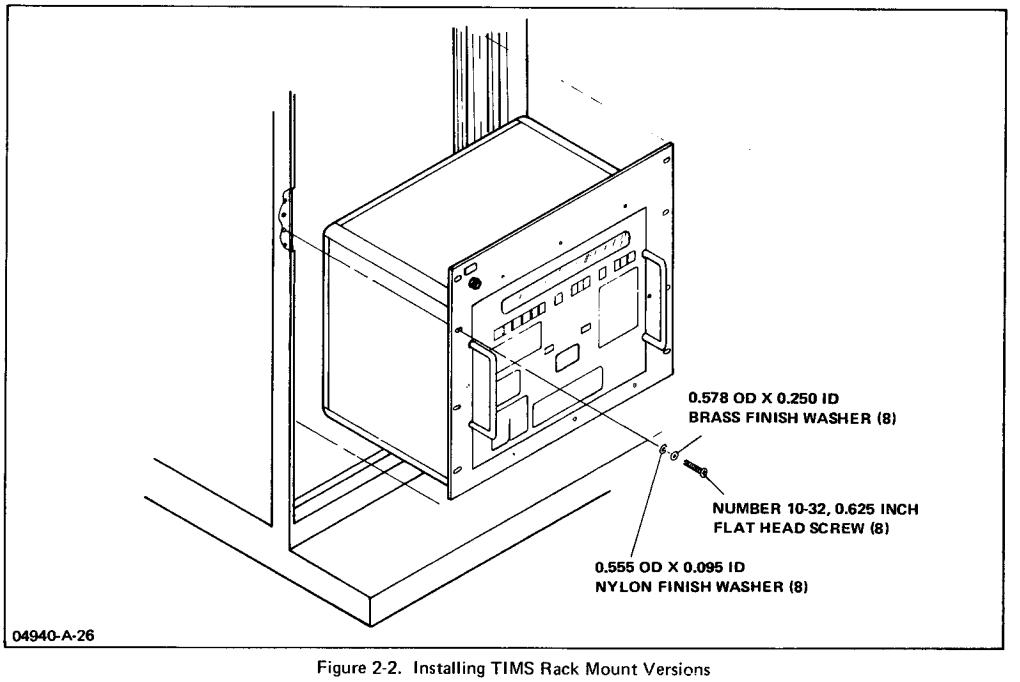
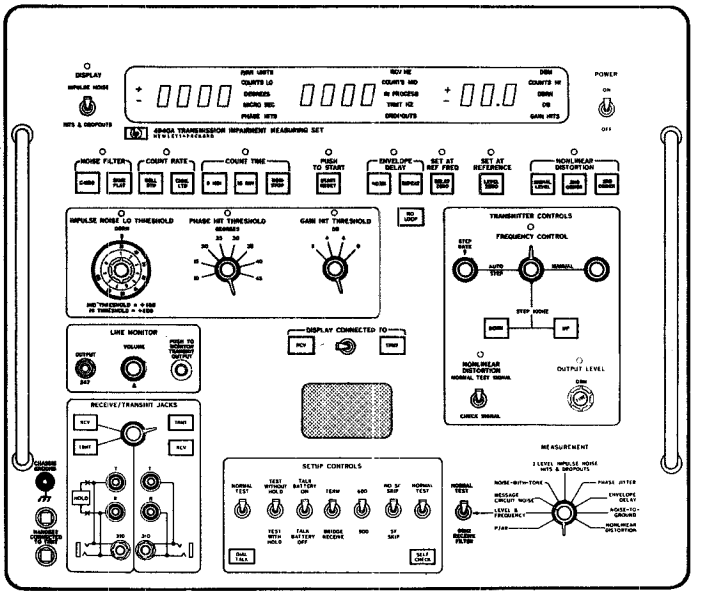


Figure 2-2. Installing TIMS Rack Mount Versions

3-1. INTRODUCTION.

3-2. Operating instructions for the Transmission Impairment Measuring Set are covered in this section. Set-up and turn on procedures are covered in figure 3-1. Dial, talk, listen, and hold procedures are covered in figure 3-2. Parameter measurement procedures are covered in figures 3-3 through 3-20. Self check procedures are covered in figure 3-21. Lamp checks and replacement procedures are covered in figure 3-22. Finally, description of controls, connectors, and indicators is covered in figure 3-23.



SETUP AND TURN ON

1. Connect power cord to receptacle on top of test set and to 117 volts, 60Hz ac power line.

CAUTION

Do not place any object, such as manuals, clipboards, etc., on top of the test set. Restriction of air from the fan or cooling fins can cause overheating and damage to the test set.

2. Throw POWER switch to ON position to apply power to test set.
3. Throw SETUP CONTROLS key to BRIDGE RECEIVE if test set is to be bridged across receive line. Throw key to TERM if test set is to be used as termination on the receive line.
4. Throw SETUP CONTROLS key to 600 or 900 to match impedance of lines under test.
5. Throw SETUP CONTROLS key to SF SKIP if transmitting over a dial-up network and single frequency (SF) signaling units are on the network.
6. Throw far-right SETUP CONTROLS key to NORMAL TEST. Refer to SELF CHECK PROCEDURES (Figure 3-21) if it is desired to run self check procedure on test set.

NOTE

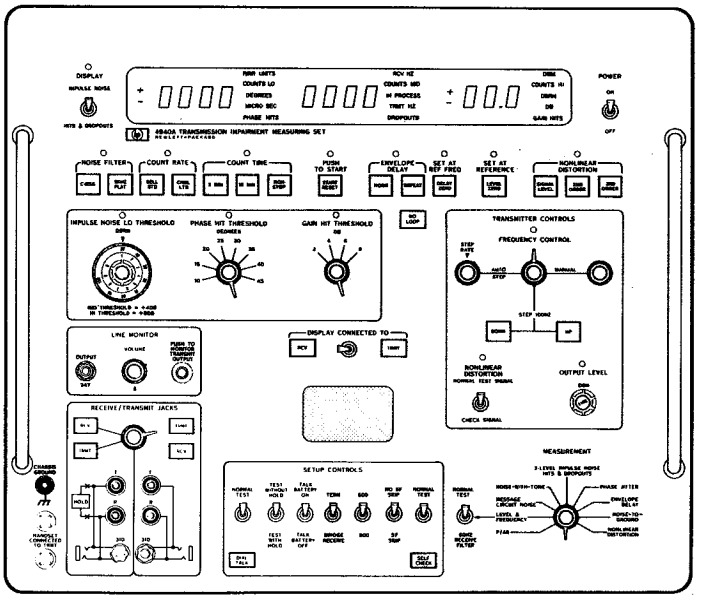
The self check procedure should be performed periodically to verify performance of the test set. SELF CHECK is recommended before transporting the test set to a remote testing site; or whenever there is any doubt about transmission measurement results.

7. Rotate OUTPUT LEVEL control full counterclockwise.
8. Rotate RECEIVE/TRANSMIT JACKS switch to select whether left jack field is to be used for TRMT or RCV. Connect transmit and receive lines (if both are required) to the appropriate TRANSMIT/RECEIVE JACKS. Refer to DIAL, TALK, LISTEN, and HOLD PROCEDURES (Figure 3-2) for proper hookup and control operation if dialing, talking, listening or holding are necessary on the lines under test.
9. Select desired MEASUREMENT mode and refer to appropriate measurement instructions section.

NOTE

The MEASUREMENT switch turns on indicator dot lamps over control groups that are active for that particular measurement. These lamps are a special aid to the selection of push-button switches. If an improper condition (i.e., all or no push-buttons depressed) exists in an active switch group, all indicator dot lamps and the display will go out, except the indicator dot lamp over the group that requires a selection.

Figure 3-1. Setup and Turn On Procedures



DIAL, TALK, LISTEN, AND HOLD

1. Perform SETUP AND TURN ON PROCEDURES (Figure 3-1) through Step 8.
2. Connect lineman's handset (butt-in) to HANDSET CONNECTED TO TRMT connector posts.
3. Refer to table below for proper hookup and control settings.

NOTE

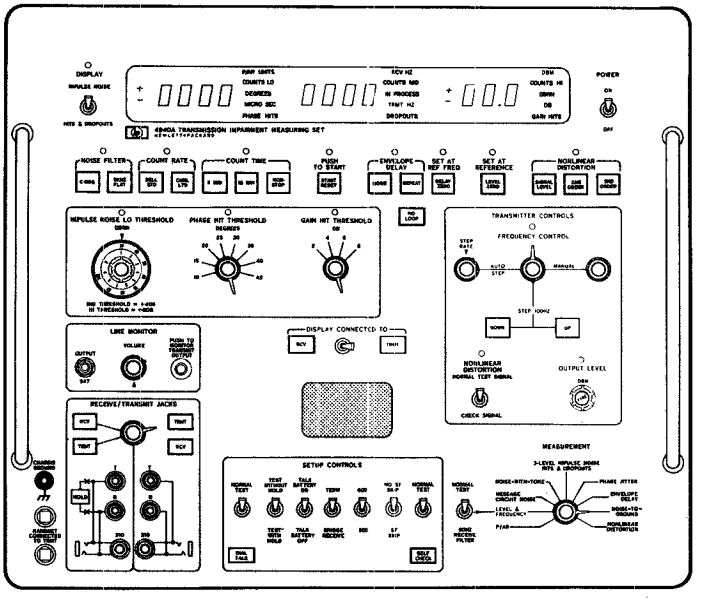
When going to NORMAL TEST mode on 2-wire wet (DDD) line, make sure SETUP CONTROLS key is in TEST WITH HOLD position before switching to NORMAL TEST. Failure to do so will cause the dial-up connection to be lost.

4. To return to talk or listen mode after normal tests are in progress, throw SETUP CONTROLS key to DIAL/TALK. Rotate RECEIVE/TRANSMIT JACKS switch as indicated for 2-wire circuits.

HOOKUP AND SETUP CONTROL SETTINGS FOR DIALING, TALKING, LISTENING, HOLDING AND TESTING

MODE	CIRCUIT		
	2-Wire Wet (DDD)	2-Wire Dry (DAA)	4-Wire Dry
HOOKUP	Transmit line connected to left RECEIVE/TRANSMIT JACKS	Transmit line connected to right RECEIVE/TRANSMIT JACKS	Transmit line connected to either RECEIVE/TRANSMIT JACKS
DIAL	DIAL/TALK; TALK BATTERY OFF; TEST WITHOUT HOLD; LEFT JACK TO TRMT (Dial with butt-in)		
TALK	DIAL/TALK; TALK BATTERY OFF; TEST WITH HOLD; LEFT JACK TO TRMT (Talk through butt-in)	DIAL/TALK; TALK BATTERY ON; TEST WITHOUT HOLD; RIGHT JACK TO TRMT (Talk through butt-in)	DIAL/TALK; TALK BATTERY ON; TEST WITHOUT HOLD (Talk through butt-in)
LISTEN	DIAL/TALK; TALK BATTERY OFF; TEST WITH HOLD; LEFT JACK TO TRMT (Listen through butt-in)	DIAL/TALK; TALK BATTERY ON; TEST WITHOUT HOLD; RIGHT JACK TO TRMT (Listen through butt-in)	Adjust LINE MONITOR as required (Listen through LINE MONITOR speaker)
TEST	TALK BATTERY OFF; TEST WITH HOLD; NORMAL TEST (Throw TEST WITH HOLD key before throwing NORMAL TEST key); LEFT JACK TO RCV IF RCV TEST SET	TALK BATTERY ON; TEST WITHOUT HOLD; NORMAL TEST; RIGHT JACK TO RCV IF RCV TEST SET	TALK BATTERY ON; TEST WITHOUT HOLD; NORMAL TEST

Figure 3-2. Dial, Talk, Listen, and Hold Procedures



LEVEL & FREQUENCY
TRANSMITTER

1. Rotate MEASUREMENT switch to LEVEL & FREQUENCY.
2. Throw DISPLAY CONNECTED TO key to TRMT.
3. Rotate FREQUENCY CONTROL switch to STEP 100 HZ. Set transmit frequency to 1004 Hz by pressing DOWN or UP push-buttons, while observing TRMT HZ on center display.
4. Adjust OUTPUT LEVEL control for "Data Level" while observing DBM output level on right display.

DATA LEVEL

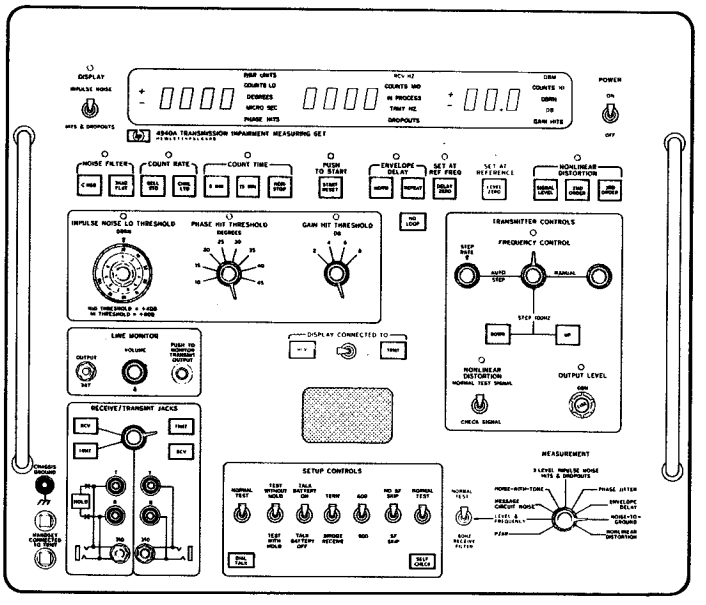
All transmission measurements should be made at Data Level. The Data Level for all presently specified data circuits is a power 13dB below the Transmission Level Point (TLP). For example, if the TLP is −16dB, the Data Level would be −29dBm. Therefore, an output level of −29dBm would be applied in this case.

5. When requested by the receiver operator, transmit the agreed upon test frequencies. When in the STEP 100 HZ FREQUENCY CONTROL mode, frequencies of 204Hz to 3904Hz can be selected in 100Hz increments by pressing the DOWN or UP push-buttons. Frequencies can also be stepped 100Hz automatically by rotating the FREQUENCY CONTROL switch to AUTO STEP and adjusting the STEP RATE control for the desired stepping rate. Frequencies other than those at the step points can be selected by rotating the FREQUENCY CONTROL switch to MANUAL and adjusting the MANUAL control for the desired frequency.

NOTE

If SF signaling units are used in the network under test, the SETUP CONTROLS key should be thrown to SF SKIP. This mode automatically blanks the transmitter output so that frequencies between 2450Hz and 2750Hz cannot be transmitted.

Figure 3-3. Level and Frequency Measurements, Transmitter



LEVEL & FREQUENCY
RECEIVER

1. Rotate MEASUREMENT switch to LEVEL & FREQUENCY.
2. Throw DISPLAY CONNECTED TO key to RCV.

1000 HZ LOSS MEASUREMENT

3. Instruct transmitter operator to send 1004 Hz tone.
4. Observe RCV HZ (nominally 1004Hz) on center display and DBM received level on right display.
5. Depress 60 HZ RECEIVE FILTER key while observing DBM received level display. If received level changes more than ± 0.2dBm, the 60 HZ RECEIVE FILTER key should be depressed throughout the measurement run.

FREQUENCY SHIFT MEASUREMENT

6. Observe RCV HZ while communicating with transmitter operator, comparing any difference between the transmitted and received frequency. The transmitting test set must be a TIMS, or other set capable of transmitting a signal known to within ±0.5Hz.

ATTENUATION DISTORTION MEASUREMENT

7. Press LEVEL ZERO push-button while receiving the reference frequency (e.g., 1004Hz). This establishes a 0dB reference.
8. Observe RCV HZ on center display and ±DB relative loss on right display as agreed upon frequencies are transmitted. +DB indicates more loss and –DB indicates less loss, relative to the reference frequency.

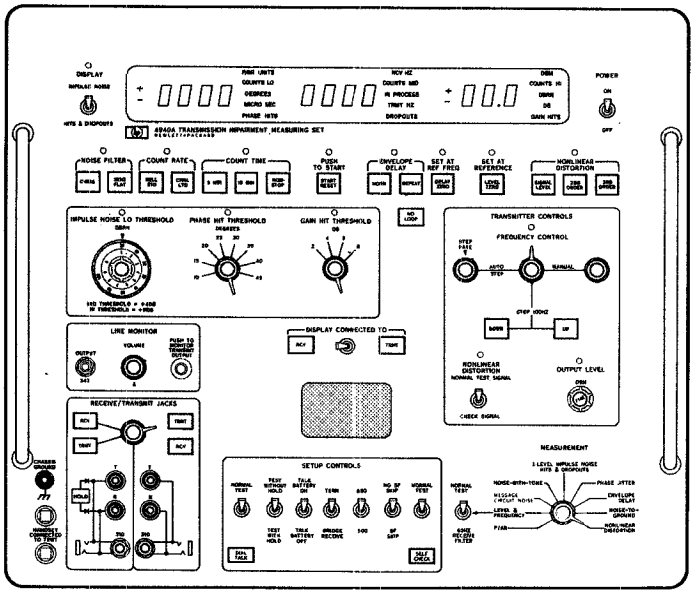
NOTE

If SF signaling units are used in the network under test, the transmitting test set should be operated in the SF SKIP mode. In this mode there will be no test signal as the transmitter frequency is adjusted through the 2450Hz to 2750Hz range.

NOTE

Attenuation distortion measurements can also be made in absolute dBm units, if desired. The test set is automatically in the dBm mode until the LEVEL ZERO push-button is pressed. To return the test set to the dBm mode, momentarily rotate the MEASUREMENT switch out of the LEVEL & FREQUENCY position, then back again.

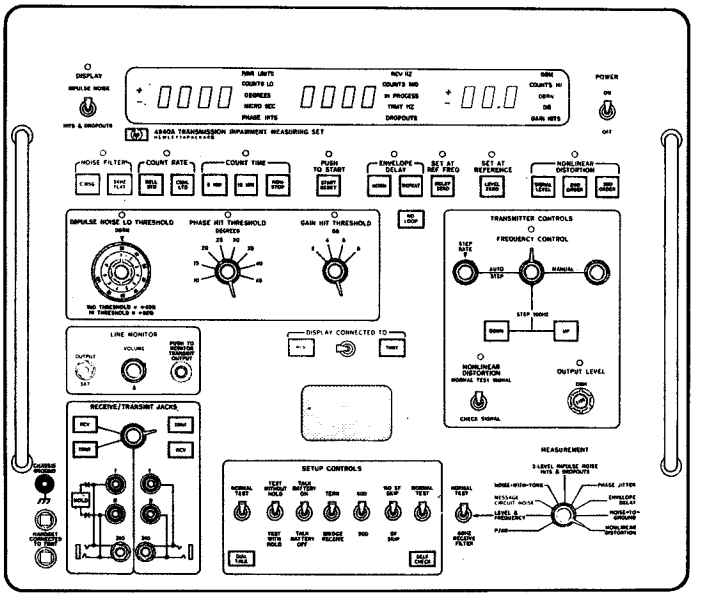
Figure 3-4. Level and Frequency Measurements, Receiver



MESSAGE CIRCUIT NOISE
TRANSMITTER

1. Rotate MEASUREMENT switch to MESSAGE CIRCUIT NOISE. This provides the TRMT jacks with a quiet termination.

Figure 3-5. Message Circuit Noise Measurements, Transmitter



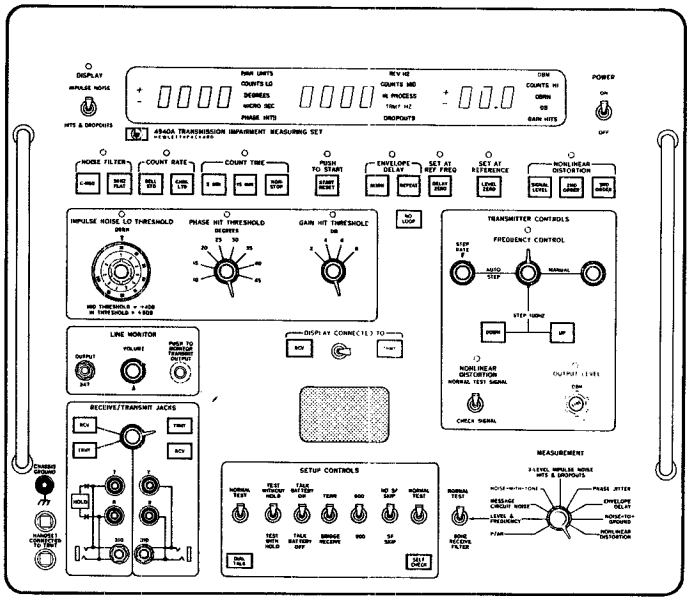
MESSAGE CIRCUIT NOISE
RECEIVER

1. Rotate MEASUREMENT switch to MESSAGE CIRCUIT NOISE.
2. Throw DISPLAY CONNECTED TO key to RCV.
3. Depress NOISE FILTER push-button (C-MSG or 3 KHZ FLAT) to select desired weighting.
4. Observe DBRN noise level on right display.

SINGLE FREQUENCY INTERFERENCE CHECK

5. Turn on LINE MONITOR by rotating VOLUME control until desired loudness is obtained in speaker or headphones. Listen for any predominant tone which will indicate a potential single frequency interference problem. A frequency selective voltmeter, spectrum analyzer, oscilloscope, etc., can be connected to the LINE MONITOR OUTPUT jack to further analyze the frequency and level of the interfering tone.

Figure 3-6. Message Circuit Noise Measurements, Receiver



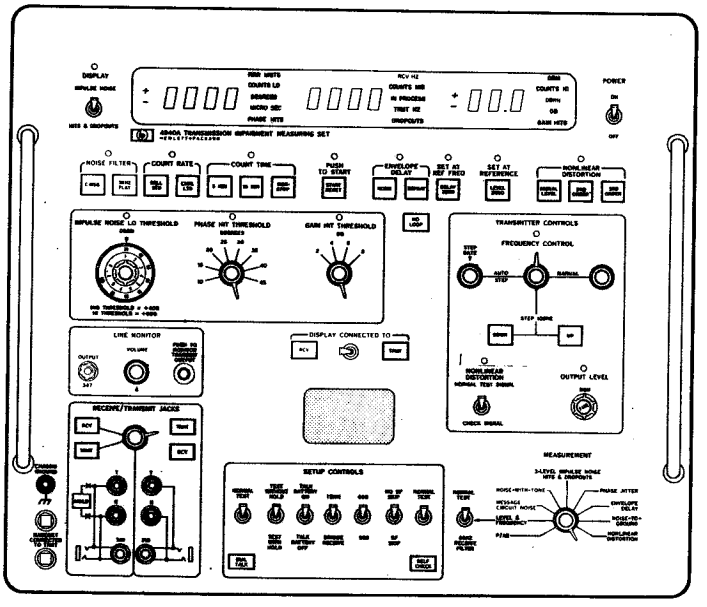
NOISE-WITH-TONE TRANSMITTER

1. Rotate MEASUREMENT switch to NOISE-WITH-TONE.
2. Throw DISPLAY CONNECTED TO key to TRMT.
3. Observe TRMT HZ on center display to verify that 1004 Hz holding tone is being transmitted.
4. Adjust OUTPUT LEVEL control for "Data Level" while observing DBM on right display.

DATA LEVEL

All transmission measurements should be made at Data Level. The Data Level for all presently specified data circuits is a power 13dB below the Transmission Level Point (TLP). For example, if the TLP is −16dB, the Data Level would be −29dBm. Therefore, an output level of −29dBm would be applied in this case.

Figure 3-7. Noise-with-Tone Measurements, Transmitter



NOISE-WITH-TONE RECEIVER

1. Rotate MEASUREMENT switch to NOISE-WITH-TONE.
2. Throw DISPLAY CONNECTED TO key to RCV.
3. Depress NOISE FILTER push-button (C-MSG or 3 KHZ FLAT) to select desired weighting.
4. Observe RCV HZ on center display to verify that holding tone between 995 Hz and 1025 Hz is being received.
5. Turn on LINE MONITOR by rotating VOLUME control until desired loudness is obtained in speaker or headphones. Listen for any predominant tone which will indicate a potential single frequency interference problem.
6. Observe DBRN noise level on right display.

SIGNAL-TO-NOISE MEASUREMENT AND CALCULATION

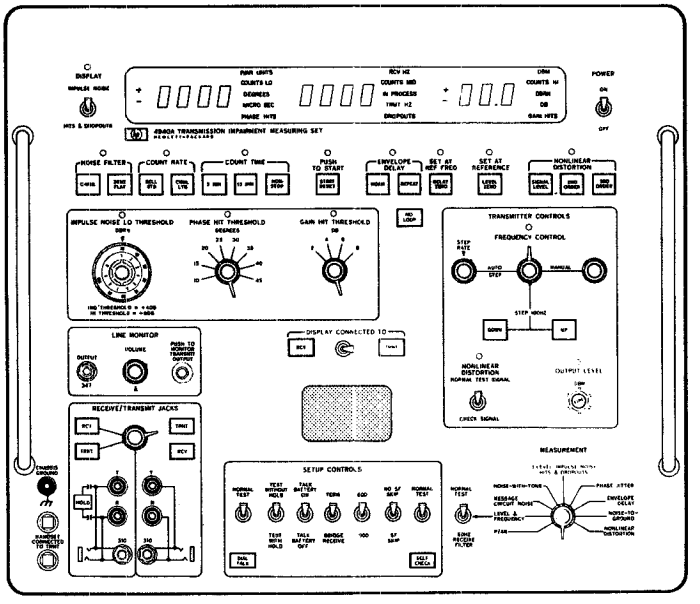
7. Depress C-MSG NOISE FILTER push-button.
8. Observe DBRN noise level on right display and note this value.
9. Rotate MEASUREMENT switch to MESSAGE CIRCUIT NOISE.
10. Observe DBRN tone level on right display and note this value.
11. Subtract noise level noted in step 8 from tone level noted in step 10. The result is SIGNAL-TO-NOISE in dB.

Example:		
	Tone level (step 10)	74dBrn
	–Noise level (step 8)	–50dBrn
	=SIGNAL-TO-NOISE	=24dB

NOTE

This measurement cannot be made on a loop-around basis using one test set since it requires the transmitting test set to be set to NOISE-WITH-TONE while the receiving test set is set to MESSAGE CIRCUIT NOISE.

Figure 3-8. Noise-with-Tone Measurements, Receiver



3-10 Figure 3-9. 3-Level Impulse Noise, Hits and Dropouts Measurements, Transmitter (Sheet 1 of 2)

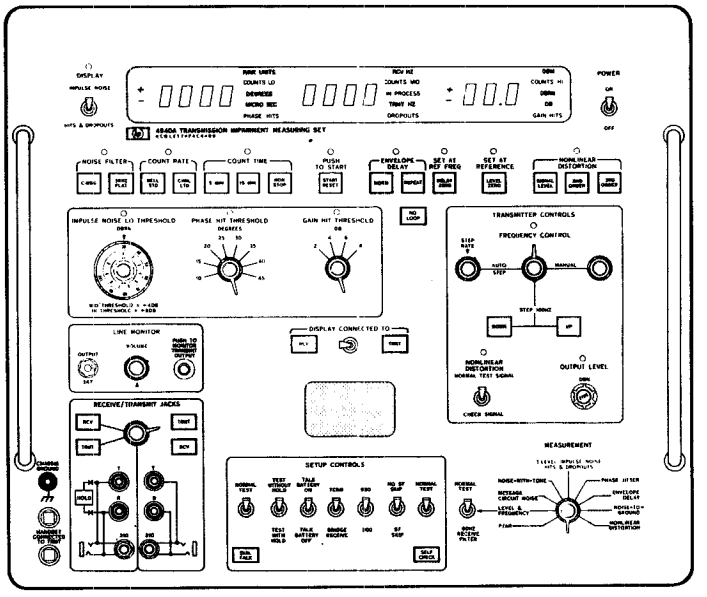
3-LEVEL IMPULSE NOISE, HITS & DROPOUTS TRANSMITTER

1. Rotate MEASUREMENT switch to 3-LEVEL IMPULSE NOISE HITS & DROPOUTS.
2. Throw DISPLAY CONNECTED TO key to TRMT.
3. Observe TRMT HZ on center display to verify that 1004 Hz is being transmitted.
4. Adjust OUTPUT LEVEL control for "Data Level" while observing DBM on right display.

DATA LEVEL

All transmission measurements should be made at Data Level. The Data Level for all presently specified data circuits is a power 13dB below the Transmission Level Point (TLP). For example, if the TLP is −16dBm, the Data Level would be −29dBm. Therefore, an output level of −29dBm would be applied in this case.

Figure 3-9. 3-Level Impulse Noise, Hits and Dropouts Measurements, Transmitter (Sheet 2 of 2)



3-12 Figure 3-10. 3-Level Impulse Noise, Hits and Dropouts Measurements, Receiver (Sheet 1 of 2)

3-LEVEL IMPULSE NOISE, HITS & DROPOUTS RECEIVER

1. Rotate MEASUREMENT switch to 3-LEVEL IMPULSE NOISE HITS & DROPOUTS.
2. Throw DISPLAY CONNECTED TO key to RCV.
3. Depress NOISE FILTER push-button (C-MSG or 3 KHZ FLAT) to select desired weighting.
4. Depress COUNT RATE push-button (BELL STD or CHNL LTD).
5. Depress COUNT TIME push-button (5 MIN, 15 MIN, or NON-STOP).
6. Rotate IMPULSE NOISE LO THRESHOLD switches to setting specified for the circuit under test.

NOTE

The general rule for determining the IMPULSE NOISE LO THRESHOLD setting is to add the threshold setting in dBrnCo (from the System Practice) to the TLP at the point of measurement.

7. Rotate PHASE HIT THRESHOLD switch to setting specified for the circuit under test.

NOTE

PHASE HIT THRESHOLD setting of 20 DEGREES recommended for most circuits. Consult applicable System Practice for specific recommendations.

8. Rotate GAIN HIT THRESHOLD switch to setting specified for the circuit under test.
9. Press START RESET push-button. The IN PROCESS annunciator will light for the duration of the count time.

NOTE

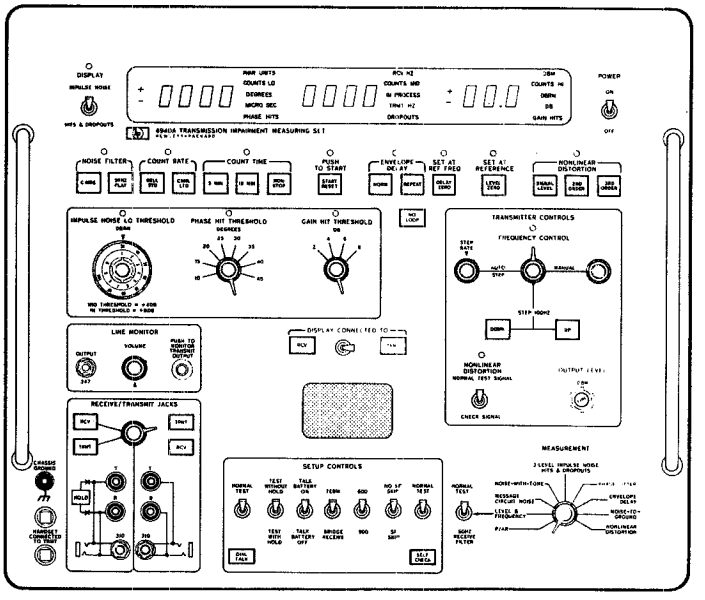
The (–) sign in the right display may light up momentarily after the START RESET button is pressed and during counting whenever a dropout is counted. This is normal. However, if the (–) sign remains lighted, it is an indication that the proper test tone is not being received.

10. Turn on LINE MONITOR by rotating VOLUME control until desired loudness is obtained in speaker or headphones. Listen for any predominant noise which can provide a clue as to the noise source.
11. At any time during or after the count time, the accumulated counts for impulse noise can be observed by throwing the DISPLAY key to IMPULSE NOISE. GAIN HITS, PHASE HITS, and DROPOUTS can be observed by throwing the DISPLAY key to HITS & DROPOUTS.
12. When the IN PROCESS annunciator goes out the total counts for the measurements period can be observed.

NOTE

To stop counting before the count time is expired (or when in NON-STOP) without erasing the display totals, rotate the threshold level switches to their maximum settings.

Figure 3-10. 3-Level Impulse Noise, Hits and Dropouts Measurements, Receiver (Sheet 2 of 2)



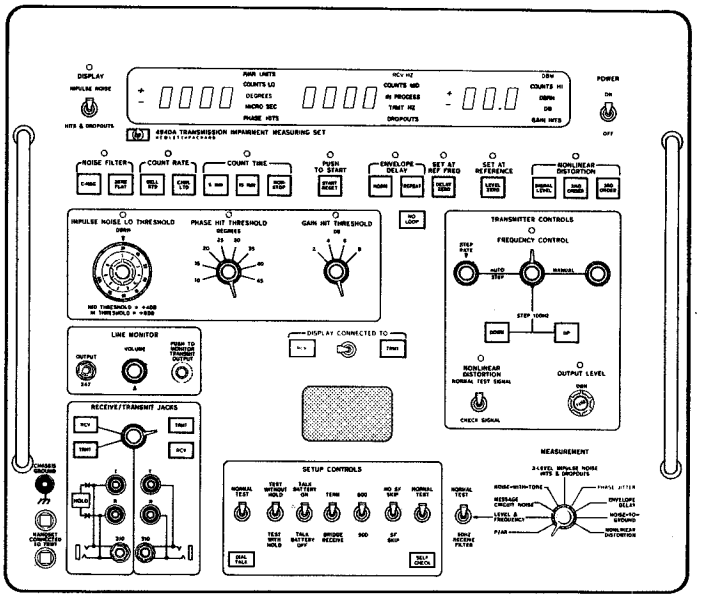
PHASE JITTER
TRANSMITTER

1. Rotate MEASUREMENT switch to PHASE JITTER.
2. Throw DISPLAY CONNECTED TO key to TRMT.
3. Observe TRMT HZ on center display to verify that 1004 Hz is being transmitted.
4. Adjust OUTPUT LEVEL control for "Data Level" while observing DBM on right display.

DATA LEVEL

All transmission measurements should be made at Data Level. The Data Level for all presently specified data circuits is a power 13 dB below the Transmission Level Point (TLP). For example, if the TLP is −16 dB, the Data Level would be −29 dBm. Therefore, an output level of −29 dBm would be applied in this case.

Figure 3-11. Phase Jitter Measurements, Transmitter



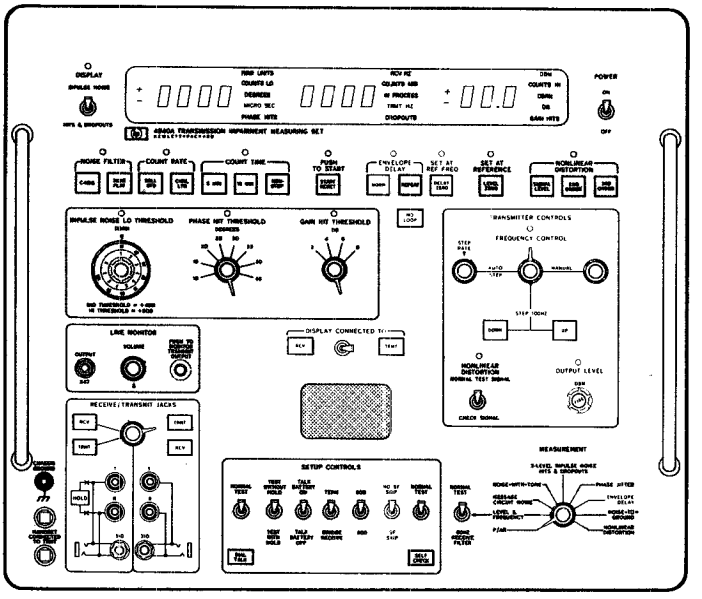
PHASE JITTER
RECEIVER

1. Rotate MEASUREMENT switch to PHASE JITTER.
2. Throw DISPLAY CONNECTED TO key to RCV.
3. Observe DBM received level on right display. This level must be −40dBm or greater for a valid measurement to be made.
4. Observe RCV HZ on center display. This frequency must be between 990Hz and 1030Hz.
5. Observe DEGREES phase jitter on left display. If the readings vary, observe for an arithmetic mean (average). [Display of only a (+) sign indicates that phase jitter is more than 25°.]

NOTE

Further analysis of phase jitter can be performed using auxiliary instruments. Signals as described on page 3-35 are available for this purpose.

Figure 3-12. Phase Jitter Measurements, Receiver



ENVELOPE DELAY
NORMAL TEST SET

1. Connect line to be tested to TRMT jack and connect return reference line to RCV jack.
2. Rotate MEASUREMENT switch to ENVELOPE DELAY.
3. Throw DISPLAY CONNECTED TO key to TRMT.
4. Depress NORM ENVELOPE DELAY push-button.
5. Adjust OUTPUT LEVEL control for "Data Level" while observing DBM on right display.

DATA LEVEL

All transmission measurements should be made at Data Level. The Data Level for all presently specified data circuits is a power 13dB below the Transmission Level Point (TLP). For example, if the TLP is −16dB, the Data Level would be −29dBm. Therefore, an output level of −29dBm would be applied in this case.

6. When the Repeat Test Set operator notifies you that he has adjusted to the desired transmission frequency (his Step 6 if Repeat Test Set is a TIMS), throw DISPLAY CONNECTED TO key to RCV.
7. Notify Repeat Test Set operator that you have completed your Step 6.

Figure 3-13. Envelope Delay Measurements, Normal Test Set (Sheet 1 of 2)

NOTE

Although the DISPLAY CONNECTED TO key is in the RCV mode, the center display will indicate TRMT HZ since this is the frequency of interest to the Normal Test Set operator.

8. Observe DBM on right display. This level must be −40dBm or greater for valid measurements.
9. Observe that NO LOOP annunciator is not lit.
10. Rotate FREQUENCY CONTROL switch to STEP 100HZ and set TRMT HZ on center display to reference frequency by pressing DOWN or UP push-buttons (e.g., 1804Hz, or frequency of minimum delay). Frequency can be set in MANUAL FREQUENCY CONTROL mode if necessary.
11. Observe ± MICRO SEC on left display. This reading may be very erratic for a few seconds until the loop stabilizes. When the display stabilizes so that only the units and tens digits are changing, press the DELAY ZERO push-button.

NOTE

This establishes a reference zero at the reference frequency. Typically, this reading will vary ±20 MICRO SEC. However, on very noisy circuits, the variation may be greater. A valid reference zero is established if these variations are evenly distributed above and below zero microseconds.

12. Observe TRMT HZ on center display. Select the desired test frequencies by pressing the STEP 100 HZ DOWN or UP push-buttons. Frequencies can also be stepped 100Hz automatically by rotating the FREQUENCY CONTROL switch to AUTO STEP and adjusting the STEP RATE control for the desired stepping rate. Frequencies other than those at the step points can be selected by rotating the FREQUENCY CONTROL switch to MANUAL and adjusting the MANUAL control for the desired frequency.

NOTE

If SF signaling units are used in the network under test, the SETUP CONTROLS key should be thrown to SF SKIP. This mode automatically blanks the transmitter output so that frequencies between 2450Hz and 2750Hz cannot be transmitted.

13. At each test frequency, observe ±MICRO SEC envelope delay on left display. If the readings vary, observe for an arithmetic mean (average).

NOTE

There are two conditions under which the test set will indicate to the operator that a valid envelope delay measurement cannot be made:

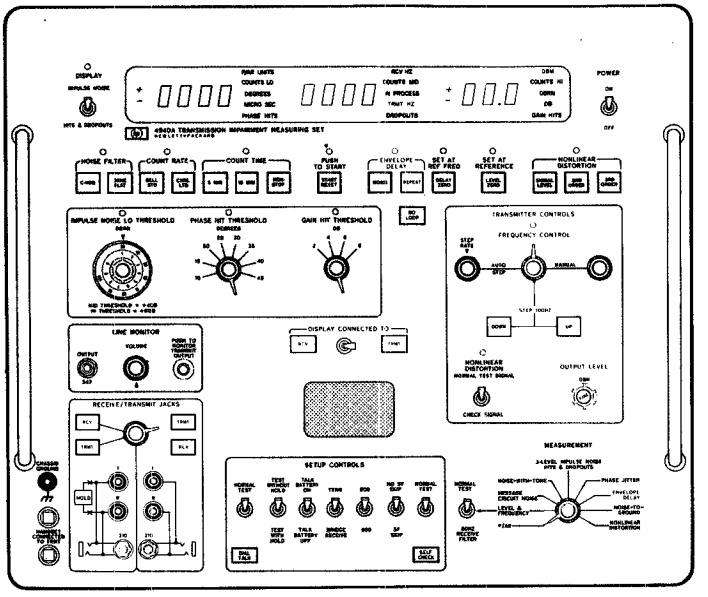
a. Under Range Condition: If the received level drops below −49dBm all three displays will blank and a (--) sign will appear in the right display. Usually the NO LOOP annunciator will also light up. This is a normal condition when the test set is in SF SKIP mode and the transmitter frequency controls are set in the 2450Hz to 2750Hz range. To clear this condition, merely readjust the frequency to outside the skip range. Measurements can proceed as soon as the MICRO SEC display stabilizes.

b. NO LOOP Condition: If the 83-1/3 Hz modulation frequency is lost the NO LOOP annunciator will light up. Whenever there is a signal loss due to a broken loop, the cause must be identified and corrected. When the loop is restored, measurements can proceed as soon as the MICRO SEC display stabilizes.

NOTE

The reference delay zero will be lost if the Normal Test Set's MEASUREMENT switch or DELAY ZERO push-button are disturbed. It will be necessary to return to Steps 10 and 11 to re-establish the reference zero.

Figure 3-13. Envelope Delay Measurements, Normal Test Set (Sheet 2 of 2)



3-18 Figure 3-14. Envelope Delay Measurements, Repeat Test Set (Sheet 1 of 2)

ENVELOPE DELAY
REPEAT TEST SET

1. Connect line to be tested to RCV jack and connect return reference line to TRMT jack.
2. Rotate MEASUREMENT switch to ENVELOPE DELAY.
3. Throw DISPLAY CONNECTED TO key to TRMT.
4. Depress REPEAT ENVELOPE DELAY push-button.
5. Adjust OUTPUT LEVEL control for "Data Level" while observing DBM on right display.

DATA LEVEL

All transmission measurements should be made at Data Level. The Data Level for all presently specified data circuits is a power 13dB below the Transmission Level Point (TLP). For example, if the TLP is −16dB, the Data Level would be −29dBm. Therefore, an output level of −29dBm would be applied in this case.

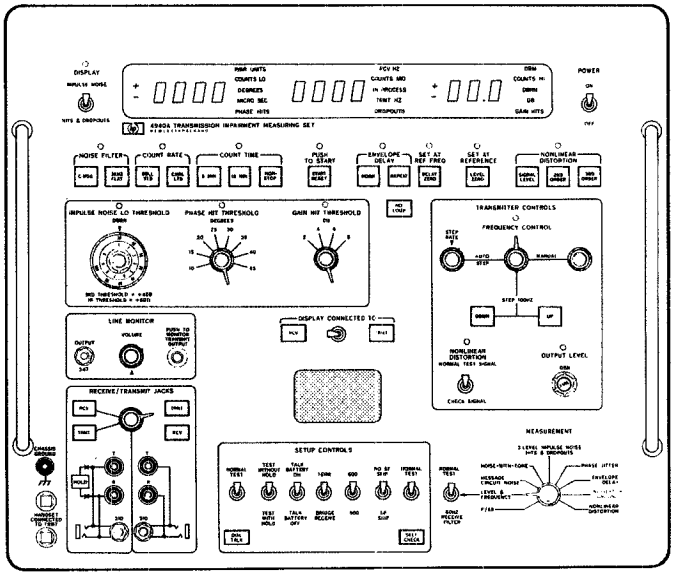
6. Rotate FREQUENCY CONTROL switch to STEP 100 HZ and set TRMT HZ on center display for desired transmission frequency on reference channel (e.g., 1804 Hz) by pressing DOWN or UP push-buttons.
7. Notify Normal Test Set operator that you have completed your Step 6.
8. When Normal Test Set operator notifies you that he has completed his Step 6 (if Normal Test Set is a TIMS), throw DISPLAY CONNECTED TO key to RCV.

NOTE

If the DISPLAY CONNECTED TO key is thrown back to TRMT at any time during the envelope delay measurements, the loop will be broken and the Normal Test Set will display erroneous measurement information.

9. Monitor DBM received level on right display to be sure it remains −40dBm or greater throughout the measurements.

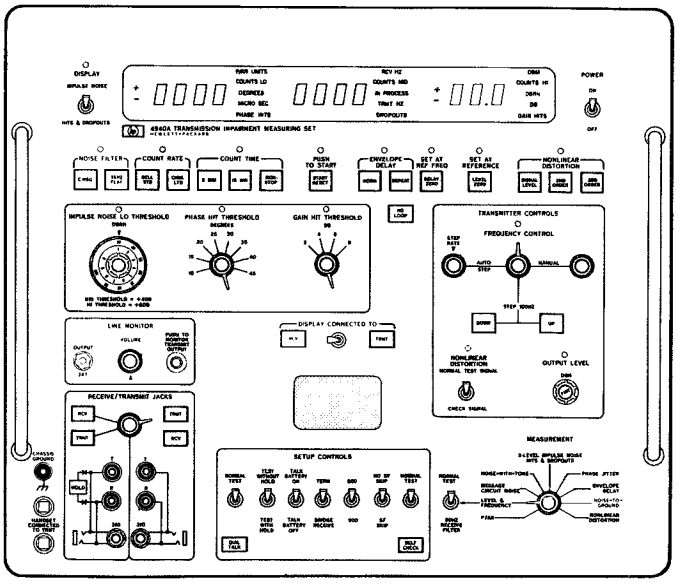
Figure 3-14. Envelope Delay Measurements, Repeat Test Set (Sheet 2 of 2)



NOISE-TO-GROUND
TRANSMITTER

1. Rotate MEASUREMENT switch to NOISE-TO-GROUND. This provides the TRMT jacks with a quiet termination.

Figure 3-15. Noise-to-Ground Measurements, Transmitter



NOISE-TO-GROUND RECEIVER

NOTE

The test set must be properly grounded for valid noise-to-ground measurements. Ground can be established through the power cord ground if there is a reliable power line bond; through the sleeve connections on the 310 RECEIVE/TRANSMIT JACKS; or by connecting the CHASSIS GROUND post to a known good ground.

1. Rotate MEASUREMENT switch to NOISE-TO-GROUND.
2. Throw DISPLAY CONNECTED TO key to RCV.
3. Depress NOISE FILTER button (C-MSG or 3KHZ FLAT) to select desired weighting.
4. Observe DBRN noise level on right display.

NOTE

TIMS provides actual noise-to-ground readings in dBrn. It is not necessary to add 40dB to the readings.

5. Turn on LINE MONITOR by rotating VOLUME control until desired loudness is obtained in speaker or headphones. Listen for any predominant tone which can provide a clue as to the noise source.

NOTE

This measurement is valid only on metallic (physical) circuits (end loops).

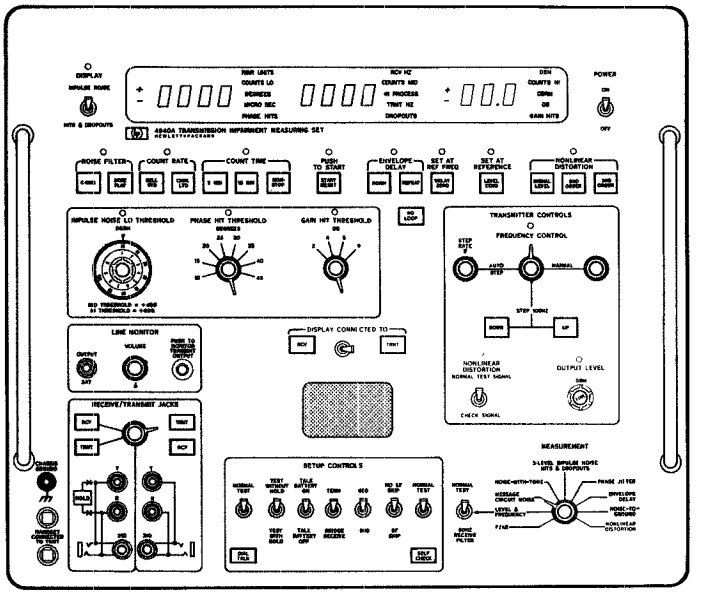
LINE BALANCE CALCULATION

6. A figure of merit for line balance can be calculated by measuring message circuit noise (N_m) and noise-to-ground (N_g) and applying the formula: Balance in dB = $N_m - N_g$ *(Note that it is not necessary to add 40dB to N_g in this equation.)*

NOTE

It is recommended that both of these measurements be made using the 3KHZ FLAT NOISE FILTER to account for the effects of power line related noise.

Figure 3-16. Noise-to-Ground Measurements, Receiver



NONLINEAR DISTORTION (Optional)
TRANSMITTER

1. Rotate MEASUREMENT switch to NONLINEAR DISTORTION.
2. Throw DISPLAY CONNECTED TO key to TRMT.
3. Adjust OUTPUT LEVEL control for "Data Level" while observing DBM on right display.

DATA LEVEL

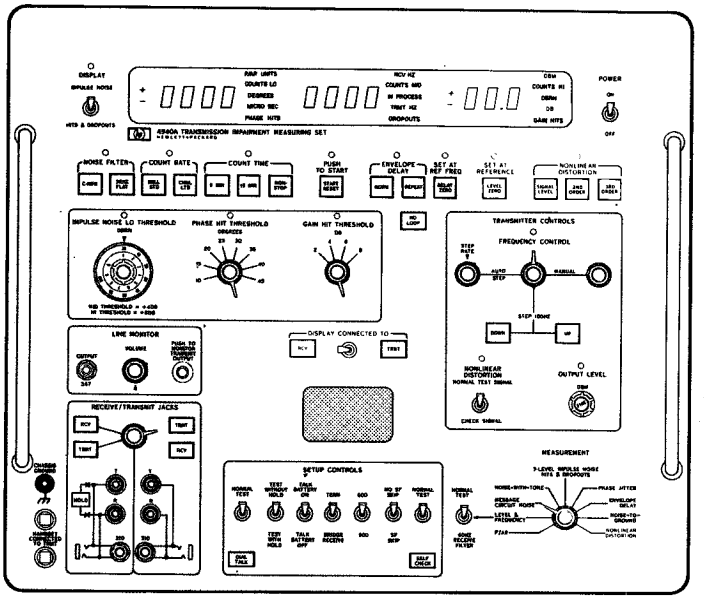
All transmission measurements should be made at Data Level. The Data Level for all presently specified data circuits is a power 13dB below the Transmission Level Point (TLP). For example, if the TLP is −16dB, the Data Level would be −29dBm. Therefore, an output level of −29dBm would be applied in this case.

NOTE

Maximum output level for nonlinear distortion is 0dBm.

4. When requested by receiver operator, hold NONLINEAR DISTORTION key in CHECK SIGNAL position.

Figure 3-17. Nonlinear Distortion Measurements, Transmitter



NONLINEAR DISTORTION (Optional)
RECEIVER

1. Rotate MEASUREMENT switch to NONLINEAR DISTORTION.
2. Throw DISPLAY CONNECTED TO key to RCV.
3. Depress SIGNAL LEVEL push-button.
4. Observe DBM received level on right display. This level must be −35dBm or greater for a valid measurement.

NOTE

The received level may take 15-20 seconds to stabilize.

5. Press LEVEL ZERO push-button. This establishes a 0dB reference so distortion products can be measured in dB relative to signal level.
6. Depress 2ND ORDER push-button.
7. Observe DB normal test signal level on right display (note this number).
8. Instruct transmitter operator to send CHECK SIGNAL.
9. Observe DB check signal level on right display (note this number).
10. Subtract check signal level reading (Step 9) from normal test signal level reading (Step 7). Refer to NOISE CORRECTION TABLE (use dB Relative column) and add the appropriate correction factor to the normal test signal reading. The result is NONLINEAR DISTORTION in dB.
11. Depress 3RD ORDER push-button and repeat Steps 7 through 10 to determine the 3rd order distortion level.

MEASURING DBM ABSOLUTE SIGNAL LEVEL

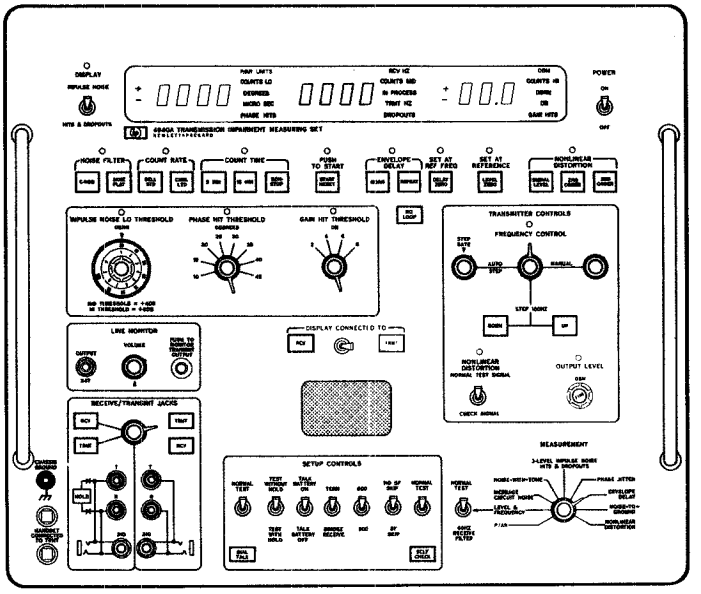
12. If measurement of distortion products directly in dBm is desired, do not perform Step 5. Proceed with Steps 6 through 11, observing DBM levels on right display. Use dBm Absolute column of NOISE CORRECTION TABLE and subtract the appropriate correction factor from the normal test signal reading.

NONLINEAR DISTORTION NOISE CORRECTION TABLE

Corrections to be made to 2nd and 3rd Order Nonlinear Distortion Measurements to correct for presence of noise		
dB difference between normal test signal and check signal readings	dB Relative Add to normal test signal reading	dBm Absolute Subtract from normal test signal reading
0	*	*
1	7	7
2	4	4
3	3	3
4-5	2	2
6-8	1	1
Over 8	0	0

*Zero difference indicates that distortion level is buried in noise. This can be interpreted as either extremely low distortion, or extremely high noise and should be further investigated.

Figure 3-18. Nonlinear Distortion Measurements, Receiver



P/AR (Optional)
TRANSMITTER

1. Rotate MEASUREMENT switch to P/AR.
2. Throw DISPLAY CONNECTED TO key to TRMT.
3. Adjust OUTPUT LEVEL control for "Data Level" while observing DBM on right display.

DATA LEVEL

All transmission measurements should be made at Data Level. The Data Level for all presently specified data circuits is a power 13dB below the Transmission Level Point (TLP). For example, if the TLP is −16dB, the Data Level would be −29dBm. Therefore, an output level of −29dBm would be applied in this case.

NOTE

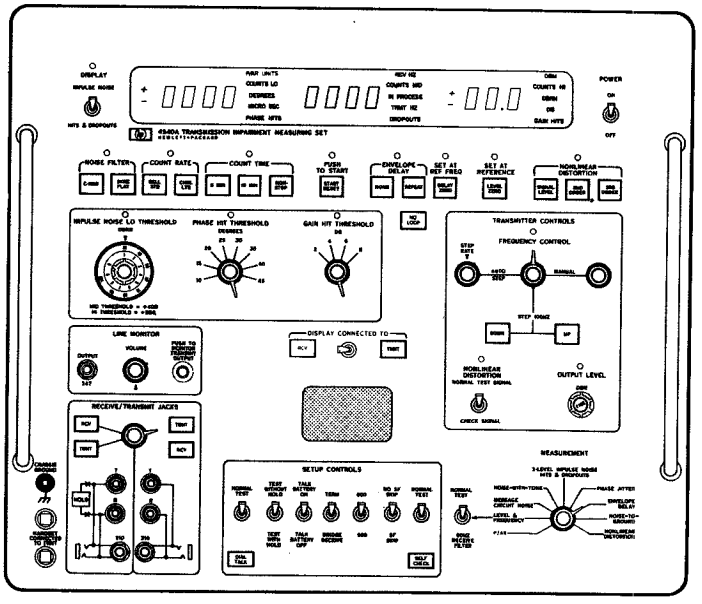
Maximum output for P/AR is 0 dBm.

4. Observe P/AR UNITS on left display and verify transmission of 99 to 101 P/AR units.

NOTE

The above P/AR measurement has been designed to improved specifications which overcome the effects of frequency translation and other phenomena; therefore, the TIMS P/AR measurement may not be compatible with other P/AR test sets.

Figure 3-19. P/AR Measurements, Transmitter



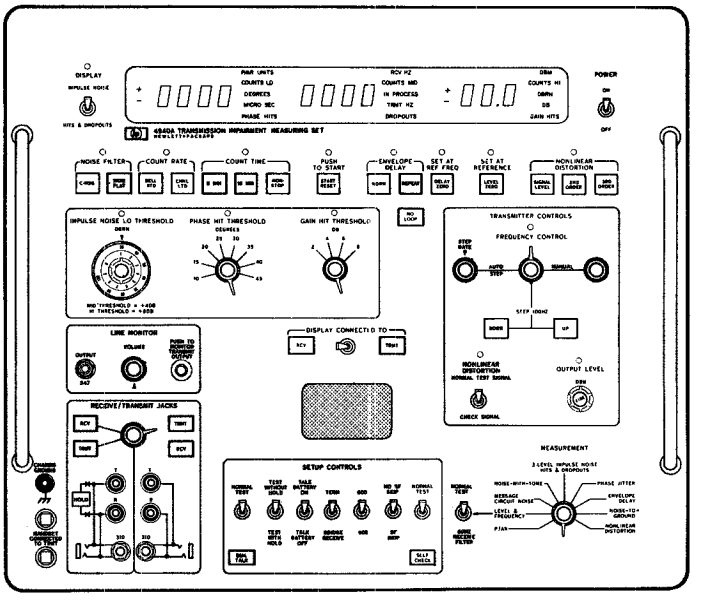
P/AR (Optional)
RECEIVER

1. Rotate MEASUREMENT switch to P/AR.
2. Throw DISPLAY CONNECTED TO key to RCV.
3. Observe DBM received level on right display. This level must be −40dBm or greater for a valid measurement.
4. Observe P/AR UNITS on left display.

NOTE

The above P/AR measurement has been designed to improved specifications which overcome the effects of frequency translation and other phenomena; therefore, the TIMS P/AR measurement may not be compatible with other P/AR test sets.

Figure 3-20. P/AR Measurements, Receiver



SELF-CHECK

NOTE

The SELF CHECK procedure should be performed periodically to verify performance of the test set. SELF CHECK is recommended before transporting the test set to a remote testing site; or whenever there is any doubt about transmission measurement results. Failure of the test set to pass any SELF CHECK indicates a malfunction that can possibly affect other measurements. It is therefore recommended that a complete SELF CHECK always be performed to determine which measurement modes are valid.

1. PRELIMINARY SETUP:
   a. Disconnect test set from on-line testing.
   b. Loop TRMT jack to RCV jack.
   c. Throw far right-hand SETUP CONTROLS key to SELF CHECK. Throw all other SETUP CONTROLS keys to up position.
   d. Throw DISPLAY CONNECTED TO key to RCV.

2. P/AR SELF CHECK (Optional):
   a. Rotate MEASUREMENT switch to P/AR.
   b. Verify a reading of 99 to 101 P/AR UNITS on left display.
   c. Verify a reading of −1 to +1 DBM on right display.

3. LEVEL & FREQUENCY SELF CHECK:
   a. Rotate MEASUREMENT switch to LEVEL & FREQUENCY.
   b. Rotate FREQUENCY CONTROL switch to STEP 100 HZ.
   c. Verify a reading of 1004 RCV HZ on center display.
   d. Verify a reading of −0.2 to +0.2 DBM on right display.

4. MESSAGE CIRCUIT NOISE AND INDICATOR LAMPS SELF CHECK:
   a. Rotate MEASUREMENT switch to MESSAGE CIRCUIT NOISE.
   b. Depress C-MSG NOISE FILTER push-button.
   c. Verify a reading of 89 to 91 DBRN on right display.
   d. Verify that all 15 indicator dot lamps are lit.

Figure 3-21. Self Check Procedures (Sheet 1 of 3)

5. NOISE-WITH-TONE SELF CHECK:
   a. Rotate MEASUREMENT switch to NOISE-WITH-TONE.
   b. Depress C-MSG NOISE FILTER push-button.
   c. Verify a reading of 58 to 62 DBRN on right display at the end of one minute.
   d. Verify a reading of 1003 to 1005 RCV HZ on center display.

6. 3-LEVEL IMPULSE NOISE HITS & DROPOUTS SELF-CHECK:
   a. Rotate MEASUREMENT switch to 3-LEVEL IMPULSE NOISE HITS & DROPOUTS.
   b. Depress C-MSG NOISE FILTER push-button.
   c. Depress BELL STD COUNT RATE push-button.
   d. Depress NON-STOP COUNT TIME push-button.
   e. Throw DISPLAY key to IMPULSE NOISE.
   f. Rotate IMPULSE NOISE LO THRESHOLD switch to 69 DBRN.
   g. Wait 30 seconds, then press START RESET push-button and verify that IN PROCESS annunciator is lit.
   h. Decrease IMPULSE NOISE LO THRESHOLD switch setting one dBrn at a time until COUNTS LO on left display start counting at a rate of at least one count per second. Verify that this setting is 62 to 66 dBrn.
   i. Continue to decrease IMPULSE NOISE LO THRESHOLD switch setting one dBrn at a time until COUNTS MID on center display start counting at a rate of at least one count per second. Verify that this setting is 3 to 5 dBrn below the setting in Step h.
   j. Continue to decrease IMPULSE NOISE LO THRESHOLD switch setting one dBrn at a time until COUNTS HI on right display start counting at a rate of at least one count per second. Verify that this setting is 7 to 9 dBrn below the setting in Step h.
   k. Verify that all counts accumulate by 1's.

NOTE

Although each display will be counting by 1s, they will not necessarily count at the same rate. It is not unusual to have different counts for COUNTS LO, COUNTS MID, and COUNTS HI.

   l. Depress CHNL LTD COUNT RATE push-button.
   m. Press START RESET push-button and verify that counts are now changing at a much greater rate than before.
   n. Throw DISPLAY key to HITS & DROPOUTS
   o. Rotate GAIN HIT THRESHOLD switch to 2 DB.
   p. Rotate PHASE HIT THRESHOLD switch to 15 DEGREES.
   q. Press START RESET push-button and verify that PHASE HITS and GAIN HITS accumulate by 2's and that DROPOUTS accumulate by 1's. A (−) sign should flash in the right display for every dropout that is counted.
   r. Rotate GAIN HIT THRESHOLD switch to 4 DB and verify that GAIN HITS stop being counted. Return GAIN HIT THRESHOLD switch to 2 DB.
   s. Rotate PHASE HIT THRESHOLD switch to 20 DEGREES and verify that PHASE HITS stop being counted. Return PHASE HIT THRESHOLD switch to 15 DEGREES.
   t. Depress BELL STD COUNT RATE push-button.
   u. Press START RESET push-button and verify that PHASE HITS, DROPOUTS, and GAIN HITS accumulate by 1's.

7. PHASE JITTER SELF CHECK:
   a. Rotate MEASUREMENT switch to PHASE JITTER.
   b. Verify a reading of 10.6 to 12.2 DEGREES on left display at the end of one minute.
   c. Verify a reading of 999 to 1009 RCV HZ on center display.
   d. Verify a reading of −1 to +1 DBM on right display.

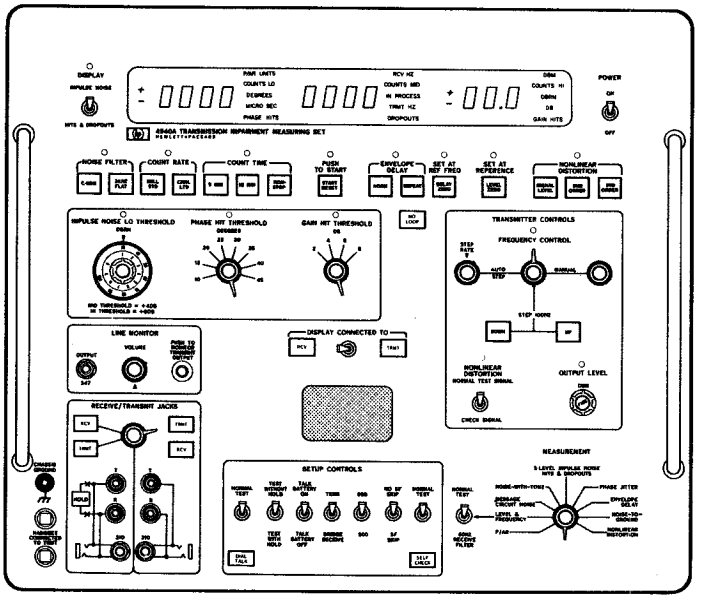
Figure 3-21. Self Check Procedures (Sheet 2 of 3)

8. ENVELOPE DELAY SELF CHECK:
   a. Rotate MEASUREMENT switch to ENVELOPE DELAY.
   b. Throw far right-hand SETUP CONTROLS key to NORMAL TEST.
   c. Depress NORM ENVELOPE DELAY push-button.
   d. Set frequency to 1004 TRMT HZ on center display by pressing STEP 100 HZ UP or DOWN push-buttons.
   e. Set OUTPUT LEVEL to 0 DBM on right display.
   f. Wait 15 seconds, then press DELAY ZERO push-button.
   g. Throw far right-hand SETUP CONTROLS key to SELF CHECK.
   h. Verify a reading of 2995 to 3005 MICRO SEC on left display at the end of 15 seconds.
   i. Verify a reading of −0.2 to +0.2 DBM on right display.
   j. Disconnect loop cord from TRANSMIT/RECEIVE JACKS. Verify that NO LOOP annunciator is lit, that all displays are blank, and that a (−) sign appears in the right display. Reconnect loop cord.

9. NOISE-TO-GROUND SELF CHECK:
   a. Rotate MEASUREMENT switch to NOISE-TO-GROUND.
   b. Depress C-MSG NOISE FILTER push-button.
   c. Verify a reading of 83 to 85 DBRN on right display.

10. NONLINEAR DISTORTION SELF CHECK (Optional):
   a. Rotate MEASUREMENT switch to NONLINEAR DISTORTION.
   b. Depress SIGNAL LEVEL push-button.
   c. Verify a reading of −1 to +1 DBM on right display at the end of 15 seconds.
   d. Press LEVEL ZERO push-button.
   e. Verify a reading of −0 DB on right display.
   f. Depress 2ND ORDER push-button.
   g. Verify a reading of +6 to +8 DB on right display at the end of 15 seconds.
   h. Depress 3RD ORDER push-button.
   i. Verify a reading of +6 to +8 DB on right display at the end of 15 seconds.

Figure 3-21. Self Check Procedures (Sheet 3 of 3)



LAMP CHECKS AND REPLACEMENT

1. INDICATOR DOT LAMPS CHECK:
   a. Refer to MESSAGE CIRCUIT NOISE SELF CHECK.

   NOTE

   Replacement of indicator dot lamps requires special equipment and procedures and should be performed only by authorized repair shops.

2. DISPLAY ANNUNCIATOR LAMPS CHECK:
   a. Display annunciator lamps can be checked while performing SELF CHECK procedures.
   b. Verify that all display annunciator lamps illuminate evenly. Each annunciator employs two lamps for backup reliability; therefore, uneven illumination may indicate a burned out lamp.

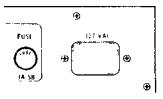
   NOTE

   Replacement of display annunciator lamps requires special equipment and procedures and should be performed only by authorized repair shops.

3. PANEL ANNUNCIATOR LAMPS CHECK:
   a. Rotate RECEIVE/TRANSMIT JACKS switch and verify that both sets of RCV and TRMT annunciator lamps light properly.
   b. Throw DISPLAY CONNECTED TO key between RCV and TRMT positions and verify that RCV and TRMT lamps light properly.
   c. Throw SETUP CONTROLS key to DIAL/TALK and verify that DIAL/TALK lamp lights properly.
   d. Throw SETUP CONTROLS key to SELF CHECK and verify that SELF CHECK lamp lights properly.
   e. Refer to ENVELOPE DELAY SELF CHECK to verify that NO LOOP lamp lights properly.

4. PANEL ANNUNCIATOR LAMPS REPLACEMENT:
   a. Switch POWER off.
   b. Insert fingernail in indentation at bottom of lens cap and pry up and out to remove lens cap.
   c. Gently grasp lamp base with needle-nose pliers and pull up and out to remove lamp.
   d. Insert new lamp with needle-nose pliers and replace lens cap. A spare lamp is located in the test set cover. In the rack mount versions, the spare lamp is located on the panel above the test set. Replace lamp with HP Part No. 2140-0405. (Oshino OL-685BPC, or equivalent).

Figure 3-22. Lamp Checks and Replacement

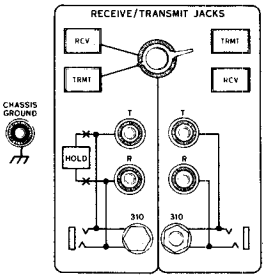


POWER CORD RECEPTACLE AND FUSE

117V AC (± 10%) 60Hz power is applied to the test set through the male power cord receptacle located on top of the test set. AC line fusing is provided by a 3 Amp (Slo Blo) fuse located in the fuse holder next to the power receptacle. A spare fuse is located in the test set cover. In the rack mount versions, the spare fuse is located on the panel above the test set.

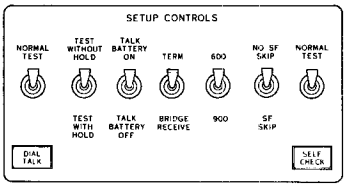
POWER SWITCH

POWER toggle switch turns the test set ON and OFF.



RECEIVE/TRANSMIT JACKS

A two position rotary switch is used to reverse the connections of the left and right jack fields. When the switch is in the up position, the left jacks are connected for RCV and the right jacks for TRMT. When the switch is in the down position, connections are reversed. Connections are indicated by the RCV and TRMT annunciators. Connections can be made either to the 310 jacks, or to the T (tip) and R (ring) binding posts, which are multipled. The left jack field should always be used for 2-wire wet transmit and receive connections; the right jack field for 2-wire dry connections. Both left and right jack fields are used for 4-wire connections. The CHASSIS GROUND binding post can be used to establish a ground reference if an adequate ground cannot be established through the 310 jack sleeves or power line plug.



SETUP CONTROLS

NORMAL TEST – DIAL/TALK

In NORMAL TEST mode the selected TRMT jack is connected to the test set's transmitter circuitry, but not to the lineman's handset posts. In DIAL/TALK mode the TRMT jack is connected to the lineman's handset posts, but not to the transmitter circuitry.

TEST WITHOUT HOLD – TEST WITH HOLD

In TEST WITHOUT HOLD mode the test set holding circuit is disconnected from the RECEIVE/TRANSMIT JACKS. In TEST WITH HOLD mode the holding circuit is connected across tip and ring of the left jack field to hold 2-wire wet (DDD) circuits while testing.

TALK BATTERY ON – TALK BATTERY OFF

In TALK BATTERY ON mode the test set provides the necessary talk battery to the lineman's handset to talk on dry circuits. In TALK BATTERY OFF mode, talk battery must be supplied by the circuit under test if talking is desired.

TERM – BRIDGE RECEIVE

In TERM mode the test set provides a termination on both the RCV and TRMT circuits. The desired terminating impedance must be selected with the 600/900 key. In BRIDGE RECEIVE mode the receiving test set is bridged across the line under test, which is terminated with another device.

NOTE

When using the BRIDGE RECEIVE mode it is still necessary to select the impedance of the line under test with the 600/900 key in order to normalize the measurements.

Figure 3-23. Description of Controls, Connectors, and Indicators (Sheet 1 of 6)

600 – 900

The 600Ω or 900Ω mode must be selected to match the characteristic impedance of the line under test. When operating in the TERM mode, both the TRMT and RCV lines are terminated in the selected impedance. When operating in the BRIDGE RECEIVE mode, the TRMT line is terminated in the selected impedance and the RCV line is bridged by more than 50kΩ. The selection also normalizes level measurements for the respective impedances.

NO SF SKIP – SF SKIP

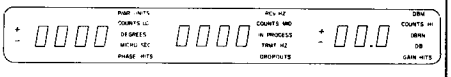
In NO SF SKIP mode the test set will transmit all selected frequencies. In SF SKIP mode the test set will not transmit any frequencies between 2450Hz and 2750Hz. This is to prevent the circuit under test from being disconnected by SF signaling units in the dial-up network.

NORMAL TEST – SELF CHECK

In NORMAL TEST mode the test set performs normal testing. In SELF CHECK mode proper operation of the test set can be verified by making measurements on its built-in self check circuitry.

HANDSET CONNECTED TO TRMT POSTS

Two "cuff-link" posts provide the connection terminals for a lineman's handset (butt-in). The terminals are connected to the selected TRMT jack when the DIAL/TALK mode is selected.

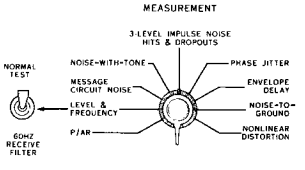


DIGITAL DISPLAYS

Three digital displays provide measurement units and quantitative information for all measurements. Ranging is automatic, and polarity and decimal points are automatically displayed when appropriate. Up to three parameters can be displayed simultaneously. The displays also indicate underrange and overrange conditions. Display of only a (–) sign indicates underrange. Display of only a (+) sign indicates overrange.

DISPLAY CONNECTED TO KEY

The digital displays will present either the transmitted or received quantities when the DISPLAY CONNECTED TO key is thrown to TRMT or RCV, respectively.



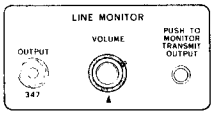
MEASUREMENT SWITCH

The MEASUREMENT switch programs the test set to perform the selected measurement. The MEASUREMENT switch sets up indicator dot lamps, guiding the operator to other controls which need to be selected. Adjacent to the LEVEL & FREQUENCY position is the NORMAL TEST/60 Hz RECEIVE FILTER key. When the spring return key is held down in the 60 Hz RECEIVE FILTER position, a high pass filter attenuates 60 Hz power hum on the received signal. This filter reduces level measurement error caused by power line related noise. The filter is disconnected in the NORMAL TEST position.

NOTE

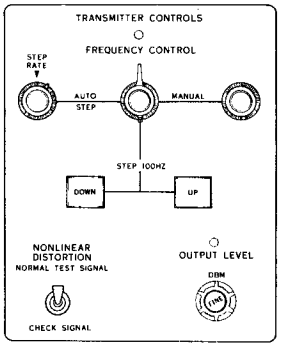
P/AR and NONLINEAR DISTORTION measurements are optional features and may not appear on some configurations of the test set.

Figure 3-23. Description of Controls, Connectors, and Indicators (Sheet 2 of 6)



LINE MONITOR

The LINE MONITOR permits listening to the line under test, or the test set transmitter, on the built-in speaker or an external headset. The LINE MONITOR is normally connected to the receive line. To monitor the transmit line, press the PUSH TO MONITOR TRANSMIT OUTPUT push-button. When a plug is inserted in the 347 OUTPUT jack, the speaker is disconnected and the amplifier drives a headset or other device connected (must have an impedance of 150Ω or greater). An oscilloscope, spectrum analyzer, or other measuring device can also be connected to the LINE MONITOR OUTPUT for further analysis of the line under test. The output is an amplified reproduction of signals on the line (except in noise measurements, where the output amplitude is weighted by the selected NOISE FILTER).



TRANSMITTER CONTROLS

FREQUENCY CONTROL SWITCH

The FREQUENCY CONTROL switch is a three position rotary switch which selects the transmitter frequency control mode. In AUTO STEP mode the frequency is automatically stepped in 100Hz increments from 204Hz to 3904Hz at a rate controlled by the STEP RATE control. Frequencies are stepped repetitively up and down between the two limits, beginning at the point where the transmitter frequency is initially set. In STEP 100 HZ mode the frequency is manually stepped in 100Hz increments from 204Hz to 3904Hz by pressing the UP or DOWN push-buttons. (The STEP 100 HZ UP or DOWN push-buttons are also active in the AUTO STEP mode and can be used to override automatic stepping.) In MANUAL mode frequency is continuously variable over the range of 200Hz to 3904Hz by adjusting the MANUAL control.

OUTPUT LEVEL CONTROL

The OUTPUT LEVEL control varies the output continuously over the range of −49dBm to +10dBm (to 0dBm for P/AR and NONLINEAR DISTORTION). Output level is adjusted while observing DBM on the right display.

NONLINEAR DISTORTION KEY

(This control is present only on test sets with the NONLINEAR DISTORTION option.) The NONLINEAR DISTORTION key permits comparison of a normal test signal and a check signal so that compensation for background noise can be made. When the key is in the NORMAL TEST SIGNAL position, two pairs of tones, centered at 860Hz and 1380Hz, are transmitted. When the spring return key is held in the CHECK SIGNAL position, power of the 860Hz tones is doubled and the 1380Hz tones are turned off.

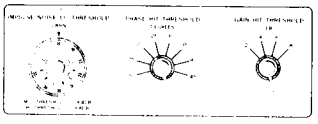
NOISE FILTER PUSH-BUTTONS

The NOISE FILTER push-buttons allow selection of either C-MSG or 3 KHZ FLAT noise weighting filters. Depressing a push-button activates the selected filter.

DISPLAY KEY

The DISPLAY key is used in conjunction with 3-LEVEL IMPULSE NOISE HITS & DROPOUTS measurements. When the key is thrown to IMPULSE NOISE position the displays will show COUNTS LO, COUNTS MID, and COUNTS HI. When the key is thrown to HITS & DROPOUTS position the displays will show PHASE HITS, DROPOUTS, and GAIN HITS. The three parameters not being exhibited are stored in the test set memory until they are recalled by the DISPLAY key. The key can also be operated while the measurements are in process to monitor a desired count accumulation.

Figure 3-23. Description of Controls, Connectors, and Indicators (Sheet 3 of 6)



IMPULSE NOISE LO THRESHOLD SELECTOR

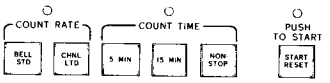
The IMPULSE NOISE LO THRESHOLD selector is a two level concentric rotary switch which sets the desired lower "window" for impulse noise counts. The setting, in dBrn, is the total of the outer ring (tens) and the inner ring (units) alignment at the index mark. The test set will totalize as COUNTS LO, impulses whose peaks are above the selected threshold. The MID THRESHOLD is fixed at 4dB above the LO THRESHOLD setting. The test set will totalize as COUNTS MID, impulses whose peaks are above the MID THRESHOLD. The HI THRESHOLD is fixed at 8dB above the LO THRESHOLD setting. The test set will totalize as COUNTS HI, impulses whose peaks are above the HI THRESHOLD.

PHASE HIT THRESHOLD SWITCH

The PHASE HIT THRESHOLD switch selects the desired threshold for phase hit counts. The test set will totalize as PHASE HITS, rapid changes of phase that exceed the switch setting.

GAIN HIT THRESHOLD SWITCH

The GAIN HIT THRESHOLD switch selects the desired threshold for gain hit counts. The test set will totalize as GAIN HITS, rapid changes of gain that exceed the switch setting.



COUNT RATE PUSH-BUTTONS

The COUNT RATE push-buttons are used in conjunction with 3-LEVEL IMPULSE NOISE HITS & DROPOUTS measurements. When the BELL STD push-button is depressed the maximum rate at which counts can be totalized is limited to seven counts per second (per Bell Tariff). When the CHNL LTD push-button is depressed the maximum rate at which counts can be totalized is limited only by the channel bandwidth and the selected NOISE FILTER in the test set.

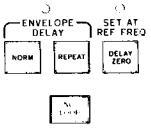
COUNT TIME PUSH-BUTTONS

The COUNT TIME push-buttons are used in conjunction with 3-LEVEL IMPULSE NOISE HITS & DROPOUTS measurements. When the 5 MIN push-button is depressed, the test set will totalize counts for 5 minutes from the time the START RESET push-button is pressed. Likewise, the 15 MIN push-button will provide a 15 minute counting interval. The IN PROCESS annunciator will light up during the counting interval and will extinguish when the interval is completed. When the NON-STOP push-button is depressed, the test set will totalize counts indefinitely from the time the START RESET push-button is pressed. The count time will cease and the displays reset to zero when another COUNT TIME push-button is depressed; when the START RESET push-button is pressed; when the MEASUREMENT switch is rotated; or when POWER is switched off.

START RESET PUSH-BUTTON

The START RESET push-button is used in conjunction with 3-LEVEL IMPULSE NOISE HITS & DROPOUTS measurements. When pressed, the push-button clears the displays of their previous counts and initiates a new count period.

Figure 3-23. Description of Controls, Connectors, and Indicators (Sheet 4 of 6)



ENVELOPE DELAY PUSH-BUTTONS

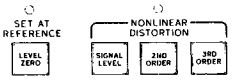
The ENVELOPE DELAY NORM and REPEAT push-buttons determine whether the test set will be used to measure envelope delay (NORM) or to re-transmit the envelope delay signal from the far-end of the circuit (REPEAT).

DELAY ZERO PUSH-BUTTON

The DELAY ZERO push-button is used in conjunction with ENVELOPE DELAY measurements. When the normal test set is adjusted to the desired reference frequency, pressing the DELAY ZERO push-button will establish a zero microsecond delay reference. All subsequent envelope delay measurements are relative to this reference point.

NO LOOP ANNUNCIATOR

The NO LOOP annunciator will light up if the envelope delay loop is broken, or if the channel is attenuating either the transmit or receive signal to the extent that accurate readings cannot be made.



LEVEL ZERO PUSH-BUTTON

The LEVEL ZERO push-button is used in conjunction with LEVEL & FREQUENCY; and NONLINEAR DISTORTION measurements. When the test set is adjusted to the desired reference frequency, pressing the LEVEL ZERO push-button will establish a zero dB reference. All subsequent measurements will be made in dB relative to this reference point. If this push-button is not pressed, measurements will be in absolute dBm.

NOTE

If LEVEL ZERO push-button is pressed and it is desired to make an absolute dBm measurement, momentarily rotate the MEASUREMENT switch out of the selected mode, then back again.

NONLINEAR DISTORTION PUSH-BUTTONS

(These push-buttons are present only on test sets with the NONLINEAR DISTORTION option.) The SIGNAL LEVEL push-button allows measurement of the total received level of the nonlinear distortion test signal. Depressing the 2ND ORDER push-button allows measurement of only second order distortion products. Likewise, depressing the 3RD ORDER push-button allows measurement of only third order distortion products.

Figure 3-23. Description of Controls, Connectors, and Indicators (Sheet 5 of 6)

PHASE JITTER OUTPUT CONNECTORS

CARRIER

The CARRIER output provides a square wave output signal whose frequency is equal to the received carrier frequency. The CARRIER output may be used to synchronize an oscilloscope to measure phase jitter of the received signal (as accessed thrpugh the LINE MONITOR-OUTPUT). The signal level is TTL derived, with a nominal 10 k-ohms source impedance. The square wave signal is derived from the Phase Jitter VCO or Frequency Tracking VCO, dependent on the MEASUREMENT switch position. The VCO will track a received signal over the frequency range specified for the receiver in that MEASUREMENT switch position.

PM (Phase Modulation)

The PM output provides an output proportional to the instantaneous phase deviation of the received signal when the MEASUREMENT switch is in the PHASE JITTER position. The PM output may be used for phase jitter spectral analysis. The table below provides the performance characteristics of this output.

PM OUTPUT PERFORMANCE CHARACTERISTICS

Source Impedance: Nominal 10 k-ohms
Phase Response: 0-60° nominal
Bandwidth: 20 Hz - 300 Hz
Sensitivity: 0.1 volts peak-to-peak/degree (± 10%)

Figure 3-23. Description of Controls, Connectors, and Indicators (Sheet 6 of 6)

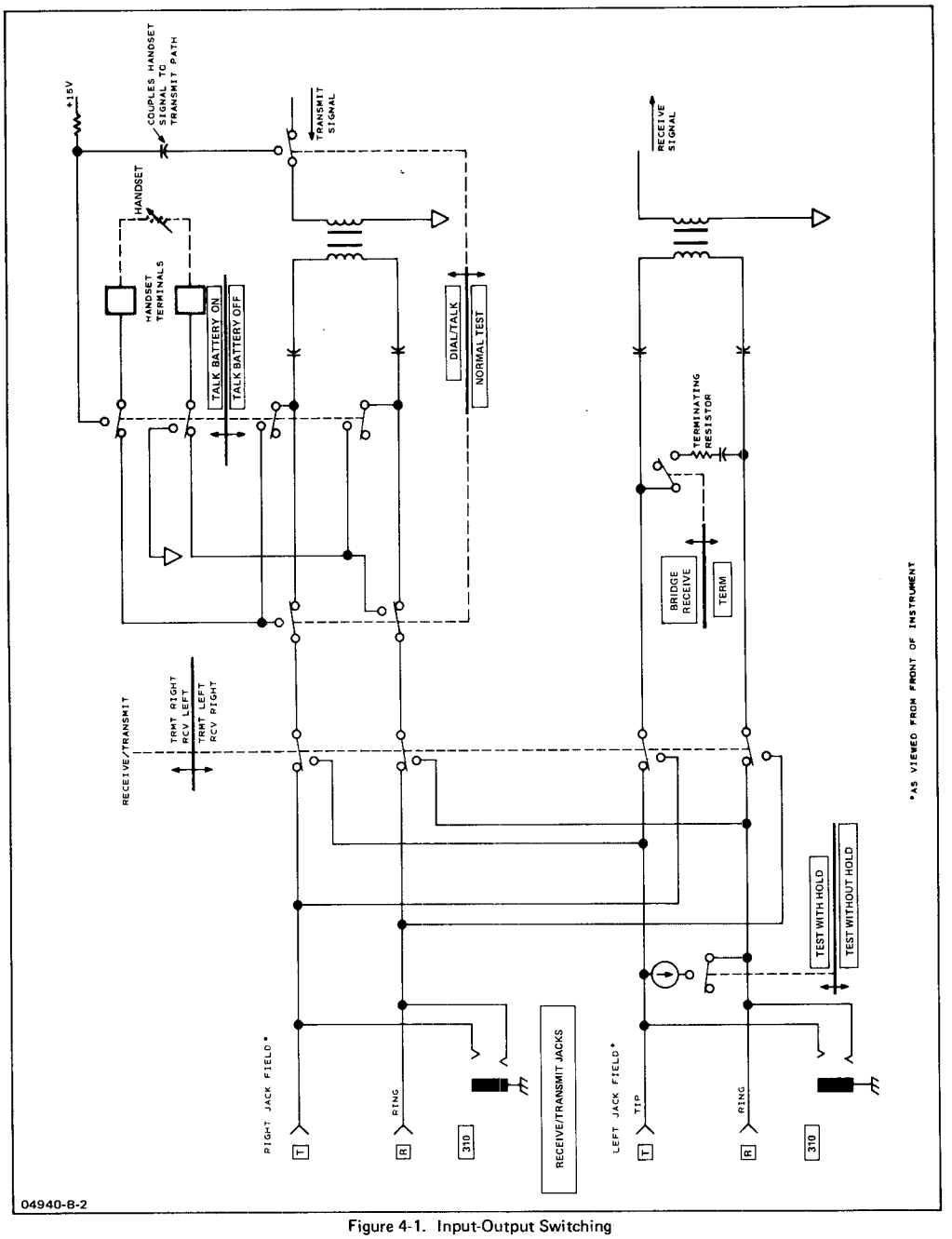


Figure 4-1. Input-Output Switching

4-1. INTRODUCTION.

4-2. This section describes the principles of all measurements made by the Transmission Impairment Measuring Set (TIMS). Included are explanations of the need for the measurements, plus the effect of certain voice channel parameters on data transmission. Block diagrams and functional descriptions are provided to explain the TIMS input-output switching and the different measurements which the test set will make.

4-3. For further information concerning the voice channel measurements described in this section, refer to the following Bell System Technical References: PUB 41008, *Analog Parameters Affecting Voiceband Data Transmission — Description of Parameters,* and PUB 41009, *Transmission Parameters Affecting Voiceband Data Transmission — Measuring Techniques.* These publications are available from Supervisor — Information Distribution Center, American Telephone and Telegraph Co., 195 Broadway, Room 208, New York, N.Y. 10007.

4-4. INPUT-OUTPUT SWITCHING.

4-5. The RECEIVE/TRANSMIT JACKS provide for interconnection of TIMS to the circuit under test. See figure 4-1. The RECEIVE/TRANSMIT switch provides for selection of either the transmit or receive function for the left jack field, and simultaneously selects the opposite for the right jack field. Both the left and right jack fields provide parallel (multipled) connection jacks: standard five-way binding posts on top and Western Electric 310 type jacks on the bottom. Either the binding posts or the 310 jacks may be used; both of them will not normally be used at the same time.

4-6. If a 2-wire wet (direct distance dialing — DDD) circuit is under test, the left jack field will normally be used to allow application of the 21 mA current source, for latching of telephone switching equipment (TEST WITH HOLD). Either the left or right jack field may be used for a 2-wire dry circuit (data access arrangement — DAA). If a 4-wire circuit (dedicated data circuit) is under test, the left jack field may be used for either transmit or receive, and the right field the opposite.

4-7. The input and output impedance of TIMS is selectable at either 600 or 900 ohms (not shown in figure 4-1), which are standard telephone circuit values. The impedance of the test set must be selected to match the circuit under test, or erroneous measurement values will be obtained.

4-8. The receive input may be terminated or bridged across the circuit under test. The terminated mode provides a resistive termination on the receive circuit to provide proper loading. When a termination is provided by some other device, then it is not necessary (nor desirable) to provide a termination. In this case the receive input should be used in the bridged mode, which provides a high impedance receive input (greater than 50 k-ohms).

4-9. The TIMS input and output circuits are balanced to match standard telephone voice channel lines. A balanced line is one that is electrically symmetrical; the two sides of the line have equal series resistance, series inductance, shunt capacitance, and leakage to ground. Only test sets (or other devices) with balanced inputs and outputs will operate properly when connected to a balanced line. If it is desired to use some device with an unbalanced input (for instance an oscilloscope or spectrum analyzer) to monitor the signal on the balanced line, then the device can be connected to the LINE MONITOR OUTPUT. This output is an unbalanced, amplified reproduction of the signal on the line (except in noise measurements, where the output amplitude is weighted by the selected NOISE FILTER).

4-10. To allow dialing, talking, and listening over the circuit under test, handset terminals (or "cuff links") are provided for the connection of a lineman's handset. In addition, talk battery is selectable for use on dry circuits (circuits which do not incorporate a power source to provide direct current flow for talking).

4-11. DATA LEVEL.

4-12. Transmission measurements on data circuits use test signals applied at data level (the standard Bell System data level is -13 dBmO). Data level is used to prevent overload on carrier systems. Data level is a power 13 dB below the transmission level point (TLP) where the tests are being made. For example, at a -16 dB TLP, the data level would be -29 dBm (-16 -13 = -29). A test power of -29 dBm would be applied here. At the zero transmission level point (O TLP), the data level would be -13 dBm, or -13 dBmO.

4-13. LEVEL AND FREQUENCY MEASUREMENTS.

4-14. The level and frequency mode allows measurement

of 1000 Hz loss and attenuation distortion. These measurements define the amplitude versus frequency response of a voice channel. The level and frequency mode also allows measurement of frequency shift. Figure 4-2 illustrates the basic setup for these measurements.

4-15. 1000 Hz LOSS.

4-16. The 1000 Hz loss measurement determines the point-to-point loss (or gain) of a 1000 Hz test tone transmitted over a voice channel. To make this measurement, a 1004 Hz test frequency is transmitted at data level. At the receiving TIMS, the received power is measured (in dBm) and subtracted from the transmitted level to determine 1000 Hz loss.

4-17. The transmitted frequency is actually 1004 Hz (not 1000 Hz), to prevent measurement errors which would occur over T-carrier systems. The test set offsets all stepped transmitter frequencies by 4 Hz. This offset avoids measurement error caused by test frequencies which are submultiples of the T-carrier sampling rate. This measurement error is not representative of actual conditions which are present when multifrequency signals like voice and data are transmitted over voice channels.

4-18. The accuracy of the received power measurement depends on the tolerance of the receiving end resistive termination. A terminating resistance of ±1% tolerance (at 600 or 900 ohms) is required to assure accurate measurements. Therefore, received level measurements should generally be made using the TIMS internal termination; either 600 or 900 ohms, as appropriate.

4-19. A switch-selectable 60 Hz high-pass receiving filter is provided for use with the level and frequency measurements. The 60 Hz filter is used to detect and/or remove excessive 60 Hz interference. The filter has a 25 dB attenuation characteristic at 60 Hz, and a 4 dB attenuation characteristic at 180 Hz (3rd harmonic of 60 Hz).

4-20. FREQUENCY SHIFT.

4-21. The frequency shift measurement checks for any difference in the received frequency with reference to the transmitted frequency (frequency translation) as caused by carrier facilities. To make this measurement, a test tone of known frequency is transmitted. At the receiving end, the received frequency is observed and compared with the transmitted frequency. Any difference between transmitted and received frequencies indicates a frequency shift in the test signal. This measurement is not valid when measured on looped around carrier facilities, since the frequency shift in one direction (near-end to far-end) may be cancelled by the frequency shift in the other direction (far-end to near-end).

4-22. ATTENUATION DISTORTION.

4-23. The attenuation distortion measurement determines the amplitude versus frequency characteristics of a voice channel; using a single frequency measurement technique. This measurement determines the usable bandwidth of the voice channel. To make this measurement, a 1004 Hz test frequency is transmitted at data level. At the receiving end, the received power is recorded to obtain a 1004 Hz reference level. The transmitted frequency is then varied over the full range of the voice channel (while maintaining data level), and the received power is noted in each case. The received powers may then be compared to the 1004 Hz received reference power to obtain the frequency attenuation characteristics of the voice channel in dBm.

4-24. To directly obtain the loss deviations relative to 1004 Hz, the LEVEL ZERO pushbutton is depressed during reception of the 1004 Hz reference signal. This action stores the received power in dBm and simultaneously displays this level as 0 dB. Level readings taken at other frequencies will then be displayed in units of dB as compared to the 1004 Hz reference. This eliminates the need to subtract the 1004 Hz reference level from other levels at other frequencies to obtain dB indications.

4-25. According to telephone industry convention, attenuation distortion is defined as a change in loss of a channel, compared to the loss of a nominal 1000 Hz signal on that channel. For example, a channel with 6 dB more loss at 2800 Hz would have an attenuation distortion of +6 dB.

4-26. The SF (single-frequency) skip setup switch is provided to automatically prevent the test set from transmitting frequencies within the range of 2450 Hz to 2750 Hz. This feature is used in attenuation distortion and envelope delay to prevent loss of voice channel connection when transmitting over a dial-up network incorporating SF signaling units.

4-27. MESSAGE CIRCUIT NOISE MEASUREMENTS.

4-28. The message circuit noise measurements attempt to determine the interfering effects of background noise and tones. Figure 4-3 illustrates the basic setup for these measurements.

4-29. The message circuit noise mode measures the noise present on a voice channel, which has a quiet termination on one end (supplied by transmitting TIMS) and a weighted

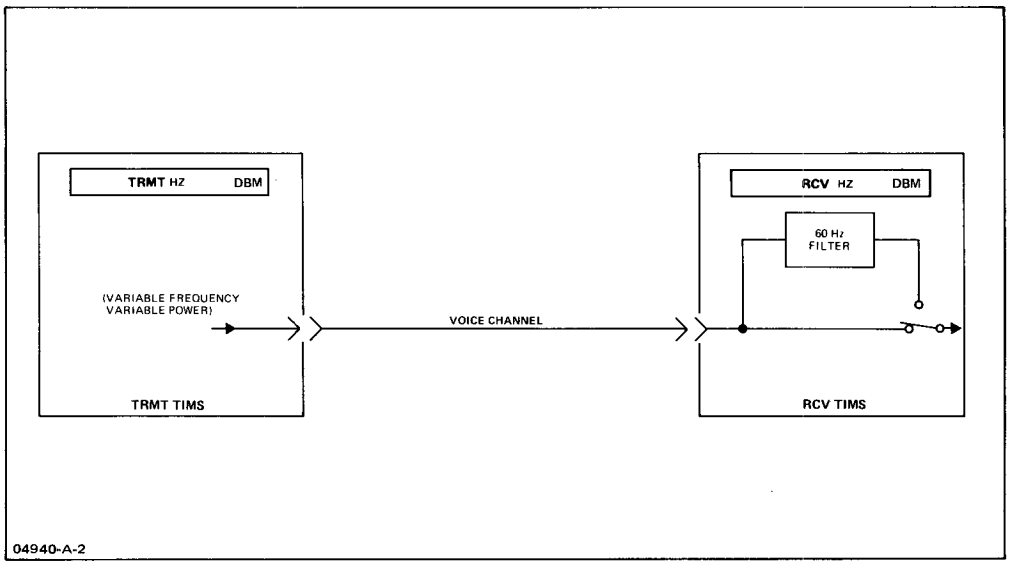


Figure 4-2. Level and Frequency Measurements

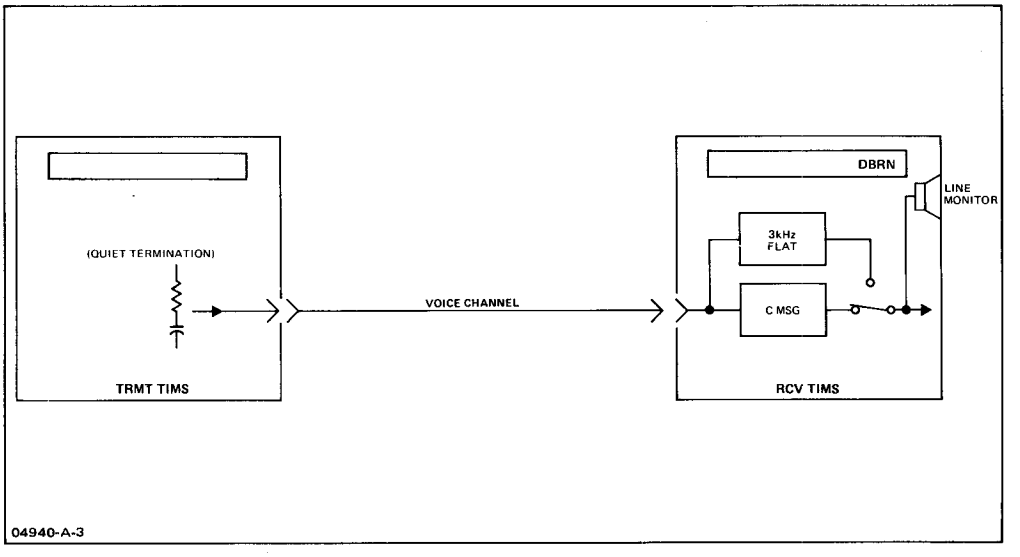


Figure 4-3. Message Circuit Noise Measurements

measuring device on the other end (receiving TIMS). The quiet termination is a simple resistive termination on the wire pair.

4-30. At the measurement end of the voice channel, TIMS includes a frequency weighting filter, either C-message or 3 kHz flat (see figures 4-4 and 4-5). The C-message filter allows measurement of only those noise signals that are of annoyance to the "typical" subscriber of standard telephone service. The C-message weighting is also used to evaluate the effects of noise on voice-grade data circuits. The C-weighting is valid for data transmission since the response characteristic is relatively flat over most of the frequency range of concern for data transmission (600 to 3000 Hz).

4-31. The 3 kHz flat filter has a response that provides much less attenuation to the low frequencies (60 Hz to 500 Hz) than the C-message filter. By comparing a 3 kHz flat noise measurement to a C-message noise measurement, the relative influence of low frequency noise (60 Hz commercial power, 20 Hz ringing, etc.) can be determined.

4-32. Received noise levels are displayed in units of dBrn, or dB with respect to reference noise (1000 Hz tone at -90 dBm). For example, a noise reading of 20 dBrn has an RMS power of -70 dBm (20 - 90 = -70). With the C-message filter selected, displayed readings are interpreted as being in units of dBrnC, or noise level in dBrn with a C-message weighted measuring device.

4-33. SINGLE FREQUENCY INTERFERENCE.

4-34. Single frequency interference refers to unwanted steady tones which may appear on voice channels. Occasional bursts of low level tones which may occur from crosstalk of multifrequency signaling, for example, do not fall in this category. Single frequency tones may interfere with certain data signals, particularly narrowband signals which are multiplexed onto a voiceband channel.

4-35. A simple audio monitoring arrangement will usually detect this interference, since tones exceeding acceptable levels are easily heard if the C-message noise is within limits. The single frequency interference check is made with the setup shown in figure 4-3. After the received noise signal passes through the C-message filter, the resultant signal is applied to the line monitor speaker. The TIMS operator listens for any predominant tone, which may indicate a single frequency interference problem.

4-36. If a single frequency tone (or tones) of long duration is heard, single frequency interference may be present and should be measured. To precisely determine the frequency and level of the interfering tone, a frequency selective voltmeter or spectrum analyzer must be used. The requirement for single frequency interference is that, when measured through a C-message filter, it be at least 3 dB below C-message noise limits.

4-37. NOISE-WITH-TONE MEASUREMENTS.

4-38. The noise-with-tone mode allows measurement of signal-to-noise ratio, which is one of the most important parameters for determining the quality of a voice channel.

4-39. NOISE-WITH-TONE.

4-40. The noise-with-tone measurement technique is used to condition compandors and/or quantizers in the transmission system to their normal operating levels for continuous data signals. Therefore, noise levels are recieved which duplicate levels present under operating conditions.

4-41. To make this measurement, a 1004 Hz test frequency (holding tone) is transmitted at data level. At the receiving TIMS, the 1004 Hz holding tone is selectively attenuated by 50 dB using a notch filter (all frequencies between 995 Hz and 1025 Hz are attenuated by 50 dB). The remaining received signal(noise) is passed through either a C-message or 3 kHz flat filter for measurement. The received noise level is displayed in units of dBrn. Figure 4-6 illustrates the combination of the C-message weighting and notch filter characteristics.

4-42. SIGNAL-TO-NOISE RATIO.

4-43. The signal-to-noise ratio of the voice channel under test may be determined by comparing the noise-with-tone level (C-message weighted) with the holding tone level. To determine signal-to-noise ratio, the noise level (dBrn) is noted after measurement as explained above. The receiving TIMS is then switched to the message circuit noise measurement mode. This action removes the notch filter from the receiving TIMS (retains C-message filter). Since the received holding tone level is normally much greater than the received noise level, the holding tone level is indicated on the TIMS display in units of dBrn. The signal-to-noise ratio (units of dB) is then obtained by subtracting the noise level from the holding tone level. For example, if the received holding tone level is measured as 70 dBrn and the noise level is measured at 50 dBrn, the signal-to-noise ratio equals 20 dB (70 - 50 = 20).

4-44. IMPULSE NOISE, HITS AND DROPOUTS MEASUREMENTS.

4-45. The 3-level impulse noise, hits and dropouts mode measures the interfering effects of transient phenomena.

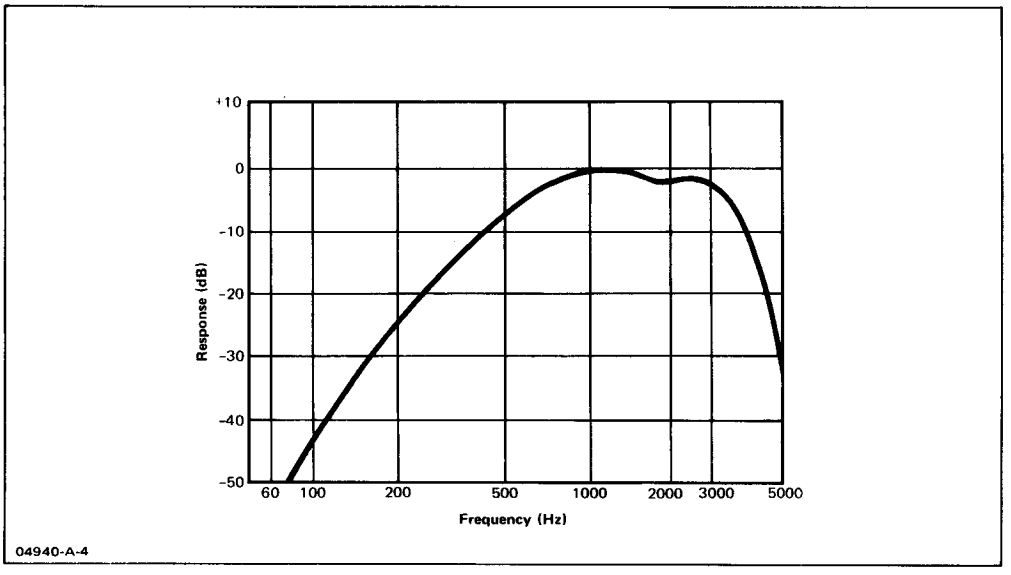


Figure 4-4. C-Message Weighting Characteristic

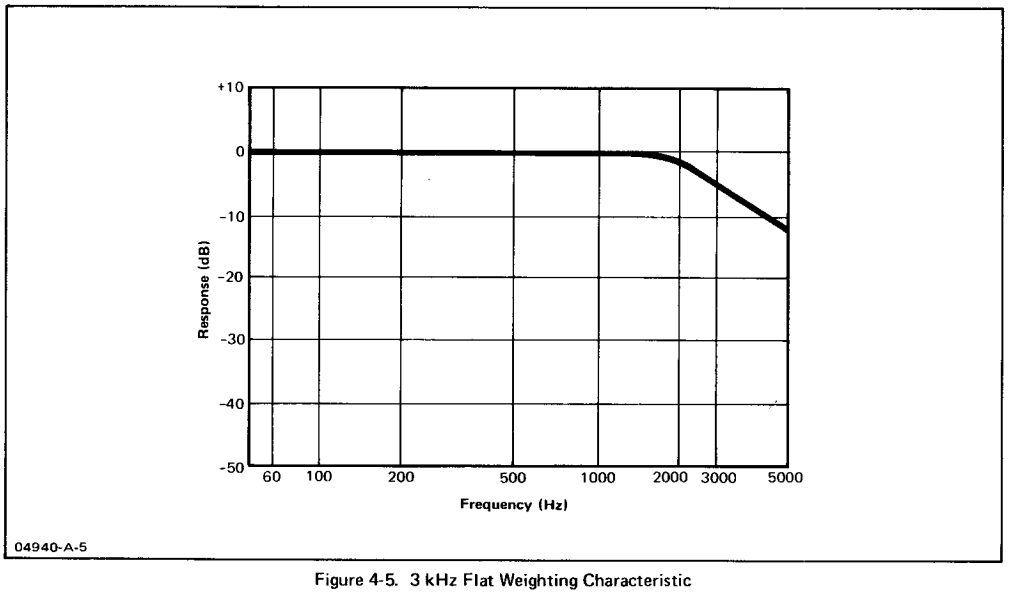


Figure 4-5. 3 kHz Flat Weighting Characteristic

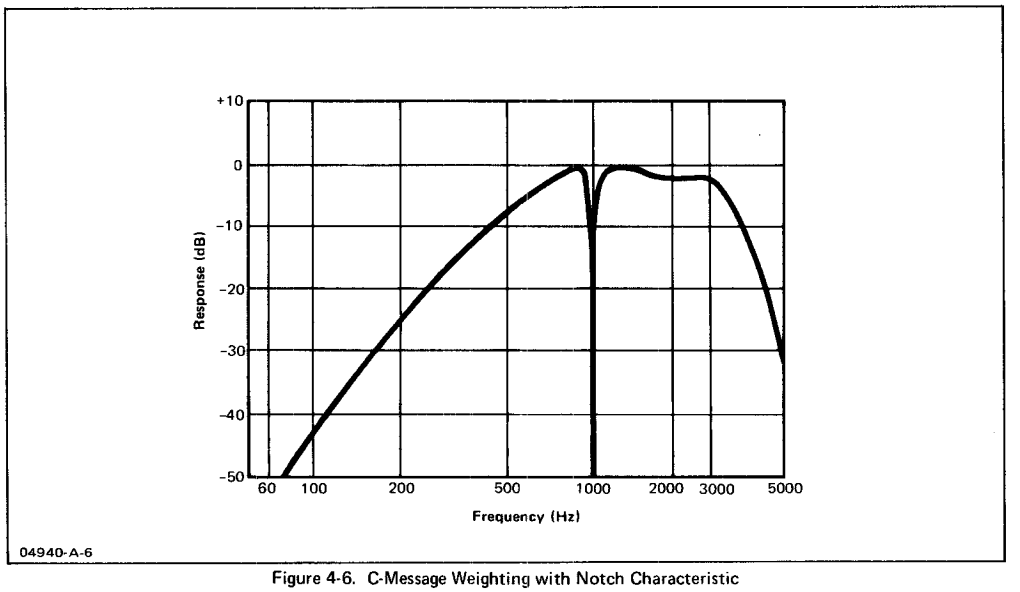


Figure 4-6. C-Message Weighting with Notch Characteristic

These transient phenomena can cause data transmission errors and/or interruptions to data communication systems. This measurement mode allows simultaneous determination of: impulse noise count at three different thresholds, phase hit count, gain hit count, and dropout count. The simultaneous measurement of these transient phenomena allows TIMS to reliably differentiate between each of them.

4-46. IMPULSE NOISE.

4-47. Impulse noise is that component of the received noise signal which is much greater in amplitude than the normal peaks of the message circuit noise, and that occurs as short duration spikes and/or bursts of energy. Studies by Bell Telephone laboratories have shown that impluse noise spikes have a duration of less than one millisecond, and that all significant effects of the noise spike disappear within four milliseconds. Waveform (b) in figure 4-7 illustrates a received holding tone (or test signal) that includes interfering impulse noise spikes. The impluse noise measurement allows determination of impulse noise count on a voice channel, given a specified amplitude threshold level, a specified count rate, and a specified measurement period (all switch selectable on TIMS).

4-48. Most impulse noise originates with actions of people. Customers initiating and terminating calls cause relays and switches to operate and release, giving rise to impulse noise from the associated electrical transients. Normal installation and repair activities also introduce impulse noise.

4-49. Impulse noise affects data transmission by causing the loss of the information signal which results in errors. In slow data rate systems, few errors occur due to impulse noise because it is easy for the receiving device to distinguish a data pulse from an impulse noise pulse. As the data rate of a system increases, it becomes increasingly difficult for the receiving device to distinguish the data pulse from the noise pulse; resulting in impulse noise caused errors.

4-50. PHASE HITS, GAIN HITS, AND DROPOUTS.

4-51. PHASE HITS. A phase hit is a sudden change (+ or -) in the received signal phase (or frequency). Phase hits may be as small as tenths of a degree (treated as phase jitter — discussed in later paragraphs) or as large as 360°. The phase of the received signal may return to its original value in a short time, or remain indefinitely at a changed value. Waveform (c) in figure 4-7 illustrates a received holding tone that includes interfering phase hits.

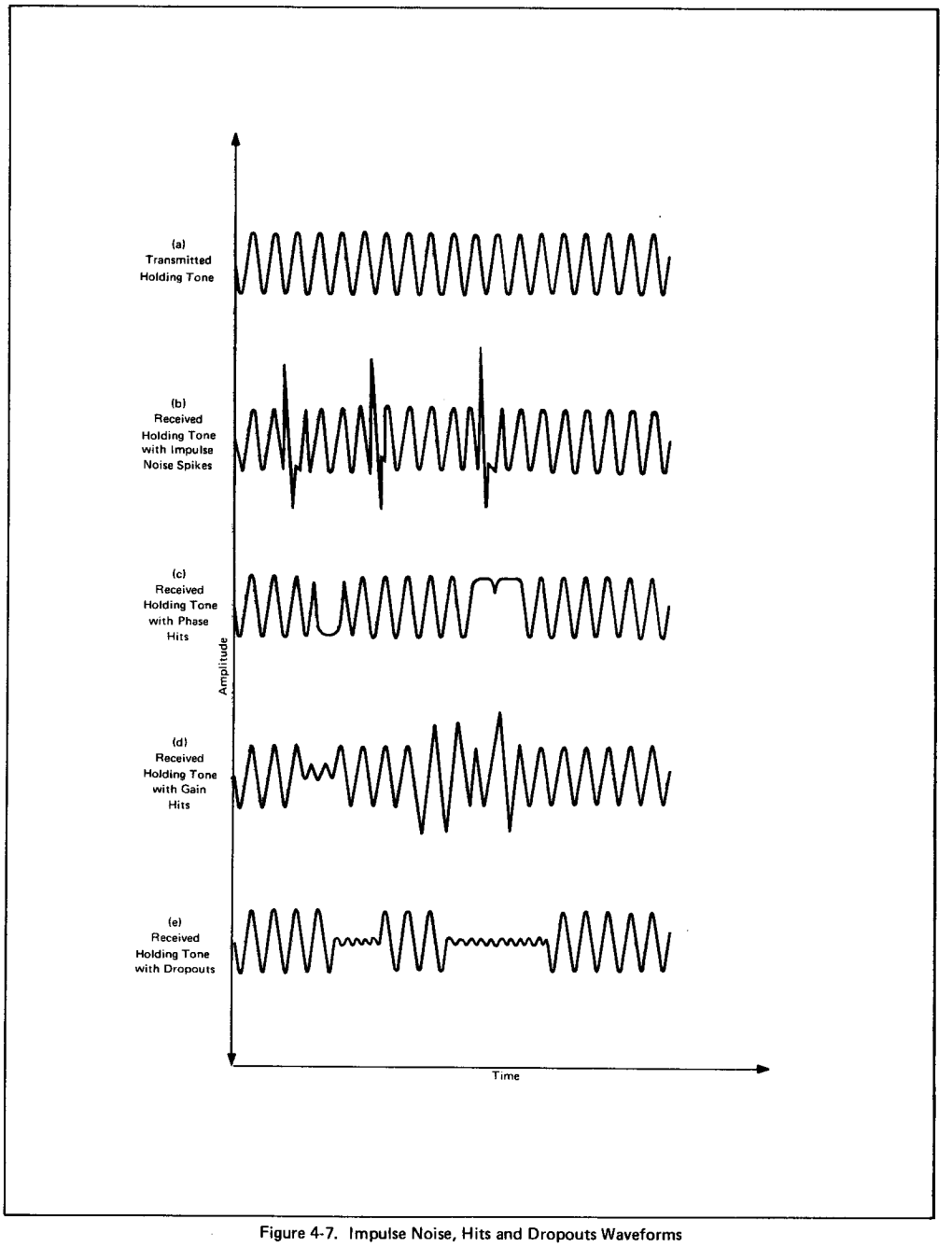


Figure 4-7. Impulse Noise, Hits and Dropouts Waveforms

4-52. Some of the more common causes of phase hits (and also gain hits and dropouts discussed below) are automatic switching to standby facilities or carrier supplies, patching out working facilities to perform routine maintenance, fades or path changes in microwave facilities, and noise transients coupled into carrier frequency sources.

4-53. Since two common modulation techniques used by data modems for transmission are phase and frequency modulation, phase hits create errors by appearing like the information carried by the data signal. For example, in a system using an 8-phase modulation technique (45° between states), frequent 25° phase hits would make it very difficult for the receiving modem to distinguish between the interfering phase hits and the phase modulation; resulting in phase hit caused errors.

4-54. GAIN HITS. A gain hit is a sudden change (increase or decrease) in the received signal level. Gain hits may be as small as tenths of a dB or as large as tens of dBs. The level of the received signal may return to its original value in a short time, or remain indefinitely at a changed value. Waveform (d) in figure 4-7 illustrates a received holding tone that includes interfering gain hits.

4-55. Amplitude modulation of a carrier signal is another common technique used by modems to transmit data. Since the information is contained in the level of the signal, gain hits can appear like the information carried by the data signal; resulting in gain hit caused errors.

4-56. DROPOUTS. A dropout is a sudden drop in received signal level. During a dropout, the signal experiences a sudden large drop in level and often becomes undetectable. Therefore, a dropout is a special case of a gain hit (a decrease in signal level). (Bell Telephone Laboratory studies have shown that some dropouts are difficult to observe, because simultaneously with a signal level drop of 20 or 30 dB, the background noise may rise to a level near the original signal level.) The level of the received signal may return to its original value in a short time or remain undetectable indefinitely. Waveform (e) in figure 4-7 illustrates a received holding tone that includes interfering dropouts.

4-57. Since dropouts interrupt the information signal between two modems, all communication ceases during the dropout, and data can be lost. Furthermore, communication cannot immediately resume when the signal returns. The receiving modem must re-reference itself to the signal before successful data communication can resume, and more information can be lost. Most modems, however, can track the receive signal to a level as low as 12 dB below their nominal receiving power. Beyond 12 dB, the modem would then consider the information signal lost.

4-58. SIMULTANEOUS MEASUREMENT OF IMPULSE NOISE, HITS AND DROPOUTS

4-59. The relationship between each of the transient distrubances is summarized in table 4-1. As can be seen in the table, the most apparent way to distinguish impulse noise from hits and dropouts is the 4 mS maximum duration of the impulse noise. Phase hits can be distinguished from gain hits and dropouts because phase hits cause a change in phase. Dropouts have to be distinguished from gain hits by definition, since dropouts are a special case of gain hits. Table 4-2 summarizes the measurement definitions necessary for implementing a practical measuring instrument.

4-60. The information needed about each of these disturbances includes how often they occur. So the measuring instrument is required to totalize each of the disturbances over a specified time period. Earlier test sets were limited to a maximum count rate of approximately 7 counts per second by the "dead time" (approximately 150 mS) of the available electro-mechanical counters. Years of experience and Bell Telephone Laboratory studies have shown that limiting the maximum counting rate to 7 counts per second produces valid impulse noise data, hence the current Bell standard (7 counts per second maximum count rate).

4-61 All of these disturbing events can occur at any time, since they are caused by random sources. Bell Telephone Laboratory studies have also shown that impulse noise can occur in clusters with only a few milliseconds between each impulse noise spike. With electronic counters (as incorporated in TIMS), it is possible to remove the 7 counts per second limitation and allow the measuring device to count disturbances at a rate limited only by its ability to distinguish between the disturbances (approximately 30 counts per second with TIMS).

4-62. Since not all disturbances are of sufficient magnitude to cause data communication problems, it is necessary to be able to set thresholds that will discriminate against small disturbances. The thresholds in TIMS are adjustable so that measurements can be made at different Test Level Points; and also so that the test set can be made to be susceptible to certain disturbances depending on the effect those distrubances have on current data communications.

4-63. By sensing all four phenomena simultaneously, TIMS is able to identify coincident phenomena situations and reliably sort out and prevent from being counted the phenomena that occurred only as the result of another phenomena. This is shown in figure 4-8.

Table 4-1. Transient Phenomena Summary

DISTURBANCE	SIGNAL RELATED	CHANGE CHARACTERISTIC	DURATION
Impulse Noise	No	Level & Phase	< 0.1 mS to 4 mS
Phase Hit	Yes	Phase	< 0.1 mS to > hours
Gain Hit	Yes	Level	< 0.1 mS to > hours
Dropout	Yes	Level	≈1 mS to > hours

Table 4-2. Measurement Definitions

DISTURBANCE	SIGNAL RELATION	DURATION
Impulse Noise	Level change not related to signal.	Lasts less than 4 mS.
Phase Hit	Phase change to the signal.	Lasts greater than 4 mS.
Gain Hit	Level change to the signal.	Lasts greater than 4 mS.
Dropout	Decrease in signal level of 12 dB.	Lasts greater than 4 mS.

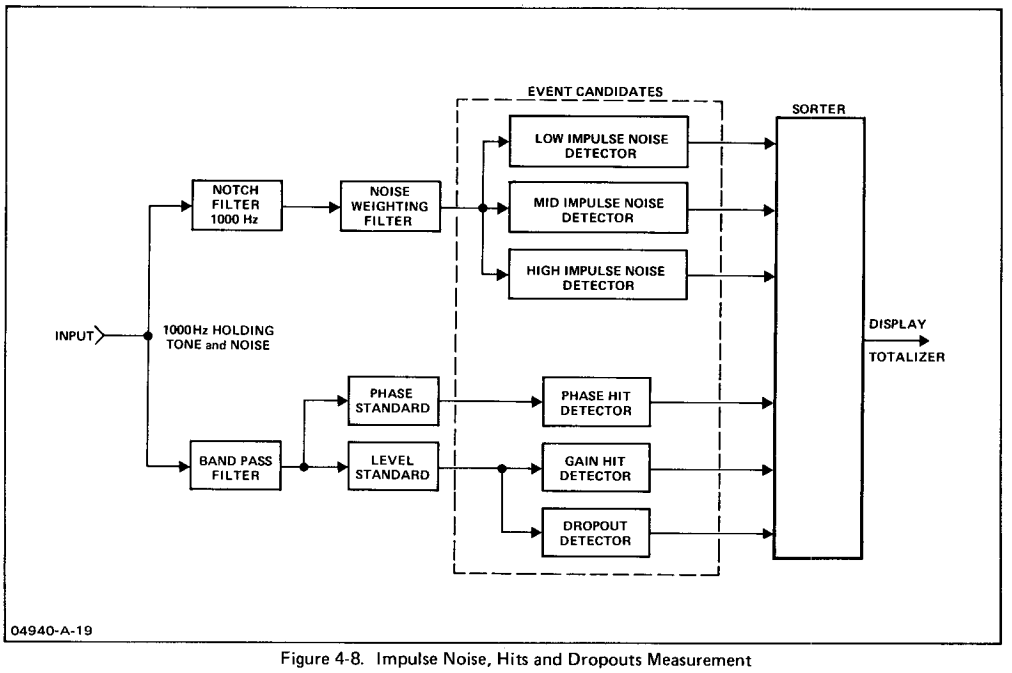


Figure 4-8. Impulse Noise, Hits and Dropouts Measurement

4-64. PHASE JITTER MEASUREMENT.

4-65. The phase jitter mode allows measurement of the peak-to-peak phase deviation on a voice channel. Phase jitter is the undesired component of a received signal which appears as phase (or frequency) modulation.

4-66. Phase jitter has an insignificant effect on voice transmission because the ear is relatively insensitive to phase information. However, phase jitter can seriously affect data transmission. Phase jitter is especially interfering to data communication systems that use phase modulation as the transmission scheme. If large phase variations occur, one data pulse may occupy the alloted time slot of another pulse (intersymbol interference), causing an error to occur. Figure 4-9 illustrates the effect of phase jitter on a reference holding tone.

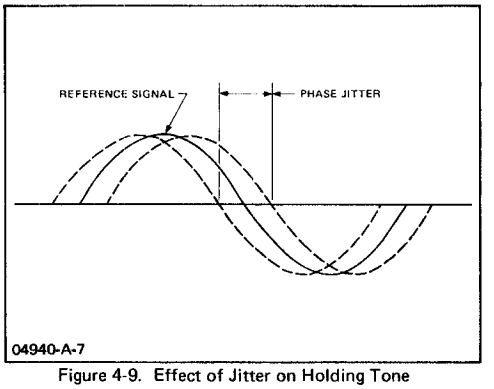


Figure 4-9. Effect of Jitter on Holding Tone

4-67. Various sources cause the instantaneous phase of a signal to jitter at rates normally less than 300 Hz. Phase jitter is typically caused by ripple in the dc power supply of the master oscillator of long haul carriers. Some phase jitter also occurs in short haul systems from incomplete filtering of image sidebands. The most commonly found frequency components of phase jitter are 20 Hz (ringing current), 60 Hz (commercial power), and the harmonics of these.

4-68. To measure phase jitter, a 1004 Hz holding tone is transmitted at data level. At the receiving end of the voice channel is the test set configured to measure phase jitter. Figure 4-10 illustrates the receiving TIMS functional configuration. The received signal passes through the 400-1550 Hz band-pass filter. This filter reduces the effective measurement bandwidth to approximately one-fourth the total channel width, centered on the test tone frequency.

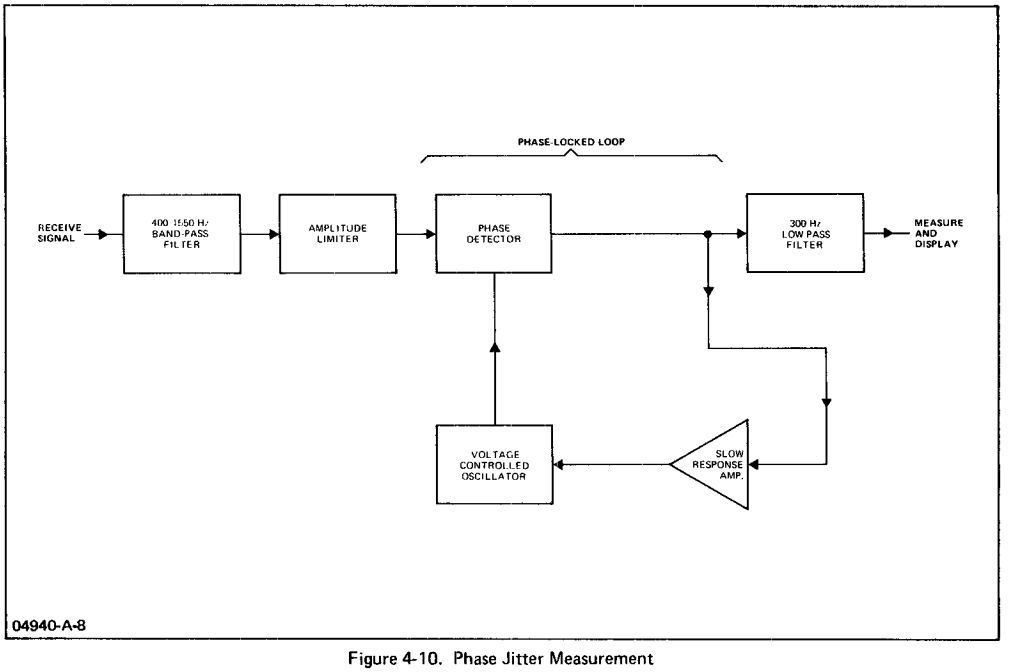


Figure 4-10. Phase Jitter Measurement

This reduces the effects of noise and other interference on the jitter measurement. The remaining received signal (test tone with both phase and amplitude variations) passes through the amplitude limiter to produce a constant amplitude signal. The phase detector compares the received signal (with phase jitter components) with the voltage controlled oscillator signal (jitter free reference). The oscillator is phase-locked to the long term average of the received signal.

4-69. Slow deviations in phase of less than a 20 Hz rate are followed by the phase-locked loop, made up of the phase detector, the slow response amplifier, and the voltage controlled oscillator. The amplifier will change the frequency of the voltage controlled oscillator. The voltage controlled oscillator then supplies the proper frequency (and phase) to the phase detector to result in a negligible phase difference between the received signal and the oscillator frequency.

4-70. The phase-locked loop will not follow fast phase changes which occur at a rate greater than 20 Hz. The slow response amplifier will not react fast enough to change the oscillator frequency to match the received frequency. Fast phase changes will cause an error signal to be generated by the phase detector.

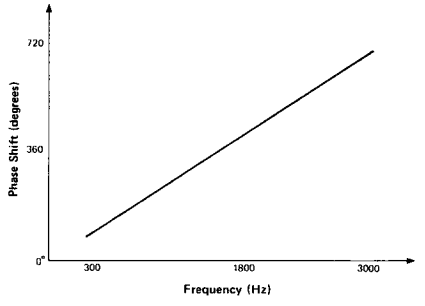
4-71. The error signal appearing after the 300 Hz low pass filter is limited in frequency between 20 Hz and 300 Hz. This pass band is utilized to include the phase jitter interference caused by 20 Hz ringing and 60 Hz power, plus their first several harmonics. Phase jitter components rarely occur above 300 Hz. However, jitter above 300 Hz is accompanied by large amounts of jitter below 300 Hz, which allows detection by the TIMS measuring arrangement.

4-72. ENVELOPE DELAY MEASUREMENT.

4-73. The envelope delay mode allows measurement of the linearity of the phase versus frequency of a voice channel.

4-74. Phase information has an insignificant effect on voice transmission, because the ear is relatively insensitive to phase distortion. However, phase distortion can seriously affect data transmission. For example, with data transmitted at speeds greater than about 2400 bits per second, over a voice channel without proper delay compensation, and data bits tend to smear out in time and overlap each other; causing intersymbol interference which produces errors.

4-75. An ideal circuit which has a linear phase shift characteristic will produce a straight line slope (a linear relationship between a change in frequency and a corresponding change in phase) as shown in figure 4-11a. The practical circuit, however, is never ideal and will produce a nonlinear phase shift characteristic (phase distortion) as shown in figure 4-11b.



(a) Ideal Linear Phase Characteristic

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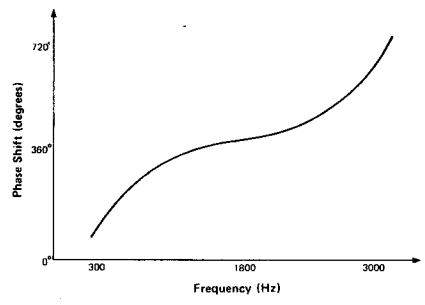

(b) Practical Nonlinear Phase Characteristic

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Figure 4-11. Phase versus Frequency Relationships

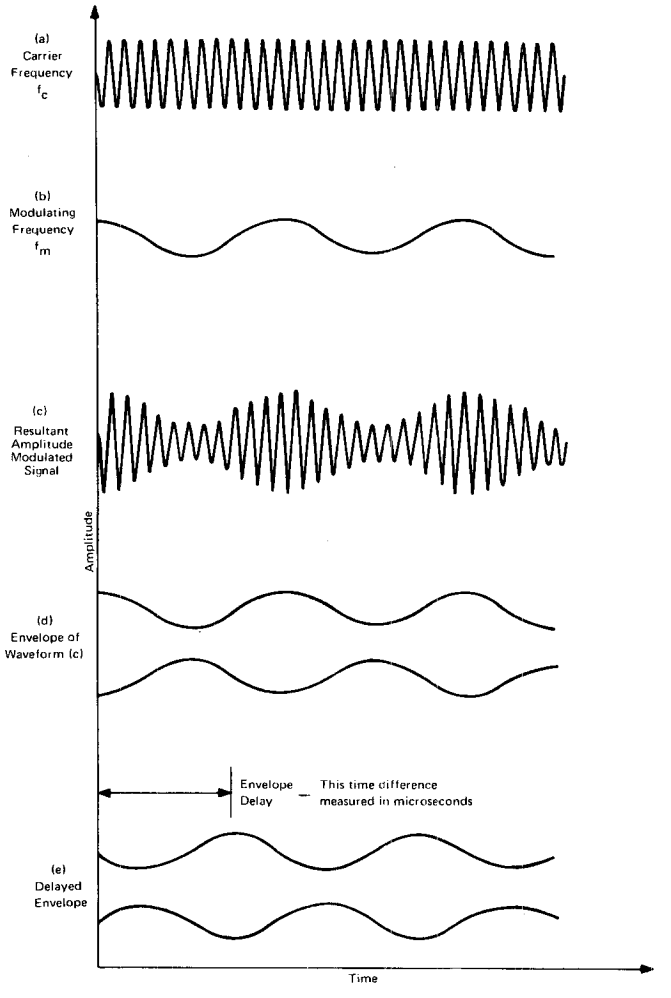


Figure 4-12. Envelope Delay Waveforms

4-76. Conventional measurement techniques make it difficult to measure the phase characteristic of a transmission system, since a phase reference is difficult to establish at the receiving end of the circuit. It is possible, however, to measure relative phase shift at the receiving end using the envelope delay measurement technique. This technique makes it possible to measure the envelope delay distortion of a voice channel, which provides a relative measure of the phase linearity (or non-linearity) of the circuit.

4-77. RELATING PHASE SHIFT TO ENVELOPE DELAY.

4-78. Amplitude modulating a low frequency sine wave (f_m) onto a carrier frequency (f_c) produces an amplitude modulated (AM) signal as shown by waveforms (a), (b), and (c) in figure 4-12. The envelope of the AM signal is the outline (or shape) of the peak excursions of the modulated signal as shown in waveform (d) of figure 4-12. The AM process produces a signal whose spectrum consists of the carrier frequency plus an upper sideband ($f_c + f_m$) and a lower sideband ($f_c - f_m$). Figure 4-13 illustrates this relationship. Since the upper sideband is of a higher frequency than the carrier, it undergoes a greater phase shift than the carrier; since the lower sideband is of a lower frequency, it undergoes less phase shift.

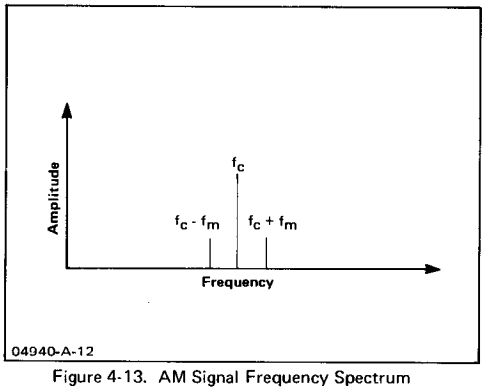


Figure 4-13. AM Signal Frequency Spectrum

4-79. If the AM signal is passed through a circuit having a phase shift characteristic which increases linearly with frequency (figure 4-11a), the envelope of the AM signal experiences a shift in time (or delay) as shown in waveforms (d) and (e) of figure 4-12. This occurs because the lower sideband experiences less phase shift than the carrier, while the upper sideband encounters more. The net result of these phase shifts is that the modulation envelope is shifted in phase (or delayed) when traversing a transmission medium.

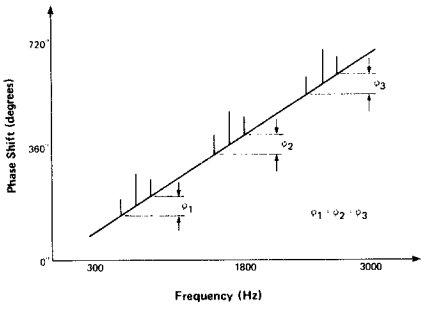
4-80. The amount of envelope delay is related to the difference in phase between the two sidebands. If the phase versus frequency characteristic of the transmission medium is linear, then any carrier frequency used (with a fixed modulation frequency) will produce a constant envelope delay value. Plots (a) and (b) in figure 4-14 illustrate this relationship. However, if the phase versus frequency characteristic is nonlinear, then different carrier frequencies will produce different envelope delay values. Plots (c) and (d) in figure 4-14 illustrate this relationship. When different values of envelope delay occur, the difference between delay values at two different carrier frequencies is termed "envelope delay distortion".

4-81. ENVELOPE DELAY MEASUREMENT TECHNIQUE.

4-82. To make this measurement, two TIMS are used in the configuration shown in figure 4-15. The TIMS normal test set transmits a test signal over the voice channel under test to the TIMS repeat test set. The repeat set responds by transmitting envelope delay information back to the normal set over the return reference voice channel. The normal set compares its received signal with its transmitted signal to determine envelope delay distortion values.

4-83. The normal set transmits an amplitude modulated test signal consisting of a variable frequency carrier (300 to 3904 Hz) and a fixed modulation frequency (83-1/3 Hz). The carrier frequency is varied over the band of interest, usually in 100 Hz steps. The test signal traverses the voice channel under test and is received by the repeat set. The receiver of the repeat set amplitude demodulates the incoming test signal to produce the AM envelope. Changing the carrier frequency as mentioned above will result in a change in the delay of the 83-1/3 Hz envelope at the repeat set, if envelope delay distortion exists. The envelope delay values received at the repeat set must now be transmitted back to the normal set for measurement. In addition, the envelope delay values received at the repeat set must be transmitted back to the normal set without the introduction of a changing envelope delay, as would be introduced by changing the return reference carrier frequency.

4-84. In the repeat set, the demodulated AM signal is used to amplitude modulate the fixed frequency carrier that is transmitted back to the normal set. The repeat set carrier oscillator remains fixed at one frequency during the envelope delay measurement. The carrier frequency is usually selected at midband (nominally 1800 Hz) because envelope delay characteristics are fairly constant and attenuation distortion characteristics are fairly flat. Since a constant return reference carrier frequency is used by the



(a) Linear Phase Characteristic with Superimposed AM Signal Components

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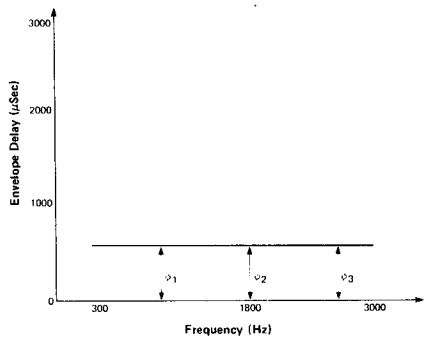

(b) Envelope Delay Characteristic of (a) above.

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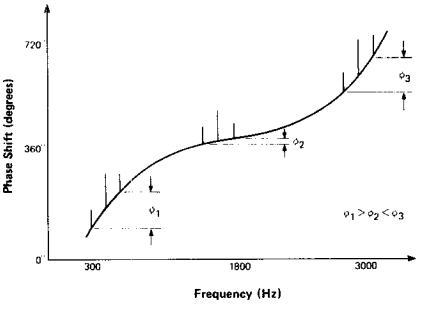

(c) Nonlinear Phase Characteristic with Superimposed AM Signal Components

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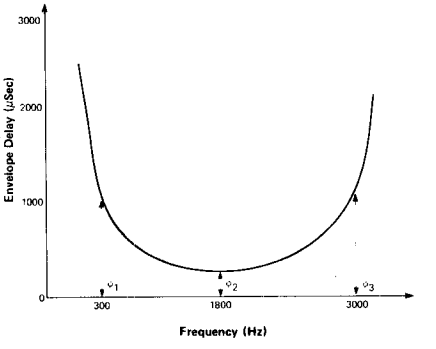

(d) Envelope Delay Characteristic of (c) above.

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NOTE: The symbol phi (ϕ) represents the difference in phase between the upper and lower sidebands of the AM signal superimposed on the phase characteristic plots.

Figure 4-14. Relating Phase Shift to Envelope Delay

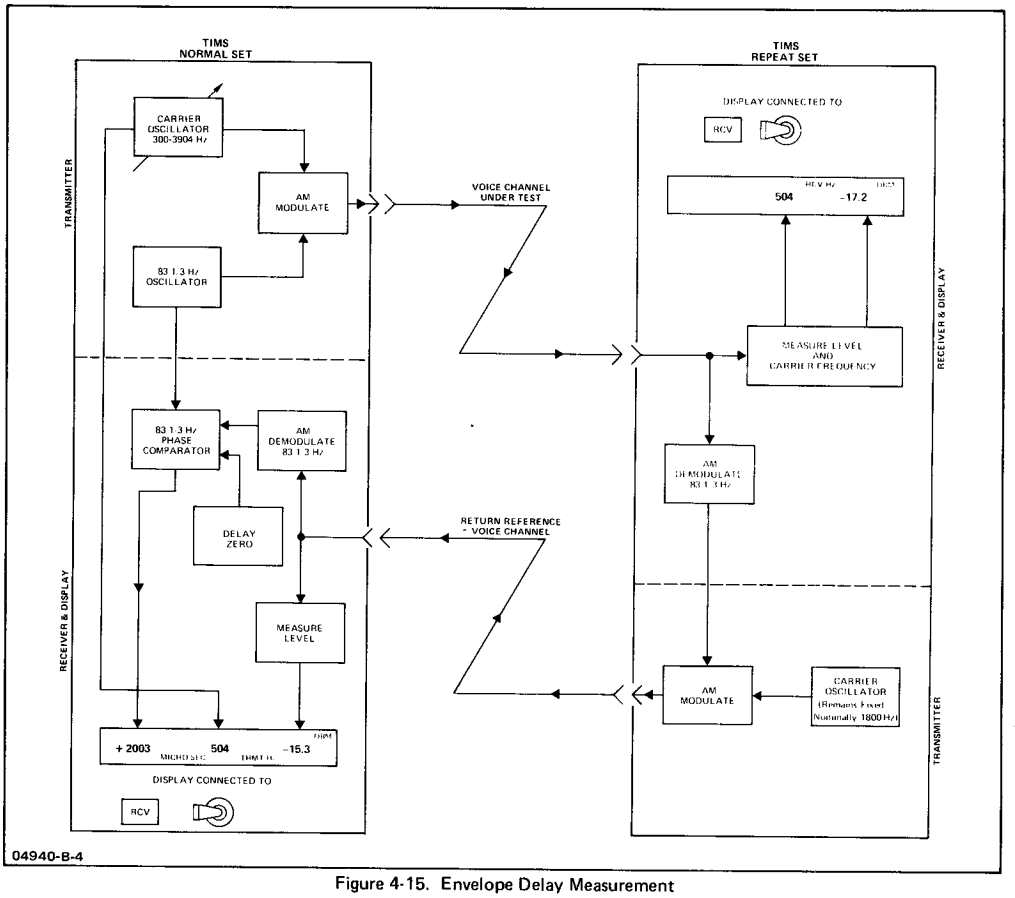

Figure 4-15. Envelope Delay Measurement

repeat set, there will be no envelope delay distortion encountered by the return reference signal (although there will be a fixed envelope delay). Therefore, the envelope delay value received at the normal set will represent the envelope delay value received at the repeat set, plus the constant envelope delay of the return reference channel.

4-85. The receiver of the normal set amplitude demodulates the incoming return reference signal. The phase of the incoming return reference envelope is then compared to the original 83-1/3 Hz oscillator signal to determine the difference in phase (envelope delay) between the two signals.

4-86. To measure the change in envelope delay from the normal set to the repeat set (with a change in carrier frequency), a delay zero control is used to "zero out" the envelope delay of the entire measurement loop. The delay zero control sets the phase difference (or envelope delay) between the 83-1/3 Hz oscillator and the demodulated return reference envelope to zero. All future envelope delay measurements on the channel will then be referenced to the carrier frequency of the normal set where the delay zero was set. By changing the normal set carrier frequency from the delay zero reference value, the only changing envelope delay (envelope delay distortion) occurring in the measurement loop is that incurred by the test signal traversing the voice channel under test.

4-87. The delay zero function is usually implemented at a normal set carrier frequency of around 1800 Hz. For some tests it is convenient to set an arbitrary zero and vary the test frequency while looking for the largest negative envelope delay value. By setting a new zero at this frequency of minimum delay, all other envelope delay measurements (on the channel under test) will have positive values.

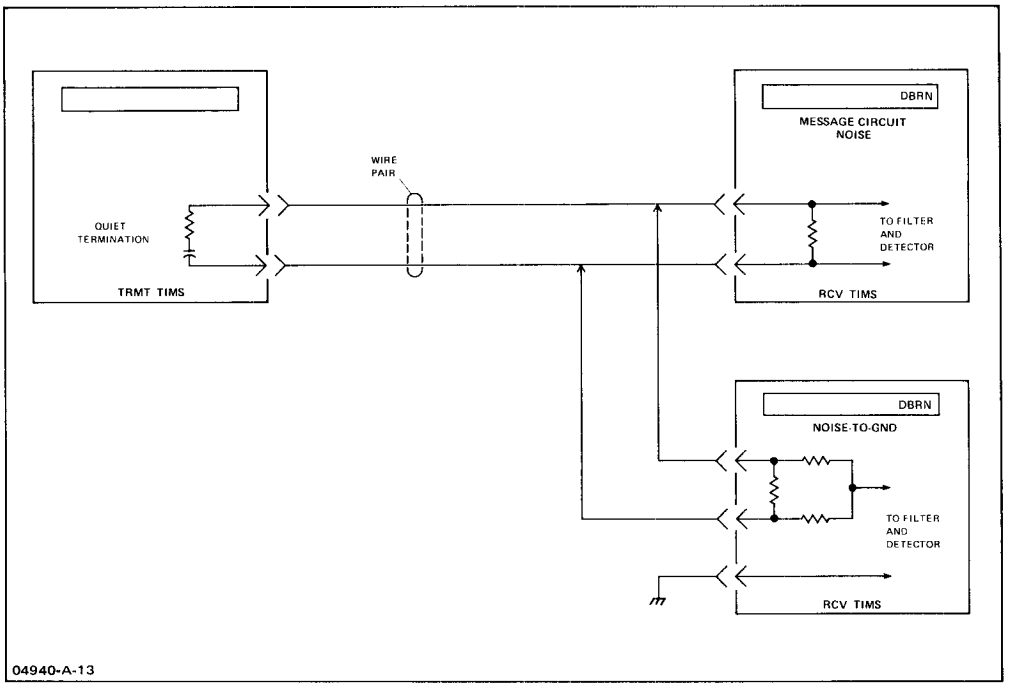

Figure 4-16. Noise-to-Ground Related to Message Circuit Noise

4-88. NOISE-TO-GROUND MEASUREMENT.

4-89. The noise-to-ground mode allows measurement of the longitudinal noise present on a voice channel, with reference to ground. The transmitting TIMS provides a quiet termination at one end of the voice channel, and the receiving TIMS provides a frequency weighted filter (C-message or 3 kHz flat) and detector at the other end. The basic measurement technique used for the noise-to-ground measurement is very similar to the message circuit noise measurement; the main difference lies in the use of a ground reference. Figure 4-16 illustrates this difference.

4-90. Noise-to-ground measurements are usually made for troubleshooting purposes; to measure the magnitude of longitudinal signals, which may indicate the susceptibility of a cable pair to electrical coupling from external sources. These measurements are also made to coordinate new installations with power companies, to minimize power line coupling.

4-91. The relative line balance of an end loop can be calculated by subtracting the measured noise-to-ground (N_g) value from the measured message circuit noise (N_m) value. This calculation is only valid if the measurements are made on a physical pair and it is assumed that the message circuit noise is caused by longitudinal noise converted to message circuit noise by line imbalance. It is recommended that both message circuit noise and noise-to-ground be measured with the 3 kHz flat weighted filter to include the effects of power line related noise.

4-92. NONLINEAR DISTORTION MEASUREMENT.

4-93. The nonlinear distortion mode allows measurement of the second and third order intermodulation distortion products of two test tone pairs transmitted over a voice channel.* The test tone pairs are selected to closely approximate the nonlinear distortion properties encountered by data signals; to minimize the effects of channel roll-off, phase jitter, frequency translation; and to avoid inaccurate readings on PCM carrier systems. Figure 4-17 illustrates the spectrum of the transmitted nonlinear distortion test signal.

*This non-linear distortion analyzer circuit is licensed under Hekimian Laboratories, Inc. U.S. Patent No. 3,862,380.

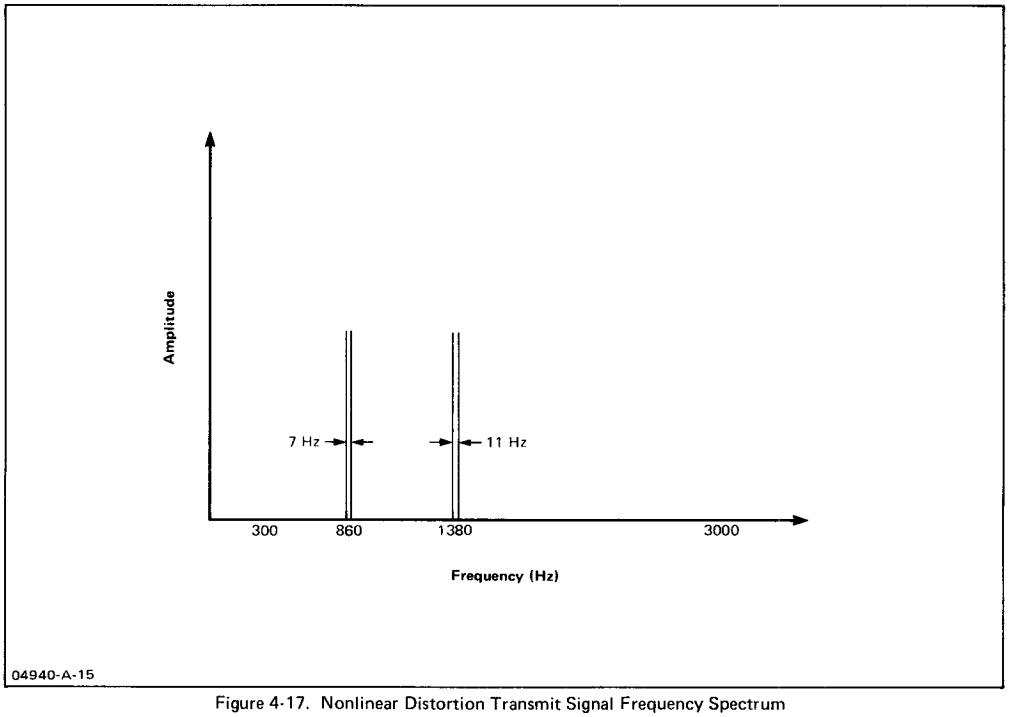

Figure 4-17. Nonlinear Distortion Transmit Signal Frequency Spectrum

4-94. Nonlinear distortion is the generation of new signal components not present in the original transmitted signal. This usually happens when a channel's loss is nonlinear with respect to input level. The main causes of nonlinear distortion are electronic devices such as modulators, demodulators, and amplifiers.

4-95. With a single frequency (f_1) applied to the input of a nonlinear device, the nonlinear distortion appears as harmonics of the input frequency, such as $2f_1$, $3f_1$, $4f_1$, etc. This type of distortion is termed "harmonic distortion". With a multiple frequency signal (f_1 and f_2) applied to the device input, the nonlinear distortion appears as harmonics of the individual input frequencies plus intermodulation products of the input frequencies, as listed in table 4-3. This type of distortion is termed "intermodulation distortion", and is the type measured by TIMS. Bell Telephone Laboratory studies have shown that it is valid to measure the power sum of the distortion products $f_1 + f_2$ and $f_2 - f_1$ as representative of the second order distortion, while $2f_2 - f_1$ may be measured as representative of the third order distortion; which is the technique utilized by TIMS.

Table 4-3. Harmonics and Intermodulation Products of a Multiple Frequency Signal (f_1 and f_2)

TYPE OF DISTORTION	OUTPUT DISTORTION THRU THE THIRD ORDER
Harmonics	$2f_1$, $3f_1$, $2f_2$, $3f_2$
Intermodulation Products	$f_1 + f_2$, $f_2 - f_1$, $2f_1 + f_2$, $2f_1 - f_2$, $2f_2 + f_1$, $2f_2 - f_1$

4-96. Intermodulation distortion and harmonic distortion measurement techniques will yield the same value for second and third order distortion in the simple case involving only one source of distortion. However, with a telephone channel there are normally multiple sources of distortion joined together by linear networks with delay distortion. This creates measurement problems in obtaining valid distortion values. Bell Telephone Laboratory studies have shown that the intermodulation distortion technique is less susceptible to these measurement problems.

4-97. The check signal provision is included in TIMS to permit correction of error caused by the presence of high background noise, an interfering tone, or T-carrier quantizing noise. When the NONLINEAR DISTORTION key is momentarily thrown to the CHECK SIGNAL position, the second tone pair shown in figure 4-17 (as centered at 1380 Hz) is supressed, and the lower tone pair is doubled in power. This allows the channel to be checked with a test signal of the same power. Without the two tone pairs being generated, the intermodulation process (as measured by TIMS) does not occur. The receiving TIMS looks for the second and third order products, but since these are not present, the measured received signals consist of noise. The second and third order products as measured with the two tone pairs may then be corrected accordingly to achieve accurate values.

4-98. PEAK-TO-AVERAGE RATIO MEASUREMENT.

4-99. The peak-to-average ratio (P/AR) mode allows measurement of the channel dispersion (spreading in time of signal amplitude) due to transmission imperfections. As the P/AR signal traverses a dispersive medium, the peak-to-average ratio will deteriorate. Then by measuring the peak-to-average ratio at the receiving end, a simple measure of dispersion is obtained. P/AR is measured as the ratio of the peak to full-wave rectified average values of a specially processed test signal transmitted over a voice channel. The test signal has a peak-to-average ratio and a spectral content that approximates a data signal. Figure 4-18 illustrates the frequency spectrum of the transmitted P/AR test signal, and figure 4-19 illustrates the signal envelope.

4-100. The P/AR rating is a single number rating of the fidelity of a channel and is a weighted measure of the total attenuation, phase distortion, and noise. The P/AR rating is derived by comparing the P/AR of an ideal signal with the P/AR of the output signal of the system under test. The P/AR measurement is most sensitive to envelope delay distortion and is also affected by noise, bandwidth reduction, gain ripples, nonlinearities such as compression and clipping, and other impairments. The P/AR rating is an indication of the general transmission quality of the voice-band channel. If the P/AR signal were received entirely undistorted, the P/AR rating would be 100, while a circuit that causes a 10% reduction in the peak-to-average ratio has a P/AR rating of 80.

4-101. The P/AR measurement provides little information about the nature of the fault condition in any particular case. However, since P/AR is a figure of merit for the channel, it can be used as a benchmark for future reference. After other measurements are made and a channel is considered acceptable, the P/AR rating can be recorded for future reference. In case of a suspected trouble on the channel, P/AR may be measured first and be compared to the benchmark P/AR value. Deviations in excess of ±4 P/AR units from an initial P/AR value provides sufficient reason to suspect that some channel characteristic has changed significantly.

4-102. The P/AR rating can also be useful in troubleshooting on the DDD network where a number of connections are to be surveyed and full data recorded on only the worst connections experienced. In private line circuits, P/AR can help to identify the worst transmission direction (near to far, or far to near) such that measurement of the parameters in the worst direction can be completed first, since it is more probable that any transmission impairment will be in that direction.

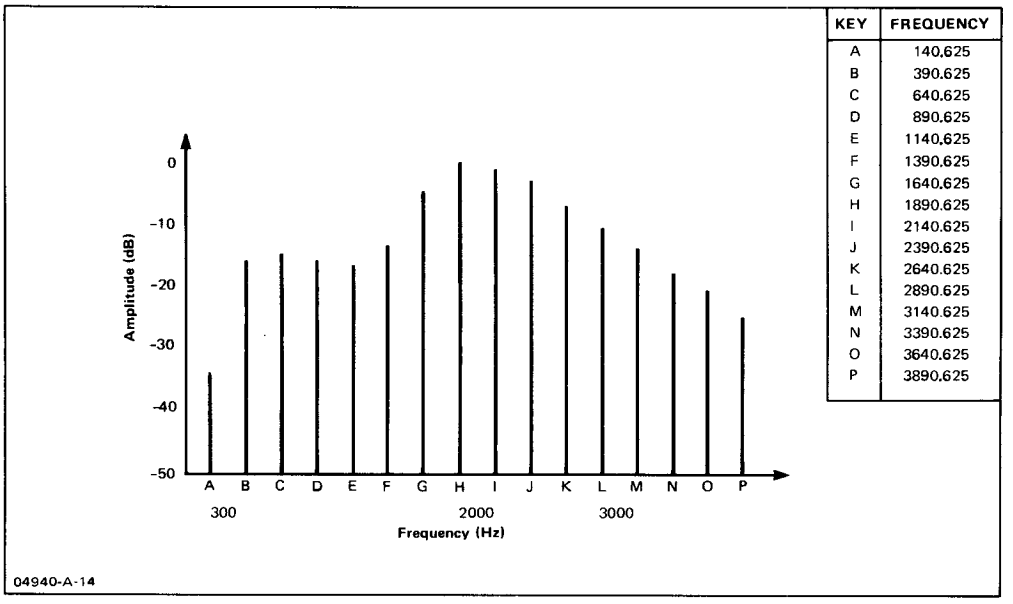

Figure 4-18. P/AR Transmit Signal Frequency Spectrum

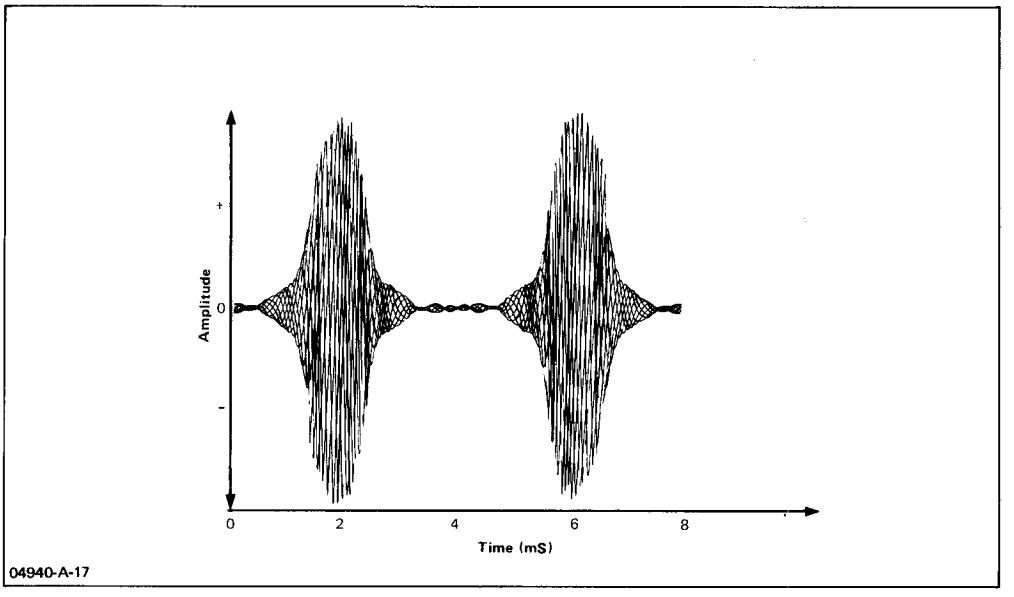

Figure 4-19. P/AR Transmit Signal Envelope

NOTICE

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Certain parts have been omitted because of space limitation. Refer to the Hewlett-Packard manual supplied with the equipment for complete details.

INSTRUCTION MANUAL

FOR

MODEL PB-1C VF LINE ANALYZER

BRADLEY TELCOM CORP.
117 Fort Lee Road
Leonia, New Jersey 07605

For PB-1C units of S/N 100, and higher, a center-position-off toggle switch,designated SINGLE AXIS with HOR and VERT momentary positions,has been added.

For PB-1C units of S/N 180, and higher, the function of the NNE ATTEN switch has been changed. The 10 dB attenuation in reading introduced by the switch affects not only the CRT display deflection sensitivity, as it did in units up to S/N 179, but also attenuates the:

Notched Noise meter reading

Speaker output (NOTCH MODE)

Notched Noise output on the tip of the Interconnect B jack.

For PB-1C units of S/N 300, and higher, an INPUT switch with BRIDGE, 600 Ohm, and LINE HOLD (OPTION) has been added. The hold coil is optional (LINE HOLD position) and must be specifically ordered. There is an extra charge for this option.

For PB-1C units of S/N 400, and higher, the operating frequency range has been changed to extend from 930 Hz to 1030 Hz

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INSERTS

Suppressed Tone Phasor Domain Measurement (Technical Bulletin) After Section I

Transparent Line Generator Models NNE 1000 and NNE 1000R (Data Sheet) After Last Section

1-1. INTRODUCTION

1-2. The PB-1C VF Line Analyzer employs a new method of displaying, identifying, analyzing, and measuring disturbances induced on signals by impairments of the voice-frequency channels through which those signals are transmitted. The new method is called Suppressed-Tone Phasor Representation. Impairments are examined in real time, as they are actually happening, without being masked or lumped together by the detection and time averaging necessary to reduce them to a numerical readout. All impairments are presented in a single meaningfully classified display. Thus it is possible not only to identify and measure out of normal conditions, but alternatively to establish, in seconds, that all dynamic impairments are within limits. Of particular importance is the response of phasor domain measurements to transient impairments. Using two units, one ahead of and one behind a facility to be examined, it is easily determined whether the facility is initiating or merely transmitting any kind of dynamic impairment. Accessing may involve the use of a selective level meter in Carrier and normal connection at the VF Band to clear a plant, or it may involve a Bradley Telcom Transparent Line Generator to access both ends of an entire transmission facility to two PB-1C's at a single physical location.

1-3. This manual covers theory, operation, and alignment of the PB-1C VF Line Analyzer, and interpretation of data displayed by the instrument. The Technical Bulletin immediately following, entitled "Suppressed Tone Phasor Domain Measurement", describes this new method, defines the various kinds of disturbances and impairments, and explains how the PB-1C permits identification and measurement of each type of disturbance, even in complex combinations of disturbances. Note that the references in the Technical Bulletin are to the PB-1 which is the predecessor instrument to the PB-1C. The material is generally applicable to both the PB-1 and the PB-1C although the mechanizations differ somewhat so that the Theory Of Operation, starting on page 5 of the Technical Bulletin, is correct in concept but not in detail.

1-4. PB-1C LINE ANALYZER, OVERVIEW

1-5. The PB-1C is an instrument for troubleshooting facilities. With a minute or two of observation, experienced craft can:

clear facilities in the case of a complaint which is not valid

tag facilities in the case of a complaint which is valid.

1-6. The PB-1C does not perform tariff measurements. What it does do is:

identify the nature and magnitude of impairments for facility maintenance personnel who are trying to clear troubles

classify facilities in a go/no-go way relative to modem requirements for data-concerned personnel.

1-7. In this instrument, the impairments induced by the facility on a test tone are visually demodulated and displayed in real time as they actually occur. Impairments are thereby distinguished with a resolution which is unique. Because of the excellent delineation of the presentation, a meaningful examination of the entire band can be carried out at one time and on one display. The PB-1C thus not only provides results extremely quickly, but it is the only existing hardware which can positively "clear" a facility against suspicion of all the dynamic impairments, including those which have not yet been defined and which either confuse, or are ignored by, conventional test equipment. This occurs because the impairment examination is not limited by a set of rules for detection and time averaging as is required to produce a numerical display. As a corollary, the instrument does not become obsolete from time to time as new impairments are discovered or rules for their detection changed.

1-8. The PB-1C approach has proven particularly useful in carrier maintenance application as a result of its capability in identifying the 'mystery problems' which other instruments do not see. One such area is in the time variation of harmonic distortion. This facility condition arises from time variation of Phase Intercept Distortion in FDM systems, from harmonic hits and from compander problems in T-carrier, and from other as yet unidentified causes. All conventional instruments rely on time averaging for several seconds. This completely masks any time varying component at frequencies above a fraction of a Hertz. Data sets making a thousand or more decisions per second respond to instantaneous (peak) impairments; thus, data-inimical harmonic distortion impairments exist on PCM and FDM facilities which are not detected by conventional harmonic and 4-tone Non-Linear Distortion measurement, or for that matter, by notched noise measurements.

1-9. Because the PB-1C examines a facility in the same real time way that modems use that facility, it provides a direct comparison of facility performance vis a vis modem requirements. The same instrument provides valid go/no-go screening capability for relatively unskilled personnel and deep diagnostic information for the more sophisticated user. There is a desirable side benefit, users of the PB-1C, at whatever level, develop better insight into the nature of impairments.

1-10. An entirely different aspect of the technique is illuminated by the question, "Just what is it that is being measured?" This is most frequently asked when the PB-1C is monitoring a quiet line, because nothing much seems to be happening. The answer is, "Everything," i.e., all dynamic impairments. The absence of activity denotes a highly desirable condition because the display not only indicates what impairments are present, but what impairments are not present. Usually one or two parameters will predominate, depending upon the type of facility, and their magnitude can be measured. Of equal, if not greater, importance is the information, implicit in the display, that everything else is negligible.

1-11. The PB-1C embodies the following:

a. INPUT - Balanced, 310 with 3 position switch. Control as follows:

- BRIDGE, input impedance greater than 40K ohm
- 600 ohm, input terminated
- LINE HOLD (OPTION), when ordered a hold coil is connected. The 600 ohm termination also remains connected.

b. Phasor Domain CRT - The CRT display functions for an imput signal between 930 and 1030 Hz and between -40 and +10 dBm. The presence of such a signal is indicated by extinguishment of the "DO NOT READ CRT" light.

CRT MODE - 4 position switch (See Figure 2-2)

- Vector notch, 20 to 300 Hz
- vector notch, unfiltered
- 2nd Harmonic
- 3rd Harmonic

SCALE MULT - 5 position switch

x 0.5 and -20 dB
x 1 and -14 dB
x 2 and - 8 dB
x 5 and 0 dB
x 10 and + 6 dB

NNE ATTEN - 2 position switch

NORMAL or -10dB, 1/3.2

This switch attenuates the CRT display and the Notched Noise meter reading, speaker output, and electrical output on the tip of the INTERCONNECT B jack by 10 dB. This switch is used when the PB-1C is operated with a Bradley Telcom NNE series Transparent Line Generator, see data sheet at end of this instruction book.

SINGLE AXIS, HOR/VET - This control is present in units having serial number 100 or higher. Two-position, center-off, spring returned toggle switch. When held downward it grounds the CRT vertical deflection input so only the horizontal component of the total excursion is obtained. This is used as a reading aid for measuring phase jitter and amplitude jitter in the Vector Notch 20 to 300 position of the mode switch.

c. METER

Meter Mode - 4 position switch selects readout of the following:

Frequency	- 300 to 3000 Hz
Level	- -44 to +10 dBm-rms
Noise	- 16 to 70 dBrn, C-message weighted, rms detected
Notched Noise	- -44 to +10 dB relative to received tone level, C-message weighted, rms detected

The Notched Noise reading is valid only for inputs between 990 and 1030 Hz and between -40 and +10 dBm.

d. SPEAKER

Speaker Mode - 2 position switch

Input
Notched Noise

Volume pot

e. OSCILLATOR -

Output - 600Ω, Balanced, dc blocked for 200 volts

Oscillator mode - 4 position switch

2713 Hz
1004 Hz
1004 Hz with 2008 Hz at -16 dB
2008 Hz

Output Level Adjust pot, range 0 to -30 dBm

f. ELECTRICAL OUTPUTS (UNBLANCED)

CRT X deflection voltage
CRT Y deflection voltage
Notched Noise - Normalized to be relative to a "0" dBm input tone level. *
Local Oscillator (Scrubbed Tone)
Input Normalized to Reference Level
Input repeated as a single-ended voltage

ELECTRICAL INPUTS (UNBALANCED)

CRT X deflection voltage
CRT Y deflection voltage

*For PB-1C serial number 12 and below, this level is approximately 12 dB higher.

1-12. Measurement Capabilities of the PB-1C

1-13. The PB-1C includes

a. An oscillator, which generates four switch selectable frequencies or frequency combinations over an adjustable level range.

b. A meter which selectably display Background Noise, Input Frequency, Input Level, and Notched Noise.

c. A speaker which monitors either the input or the notched noise.

d. A phasor domain CRT display.

1-14. The CRT display, notched noise meter reading, and notched noise acoustic output are valid only when the input is between 990 and 1030 Hz and between +10 and -40 dBm. The presence of a valid input is signaled by the DO NOT READ CRT light which is then extinguished.

1-15. The Phasor Domain CRT measures the below indicated quantities.

1-16. Tone Parameters

a. Frequency Hits: bidirectional transient changes in frequency followed by return to the original frequency.

b. Frequency Shift

1-17. Tone-Correlated Amplitude Disturbances

a. Amplitude Jitter: the combined effects of pure amplitude modulation and uncorrelated disturbances (such as noise or SFI) on the amplitude of the received tone.

b. Amplitude Modulation

c. Gain Hits: bidirectional transient changes in amplitude that return to approximately the original amplitude. A positive gain hit is an increase in amplitude followed by a decrease to the original amplitude; a negative gain hit is a decrease in amplitude followed by an increase to the original amplitude. Typical hit durations are 50 to 150 milliseconds.

d. Gain Steps: unidirectional positive or negative transient changes in amplitude.

e. Dropouts: negative gain hits of at least 12 dB for at least 10 milliseconds.

1-18. Tone-Correlated Phase Disturbances

a. Phase Jitter: the combined effects of pure angle (phase or frequency) modulation and uncorrelated disturbances (such as noise or SFI) on the phase of the received tone.

b. Phase Modulation

c. Phase Hits: bidirectional transient changes in phase that return to approximately the original phase.

d. Phase Steps: unidirectional positive or negative transient changes in phase.

1-19. Non-Correlated Disturbances

a. Notched Noise: received signal with quiet-tone removed.

b. Single-Frequency Interference: undesired or spurious steady tones. This category does not include phenomena such as tone bursts that may result from crosstalk of multifrequency signaling on other channels.

c. Impulses

1-20. Distortion

a. 2nd Harmonic Distortion

b. 3rd Harmonic Distortion

c. Phase Intercept Distortion

1-21. PCM Disturbances

a. Quantizing Disturbances

b. Foldback Products

c. Compandor Mistracking

1-22. The PB-1C is also capable of detecting and identifying the following 'data-disturbing faults' which have been observed on transmission channels that meet all 'normally measured' performance criteria.

a. Differentiates between jitter, noise, and single-frequency interfering tone (SFI).

b. Differentiates between amplitude jitter and phase jitter. Amplitude jitter is similar to phase jitter except that it is predominantly on the in-phase axis. (Most 9600-bit modems appear to be more sensitive to amplitude jitter than they are to the equivalent sideband energy when it appears as phase jitter).

c. Measures low-frequency jitter, down to 1 Hz.

d. Measures high-frequency jitter.

e. Detects phase hits and gain hits which are too short or too slow to be registered on conventional hit counters. Continuous small phase hits or gain hits occasionally add linearly with the noise and jitter to place a transient outside the no-go error limit.

f. Indicates hit duration and hit direction.

g. Detects noisy dropouts and fast dropouts.

h. Monitors phase-intercept distortion (PID). Continuous variation of PID corresponds to frequency translation. Rapid variation of PID causes data errors. Brief periods of rapid variation in phase intercept distortion result in phase hits too slow to be seen by conventional hit counters, but in instantaneous frequency shifts large enough to confuse modems.

i. Identifies the location of harmonic distortion sources with respect to (i.e., before or after) any frequency translation which may exist on the channel.

j. Provides facility 'signature' information.

k. Provides impairment 'signature' information.

l. The Notched Noise audio output is an important part of the diagnostic capability of the PB-1C. It permits audible and visual correlation of disturbances. It is particularly useful for transient phenomena because correlated disturbances (phase and gain hits) and uncorrelated disturbances (impulse hits) have different acoustic signatures.

1-23. For the benefit of users familiar with the PB-1, the following describes the ways in which the PB-1C differs from the PB-1:

a. A four-mode meter display has been added to provide a voice-band level, frequency, noise and notched noise meter. The holding tone for notched noise is 990 to 1030 Hz.

b. The CRT readout of Frequency and Level measurement modes of the PB-1 have been removed. Their function is replaced by the panel meter.

c. A four-mode independent oscillator has been added.

d. For the functions involving the CRT display, frequency ranges other than 990 to 1030 Hz have been deleted.

e. The AGC range has been extended so that no level adjustment is necessary, and this control has been removed.

f. The 20 to 600 Hz filter has been deleted.

g. A scale sensitivity attenuation switch complementary to the Bradley Telcom NNE series Transparent Line Generators has been added.

h. The input is 600 ohms terminated only.

i. The electrical outputs have been modified.

j. The unit is 5¼" high x 17" wide x 12½" deep. A 19" rack mounting adapter kit is available.

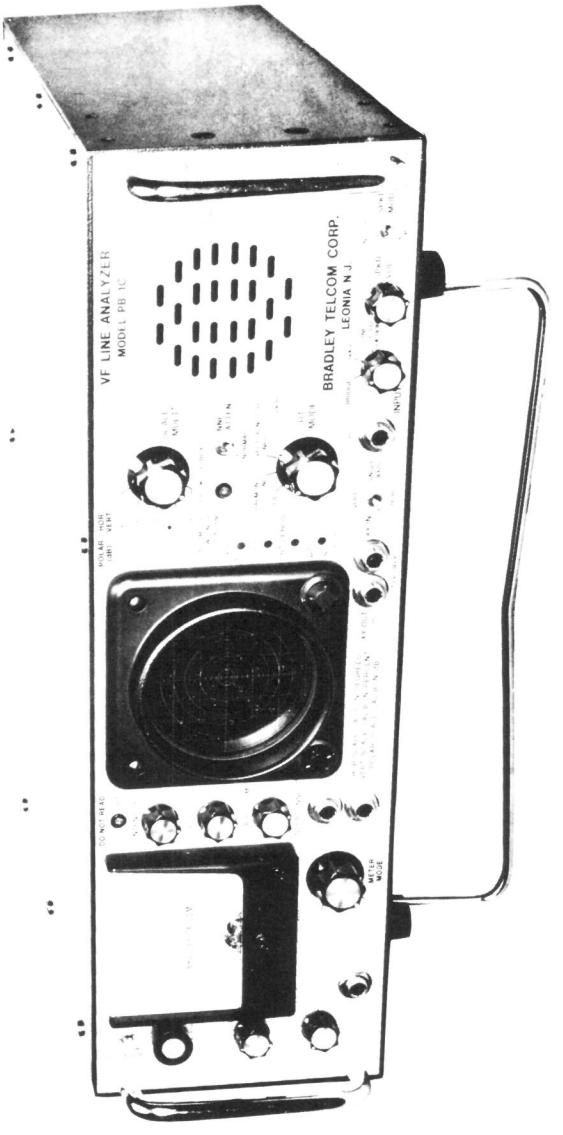


Figure 2-1 Line Analyzer Model PB-1C

DESCRIPTION OF PB-1C LINE ANALYZER

2-1. EXTERNAL DESCRIPTION, See Figure 2-1.

2-2. The PB-1C is contained in a portable case 17 1/2" wide, 5 1/4" high, and 12 1/2" deep, exclusive of panel controls. On the underside of the instrument is a bail or tilt stand that permits the front of the instrument to be tilted up for ease of viewing the CRT display and the operating controls. A rack mounting adapter kit is available for mounting the PB-1C in a 19" rack. The feet and bail assembly are outside the 5 1/4" height and they must be removed to mount the PB-1C in a 5 1/4" high panel slot.

2-3. The PB-1C instrument comprises the following:

a. Phasor Domain CRT display (center of panel), which monitors a tone input between 990 and 1030 Hz in frequency, and between -40 and +10 dBm in level. The presence, at the INPUT jack, of a tone in this range is indicated by the red DO NOT READ CRT indicator being extinguished. Four CRT display modes and five scale sensitivities are provided.

b. Meter Display (left side of panel) which selectively monitors the following:

Frequency
Level
Background Noise Level
Notched Noise Level

NOTE - The Frequency, Level, and Noise meter display is valid for any VF input, i.e., it is not limited to the 990 to 1030 Hz range as is the CRT display. The Notched Noise reading is only valid if the DO NOT READ CRT is extinguished.

c. Oscillator (extreme left side of panel) - Four different frequencies, or frequency combinations, are provided at an adjustable level between 0 and -30 dBm.

d. Speaker (right side of panel) - May be selectively connected to either the input or the notched noise. The notched noise acoustic output is valid only when the DO NOT READ CRT light is extinguished.

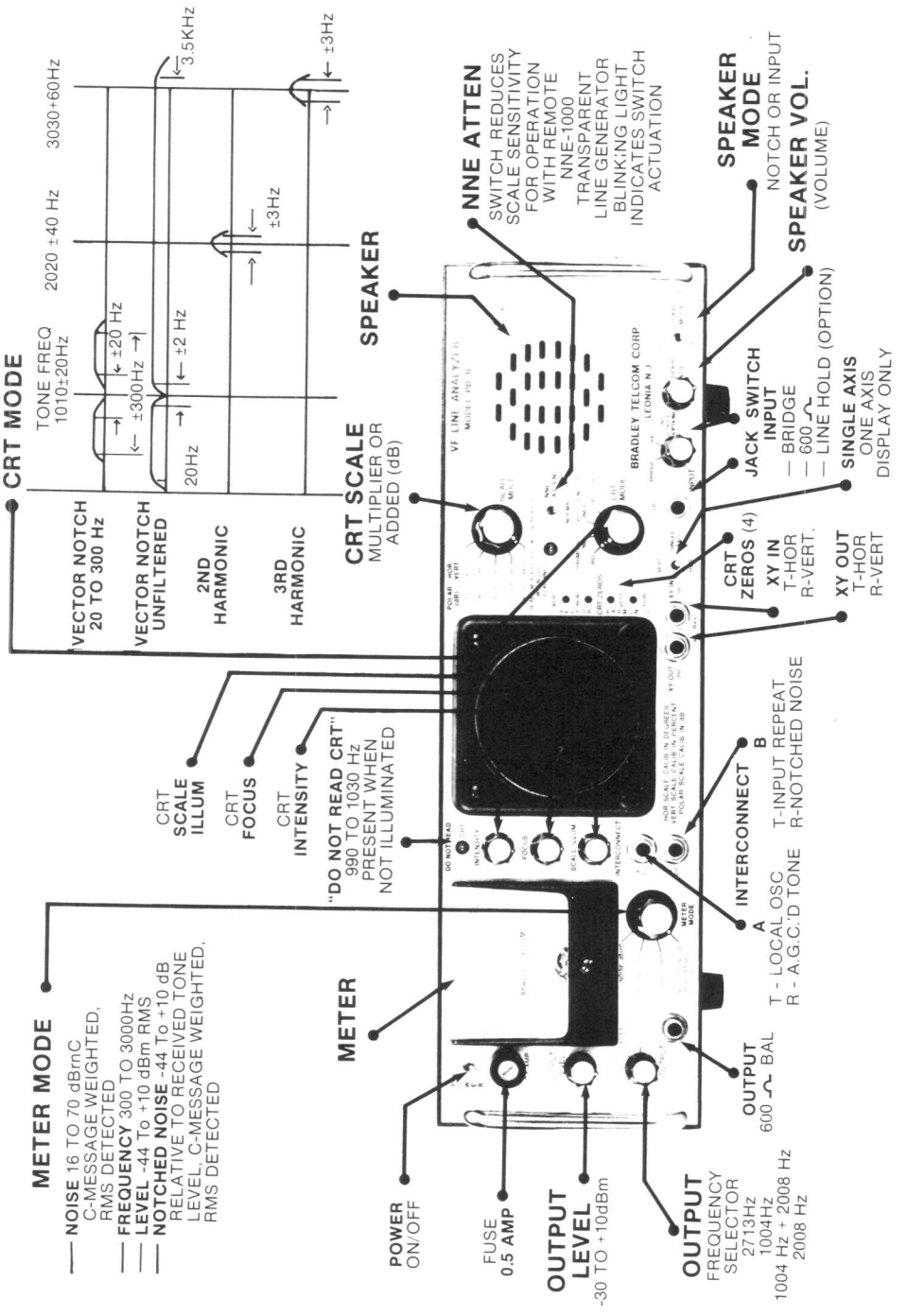


Figure 2-2 PB-1C Controls

2-4. CONTROLS, see Figure 2-2

2-5. AC line - Receptacle - 115 ± VAC 50/60 Hz - Rear of unit
POWER "ON" switch - upper left corner of panel
"0.5 Amp" fuse - upper left corner of panel

2-6. Oscillator (bottom left corner of panel)

a. "OUTPUT" Frequency Selector - 2713 Hz
1004 Hz
1004 Hz + 2008 Hz (2008 is -16 dB relative to 1004)
2008 Hz

b. "LEVEL" - Adjusts level at OUTPUT jack from 0 to -30 dBm.

c. "OUTPUT" jack - 310 - 600 ohms, balanced, dc blocked for 200 volts. At 1004 Hz the oscillator output contains less than -55 dB of second and third harmonic content. At 2008 Hz and 2713 Hz, the harmonic content increases to -45 dB; however, this is not significant because it is out of band. AC line related noise is also less than -55 dB for output levels above -16 dBm.

d. To set oscillator output level, patch OUTPUT to INPUT, set METER MODE to LEVEL and adjust oscillator LEVEL control for desired value.

2-7. METER Display (left side of panel)

The meter monitors the signal applied to the INPUT jack. The INPUT jack is 310, 600 ohms, balanced, dc blocked for 200 volts. The METER MODE switch (under the meter) selects the following meter read out modes:

FREQUENCY, Hz - 300 to 3000 Hz, read on upper scale, smallest division equals 50 Hz.

LEVEL, dBm - -44 to +10 dBm, read on center scale, smallest division equals 1 dB. Detector is rms.

NOISE, dBrnC - 16 to 70 dBrnC, read on lower scale, smallest division equals 1 dB. Detector is rms, filter is C-message weighted.

NOTCHED NOISE, dB RELATIVE TO TONE - -44 to +10 dB, read on center scale, smallest division is 1 dB. Detector is rms, filter is C-message weighted, notch is more than 50 dB deep. This reading is valid only if the red DO NOT READ CRT lamp is extinguished.

2-8. SPEAKER (right side of panel)

a. The SPEAKER toggle switch has two positions labeled INPUT and NOTCH. In the INPUT position, the received tone is fed to the loudspeaker. In the NOTCH position, the Normalized Notched Noise is fed to the loudspeaker. This acoustic output is a valuable aid in identifying certain types of impairments by means of their characteristic 'signatures'.

2-9. PHASOR DOMAIN CRT DISPLAY (center of panel)

a. For a 990 to 1030 Hz, -40 to +10 dBm signal connected to "INPUT" jack, the DO NOT READ CRT light is extinguished and CRT displays data in accordance with the selected "CRT MODE" and "SCALE MULT". "FOCUS", "INTENSITY", AND "SCALE ILLUM" controls are provided on the left side of the CRT. There are two HARMONIC modes and two VECTOR NOTCH modes. Separate HOR and VERT spot centering adjustments are provided for the HARMONIC and VECTOR NOTCH modes.

b. INPUT jack & switch - 310 jack

BRIDGE - Impedance greater than 40K ohms, dc blocked for 200 volts.

600 Ohm - Terminating resistor capable of withstanding CO battery placed across input.

LINE HOLD (OPTION) - 180 ohm (dc resistance) coil with 2 henries at 60 ma dc and 1.3 henries at 100 ma dc. This coil is placed across input in parallel with 600 ohm resistor above.

NOTE - When the XY IN jack, below CRT, has an input patched, normal CRT operation is pre-empted and the CRT horizontal and vertical deflection is controlled by the voltage on the Tip and Ring of the XY IN 310. The sleeve of the 310 must be connected to the XY IN signal source ground. The SCALE MULT switch selects the XY IN deflection sensitivity.

c. The INTENSITY control permits continuous variation of the CRT spot brightness.

d. The FOCUS control permits adjustment of CRT spot size. Interaction between INTENSITY and FOCUS controls may necessitate readjustment of FOCUS control when INTENSITY control setting is changed.

e. NOTE - To avoid burning center of screen, if spot remains undeflected for long period, reduce setting of INTENSITY control. Do not change setting of FOCUS control, even though the reduced-intensity spot may be defocused. When intensity is increased to former level, spot will again be in focus.

f. The SCALE ILLUM control permits continuous variation of the brightness of the graticule scales.

g. The graticule mounted in front of the cathode-ray-tube screen has three sets of illuminated scales that permit measurements of the various types of input signal displays selected by the MODE switch, see Figure 2-3. The graticule scales are calibrated as follows:

The vertical scale is divided by equally-spaced horizontal lines that are numbered along the vertical axis from bottom to top, as follows: -6, -4, -2, (0), +2, +4, and +6. As noted by the legend below the CRT bezel, the vertical scale numbers represent percent.

The horizontal scale is divided by equally-spaced vertical lines that are numbered along the horizontal axis from left to right as follows: -3, -2, -1, (0), +1, +2, and +3. As noted by the legend below the CRT bezel, the horizontal scale numbers represent angular degrees.

The polar scale is divided by concentric circles that are numbered along a diagonal from lower left to center as follows: -10, -12, -14, -16, and -20. The innermost circle, representing -30, is not numbered on the graticule. As noted by the legend below the CRT bezel, the polar scale numbers represent dB separation from received tone.

h. CRT MODE - In the absence of a patch to XY IN, this control selects one of the four following modes (see Figure 2-2):

VECTOR NOTCH, 20 to 300 Hz - The steady state tone is suppressed and the remaining notched noise, in the band from nominally 700 Hz to 980 Hz and from 1020 Hz to 1030 Hz, is visually demodulated and presented on the CRT display.

VECTOR NOTCH, UNFIL - The steady state tone is suppressed and the remaining notched noise, in the band from nominally 20 Hz to 3.5 kHz, with a $\pm$ 2 Hz wide notch at the tone frequency, is visually demodulated and presented on the CRT display.

HARMONIC, 2ND - The components of the received signal within $\pm$ 3 Hz of the 2nd harmonic of the received tone are visually demodulated with respect to the 2nd harmonic of the input and are presented on the CRT display.

HARMONIC, 3RD - The components of the received signal within $\pm$ 3 Hz of the third harmonic of the received signal are visually demodulated with respect to the third harmonic of the input and are presented on the CRT display.

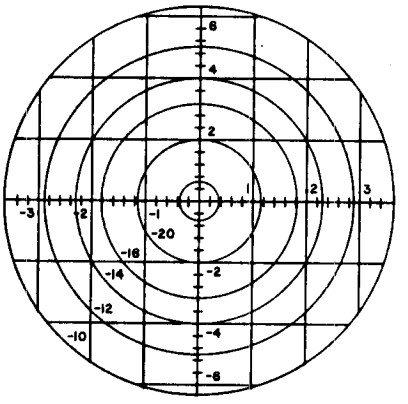


Figure 2-3 Graticule

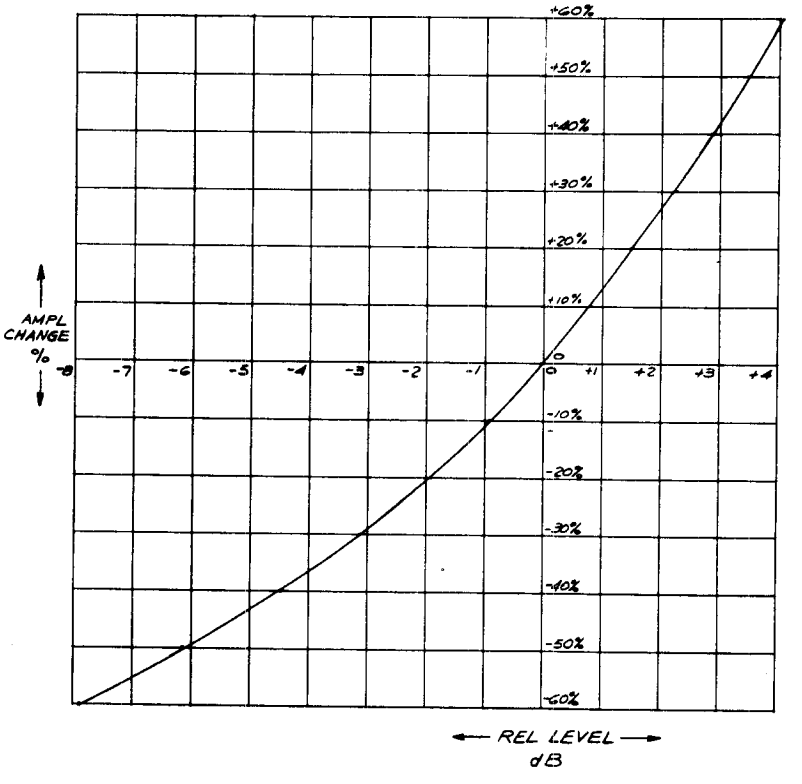


Figure 2-4 Conversion From Percent to dB

i. SCALE MULT - Selects one of five CRT display sensitivities. The horizontal and vertical graticule calibration are linear and modified by the multiplicative factors. The horizontal scale is in terms of degrees of phase jitter and is read peak to peak. The vertical scale is in terms of percent Amplitude Jitter and is read zero to peak. The circular (polar) scales are logarithmically divided and are read in terms of dB separation from the tone. The additive (dB) factor selected the SCALE MULT switch is added to (or subtracted from) the polar scale graticule marking.

j. The SCALE MULT control is a five-position rotary selector switch. The corresponding HOR/VERT and POLAR dB scale factors for each of the five positions are:

HOR/VERT	X0.5	X1	X2	X5	X10
POLAR dB	-20	-14	-8	0	+6

k. The horizontal scale on the graticule is numbered ±(1, 2, 3), and the vertical scale is numbered ±(2, 4, 6). The horizontal scale represents angular degrees, and the vertical scale represents percent change. Although the horizontal and vertical scales represent different units, the same SCALE MULT switch HOR/VERT multiplication factors apply to both simultaneously, as shown in the table below.

		SCALE MULT Switch HOR/VERT Setting				
		X0.5	X1	X2	X5	X10
Horizontal	1	0.5	1	2	5	10
	2	1.0	2	4	10	20
	3	1.5	3	6	15	30
Vertical	2	1	2	4	10	20
	4	2	4	8	20	40
	6	3	6	12	30	60

l. Phenomena such as gain hits and gain steps are displayed as vertical deflections in percent, but are customarily referred to in dB relative to the tone amplitude. Figure 2-4 is a plot of the relationship between percent change and dB change.

m. The graticule circles used for the POLAR dB are calibrated in -10, -12, -14, -16, -20, and -30 dB from the outermost to the innermost. All but the innermost are numbered. Since the calibrations of the circles represent dB relative to the POLAR dB setting of the SCALE MULT switch, the dB value at each setting of the SCALE MULT switch must be added algebraically to the graticule circle values.

n. The following table shows how the POLAR dB setting and the graticule reading are added to give the total level in dB of any deflection:

	SCALE MULT Switch POLAR dB Setting				
Graticule Reading	-20	-14	-8	0	+6
-30	-50	-44	-38	-30	-24
-20	-40	-34	-28	-20	-14
-16	-36	-30	-24	-16	-10
-14	-34	-28	-22	-14	- 8
-12	-32	-26	-20	-12	- 6
-10	-30	-24	-18	-10	- 4

o. "NNE ATTEN" - This toggle switch is kept in the NORMAL position except when the PB-1C unit is being used to read the output of a Bradley Telcom NNE Series Transparent Line Generator. In the "-10 dB, x 1/3.2" position, the adjacent red indicator light is illuminated and the PB-1C display sensitivity is reduced by a factor of 10 dB or 3.2. This factor is the reciprocal of one of the Notched Noise Enhancement factors of the NNE. In this position of the switch, the CRT scales are direct reading in terms of the impairments at the input to the remote NNE (in the +10 dB, x 3.2 "NOISE GAIN" position of the NNE). For units of S/N 180 and above the switch also attenuates all other Notched Noise functions, i.e., meter Notched Noise reading, speaker output (NOTCH MODE), and "INTERCONNECT B" tip output. For those who wish further information, a data sheet describing the Transparent Line Generator is provided at the end of this instruction book.

2-10. ELECTRICAL OUTPUTS -

INTERCONNECT A & B patch to the 75L Hit Counter
XY OUT is an output for recording
XY IN is an input for constellation pattern generators

The following signals are available where indicated:

a. "INTERCONNECT A"

Tip - Phase lock loop local oscillator (in quadrature with input signal). This voltage is nominally five volts peak to peak.

Ring- Normalized input voltage. In the presence of a valid signal at the INPUT jack (990 to 1030 Hz, -40 to +10 dBm), this voltage is a nominally 3.5 volts p to p sine wave which is offset 4.5 volts above ground. In the absence of a valid signal, this output (average) is nominally at ground potential and the sine wave is removed.

b. "INTERCONNECT B"

Tip - Notched Noise. Source impedance is 600 ohms and the output level is relative to a "0" dBm input when loaded with 600 ohms, i.e., the notched noise in dBm is its separation from input level in dB. This is independent of the actual tone input level. For PB-1C units of serial number 12 and below, this output is approximately 12 dB higher.

Ring- Input signal repeated as a single-ended voltage 3 vpp for 2.2 vpp input sine wave (0 dBm).

c. "XY OUT"

Tip - CRT X Deflection voltage

Ring- CRT Y Deflection voltage

d. "XY IN"

The XY IN jack, when patched, has its Tip connected to the CRT X deflection amplifier and its Ring to the Y deflection amplifier. The sleeve is used to carry ground from the deflection voltage source and this ground must be connected. This jack permits the PB-1C to be used as an X-Y oscilloscope or vectorscope to display modem "eye" patterns, 'constellation' patterns, or decision spaces. Many modems have X-Y outputs for this purpose. Both inputs have the same nominal deflection sensitivities, which are related to the SCALE MULT switch settings as follows:

SCALE MULT switch setting	X0.5	X1	X2	X5	X10
EXT INPUT sensitivity, mV/cm	40	80	160	400	800

2-11. RACK MOUNTING ADAPTER

A rack adapter kit is furnished for mounting the PB-1C in a standard 19" relay rack. The kit comprises two L-shaped adapter brackets and eight 10-32 x 5/16 flat head (undercut) machine screws. Four countersunk holes in each bracket mate four 10-32 tapped holes in each side wall of the PB-1C case. The brackets are fastened to the side wall using the machine screws. The PB-1C will fit into a 5¼" high rack slot if the feet and bail assembly are removed. The feet are fastened to the case with 6-32 binding head screws and they may be removed by removing the screws. If the feet are replaced at some future time, each front foot (which also supports the bail assembly) is mounted with two ½" long screws and each rear foot with one 3/8" long screw. Adapters for 23" telephone racks are available on order.

3-1. GENERAL

3-2. SUPPRESSED-TONE PHASOR ANALYSIS METHOD

a. When a sinusoidal test tone is transmitted over a voiceband channel, the received signal contains a steady-state tone or quiet tone, plus tone-correlated disturbances (incidental AM, PM, and FM; harmonics; and hits, steps and dropouts) as well as non-correlated disturbances (SFI and noise).

b. Since the disturbances in the received signal are generally much smaller in magnitude than the test tone, it is difficult to measure those disturbances in the presence of that tone, which tends to obscure the disturbances. It is therefore desirable to remove the test tone (and only the test tone) from the received signal, so that the resulting 'notched noise' contains only the disturbances to be identified and measured.

c. It is also desirable to normalize the amplitude of the received signal so that the residual disturbances that constitute the notched noise can be measured against a calibrated scale.

d. The suppressed-tone phasor analysis method normalizes the received signal and eliminates the steady-state tone from the received signal; it then resolves the remaining disturbances into in-phase and quadrature components and displays them on a cathode-ray tube so that they can be separately identified and measured by means of calibrated scales on the CRT graticule.

e. The suppressed tone phasor analysis method employs two high-gain closed loops, an Automatic Gain Control (AGC) loop, and a Notch Phase-Lock Loop (NPLL), which are interconnected to operate as a narrowband notch filter that automatically tracks and suppresses the steady-state or quiet-tone component of a received signal.

f. The NPLL tracks the frequency of the quiet tone and generates two orthogonal reference tones, one in phase with the quiet tone, and one in quadrature with the quiet tone.

g. The AGC loop tracks the level of the quiet tone and normalizes the received signal by amplifying the quiet tone to the same amplitude as that of the in-phase reference tone. Since the in-phase reference tone is of the same amplitude and phase as the quiet tone, it is equivalent to the quiet tone, and may be subtracted from the normalized received signal, leaving 'normalized notched noise" (NNN) (i.e., normalized received signal minus quiet tone) containing only the normalized disturbances. This is equivalent to eliminating the quiet tone by means of an extremely narrow notch filter, but has the advantage that it automatically follows or tracks slow frequency variations of the quiet tone.

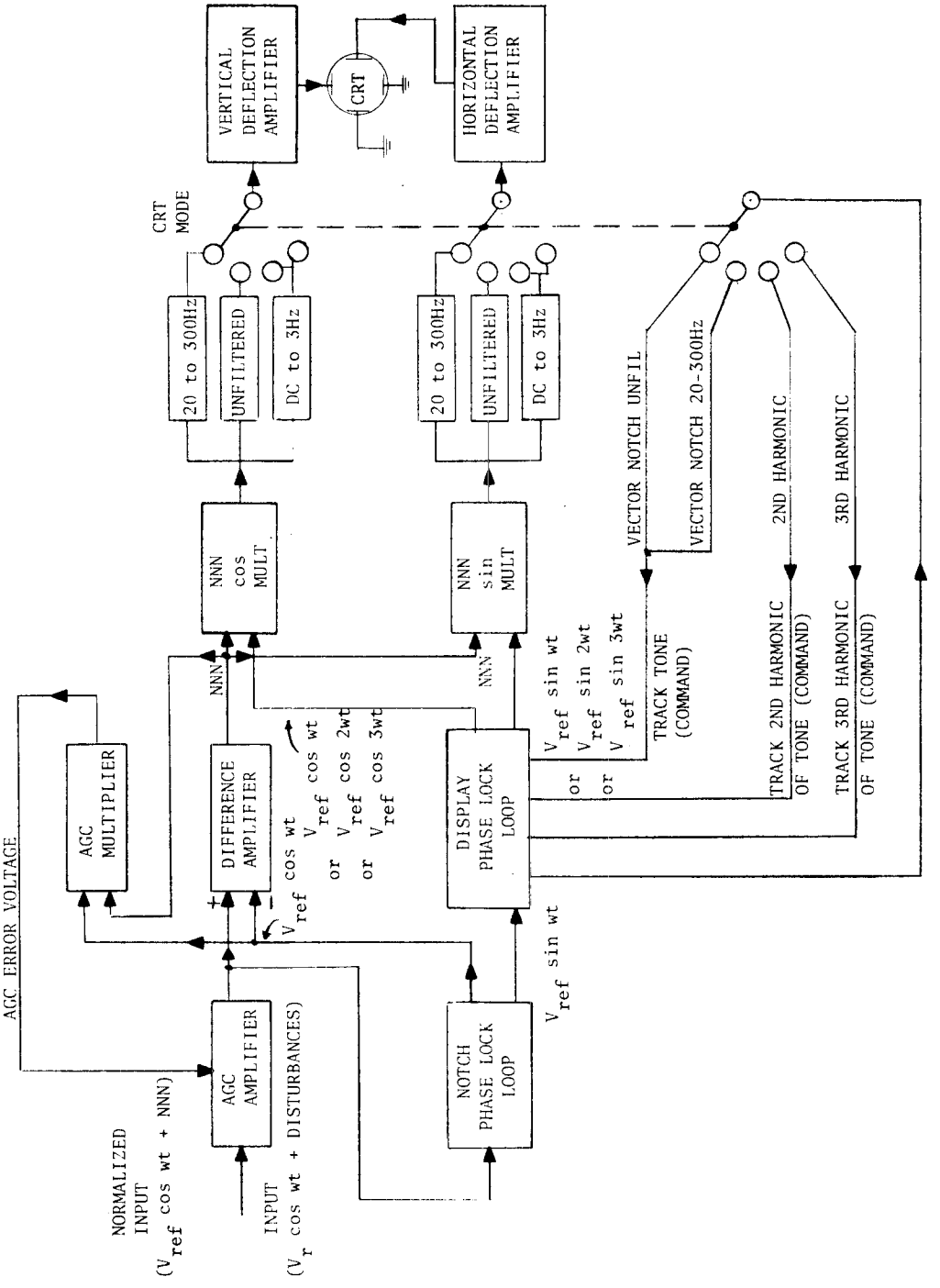


Figure 3-1 SIMPLIFIED BLOCK DIAGRAM

3-3. PB-1C SIMPLIFIED BLOCK DIAGRAM (Figure 3-1)

3-4. The simplified block diagram of Figure 3-1 shows how the suppressed-tone phasor analysis method is implemented by means of two interconnected loops, the Automatic Gain-Control (AGC) loop and the Notch Phase-Lock Loop (NPLL).

a. The received signal, comprising the tone (V_r cos wt) and its accompanying disturbances, is fed to the AGC Amplifier, which amplifies the received signal to the level at which the tracking tone is equal to the in-phase reference tone (V_{ref} cos wt) from the NPLL. The quiet tone and its disturbances, which are thus normalized in amplitude, are fed to the (+) input of the Difference Amplifier, as well as to the NPLL.

b. The NPLL locks to the quiet tone (V_r cos wt) in the normalized received signal and generates two synchronous reference tones; a reference tone (V_{ref} cos wt) in phase with the quiet tone, and a reference tone (V_{ref} sin wt) in quadrature with the quiet tone. The in-phase reference tone (V_{ref} cos wt) is fed to the (-) input of the Difference Amplifier and also to one input of the NNN Cos wt MUltiplier; the quadrature reference tone (V_{ref} sin wt) is fed to the Display Phase Lock Loop (DPLL).

c. Since the (+) input to the Difference Amplifier is the normalized signal (V_r cos wt + disturbances), and the (-) input is the reference tone (V_{ref} cos wt), the output of the Difference Amplifier will be the normalized signal minus the quiet tone, or the normalized disturbances alone. Disturbances remaining after the quiet tone component of the received signal is removed, suppressed, or 'notched' from the signal, are conventionally called 'notched noise'. Since the PB-1C notches the quiet tone from the normalized received signal, the remaining disturbances are referred to as 'normalized notched noise', (NNN).

3-5. The NNN voltage from the Difference Amplifier is fed to the AGC Multiplier where it is multiplied by the in-phase reference tone (V_{ref} cos wt) from the NPLL to measure that component of NNN which is in-phase with the quiet tone. This is the quantity which is to be reduced to zero by the AGC Amplifier in order to leave only NNN at the Difference Amplifier output.

3-6. The quadrature output of the NPLL, V_{ref} sin wt, is used to synchronize the Display Phase Lock Loop (DPLL). Depending upon the position of the CRT MODE switch, the DPLL phase locks to the tone, second harmonic of the tone, or the third harmonic of the tone. The cosine (in-phase) and sine (quadrature) outputs of the DPLL are connected to one input of the NNN cosine and NNN sine multiplier respectively. The other input to each of these multipliers is the NNN.

3-7. Depending upon the DPLL frequency, the output of the NNN cos Multiplier is NNN cos wt, NNN cos 2wt, or NNN cos 3wt. Similarly the output of the NNN sine Multiplier is NNN sin wt, NNN sin 2wt, or NNN sin 3wt. In the upper position of the CRT MODE switch, NNN cos wt and NNN sin wt are coupled via 20 to 300 Hz filters to the vertical and horizontal CRT deflective Amplifiers. The second position of the CRT MODE switch couples these same outputs through a filter which passes the entire voice band. In the third position, the DPLL outputs are at the second harmonic frequency and the multiplier outputs are coupled to the deflection amplifier via the DC to 3 Hz filter. In the fourth position of the CRT MODE switch, the DPLL outputs are at the third harmonic of the tone frequency and the multiplier outputs are passed through the DC to 3 Hz filter.

3-8. The time constants of the AGC Loop and of the Phase Lock Loops are chosen so that both loops operate rapidly enough to recover from transients within the 1/7 second dead-zone interval of hit counters, but do not operate so rapidly that they mask hits, steps, or other transients.

3-9. PHASOR CRT DETAILED BLOCK DIAGRAM (Figure 3-2)

3-10. AUTOMATIC GAIN CONTROL (AGC) LOOP

The AGC Loop comprises the AGC Amplifier, Difference Amplifier, AGC multiplier, and AGC Error Voltage Integrator.

3-11. The gain of the AGC Amplifier is controlled by the AGC Voltage from the AGC Integrator. The output of the AGC Amplifier, which is the quiet tone (V_r cos wt) plus distrubances, is fed to the (+) input of the Difference Amplifier; and the in-phase reference tone (V_{ref} cos wt) from the Phase-Lock Loop is fed to the (-) input of the Difference Amplifier. The output of the Difference Amplifier is therefore

$$(V_r \cos wt + \text{disturbances}) - V_{ref} \cos wt,$$

which may be written

$$(V_r \cos wt - V_{ref} \cos wt) + \text{disturbances},$$

or

$$(V_r - V_{ref}) \cos wt + \text{disturbances}$$

a. If the quiet tone (V_r cos wt) is not equal to the in-phase reference tone (V_{ref} cos wt), the output of the Difference Amplifier will contain the residual tone ($V_r - V_{ref}$) cos wt plus the disturbances.

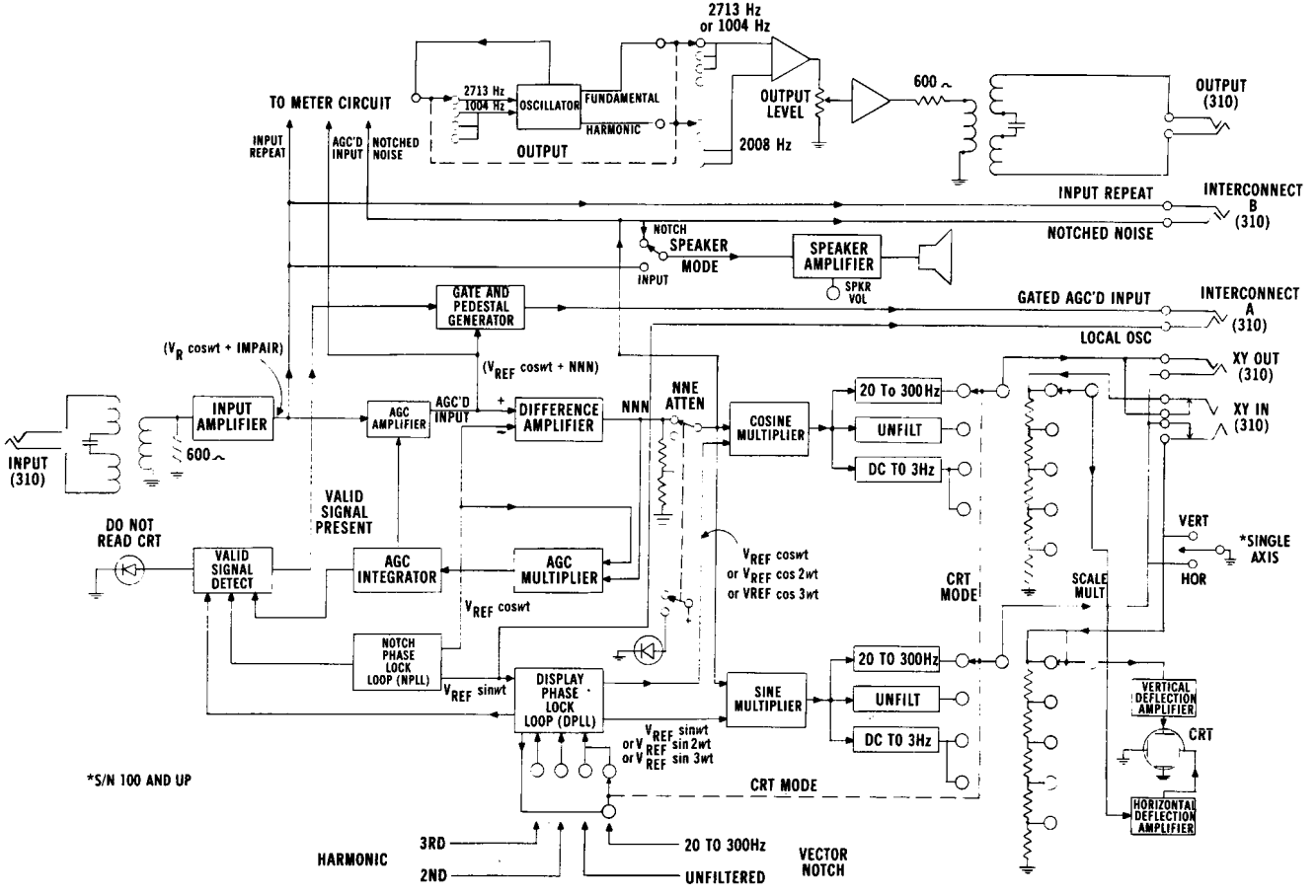


Figure 3-2 PHASOR CRT DETAILED BLOCK DIAGRAM

b. If the quiet tone is equal to the in-phase reference tone, the residual tone becomes zero, and the Difference Amplifier output contains only the disturbances. Since the entire received signal has been normalized in the process of amplifying the quiet tone (V_r cos wt) to exactly the same level as the in-phase reference tone (V_{ref} cos wt), the disturbances or notched noise remaining after the quiet tone has been removed, may be called Normalized Notched Noise (NNN).

3-12. The output of the Difference Amplifier is fed to one input of the AGC Multiplier, and the in-phase reference tone (V_{ref} cos wt) from the NPLL is fed to the other input. The output of the AGC Multiplier depends on whether the residual tone ($V_r - V_{ref}$) cos wt is equal to zero.

a. If the residual tone, ($V_r - V_{ref}$) cos wt is equal to zero, the output of the AGC Multiplier is the in-phase component of Normalized Notched Noise, or NNN cos wt.

b. If the residual tone ($V_r - V_{ref}$) cos wt is not equal to zero, the output of the Multiplier will contain, in addition to the NNN Cos wt voltage, a $(\cos wt)^2$ term. From the trigonometric identity,

$$(V_r - V_{ref})\ (\cos wt)^2 = \{\tfrac{1}{2} + \tfrac{1}{2}(\cos 2\ wt)\},\ (V_r - V_{ref})$$

it can be seen that the $(\cos wt)^2$ term comprises a DC average component and an AC component at twice the frequency of the quiet tone.

3-13. The output of the AGC Multiplier is fed to the AGC Integrator. The AGC Integrator filters out all AC components and integrates the DC component. The integrated DC output of the AGC Error-Voltage Integrator is used as the AGC Control Voltage, which varies the gain of the AGC Amplifier until the DC component in the output of the AGC Multiplier becomes zero. This occurs when the quiet tone. (V_r cos wt) in the AGC Amplifier output is exactly equal in amplitude to the in-phase reference tone (V_{ref} cos wt) from the NPLL, so that the residual tone ($V_r - V_{ref}$) cos wt becomes zero. In this condition, there is no $(\cos wt)^2$ component in the output of the AGC Multiplier, which thus contains only the in-phase component (NNN cos wt) of Normalized Notched Noise.

3-14. Operation of the NPLL phase lock loops is conventional. Two sinusoidal outputs are generated, one in phase with the tone component (cos wt) of the input and one in quadrature (sin wt), both are at reference level. The DPLL phase lock loop is capable of tracking the NPLL or of tracking either its second harmonic or its third harmonic depending upon the positions of the CRT MODE switch.

3-15. In order for a test tone to be monitored by the phasor CRT, the AGC Amplifier must be within its control range and both the NPLL and DPLL phase lock loops must be tracking. These three conditions are sensed by the Valid Signal Detector, which, in the presence of a test tone between 990 and 1030 Hz and between -40 and +10 dBm, extinguishes the DO NOT READ CRT light. It also gates, and placed on a positive voltage pedestal, the output of the AGC Amplifier to the ring of Interconnect B.

3-16. The NNN at the Difference Amplifier output is connected to four places:

a. via the NNE ATTEN divider and switch to the sine and cosine multipliers. The NNE ATTEN reduces the NNN by a ratio of 3.2 or -10 dB. This is the reciprocal of the noise enhancement factor of the Bradley Telcom NNE-1000 Transparent Line Generator. It is only operated when the PB-1C is used with an NNE to reduce the scale sensitivity by the same amount the the NNE has increased the scale sensitivity.

b. to the notched noise meter circuit

c. to the Speaker via the SPEAKER MODE switch

d. to the top of the INTERCONNECT B jack

e. For units of S/N 180, and above, the NNE ATTEN switch also attenuates the NNN input to the meter, speaker, and jack circuits, b., c., and d. above.

3-17. The CRT MODE switch selects the DPLL frequency and the display filters. The output of the filters is connected to the SCALE MULT attenuator which selects the display sensitivity. This connection is via two NC contacts on the XY IN jack. When the XY IN jack is patched, the NC contacts are interrupted and the Tip and Ring inputs to the jack are substituted for the filter outputs as the input to the deflection amplifier.

3-18. The deflection inputs, as available at the SCALE MULT switch, are coupled to the CRT deflection system via the Deflection Amplifier. The deflection inputs are also connected to the Tip and Ring of the XY OUT jack.

3-19. The INTERCONNECT A + B jacks are connected to signals as shown.

3-20. SPEAKER

The Speaker Amplifier is selectably connected to the Notched Noise or to the input via the SPEAKER MODE switch. The SPKR VOL control adjusts the gain of the Speaker Amplifier. In order to

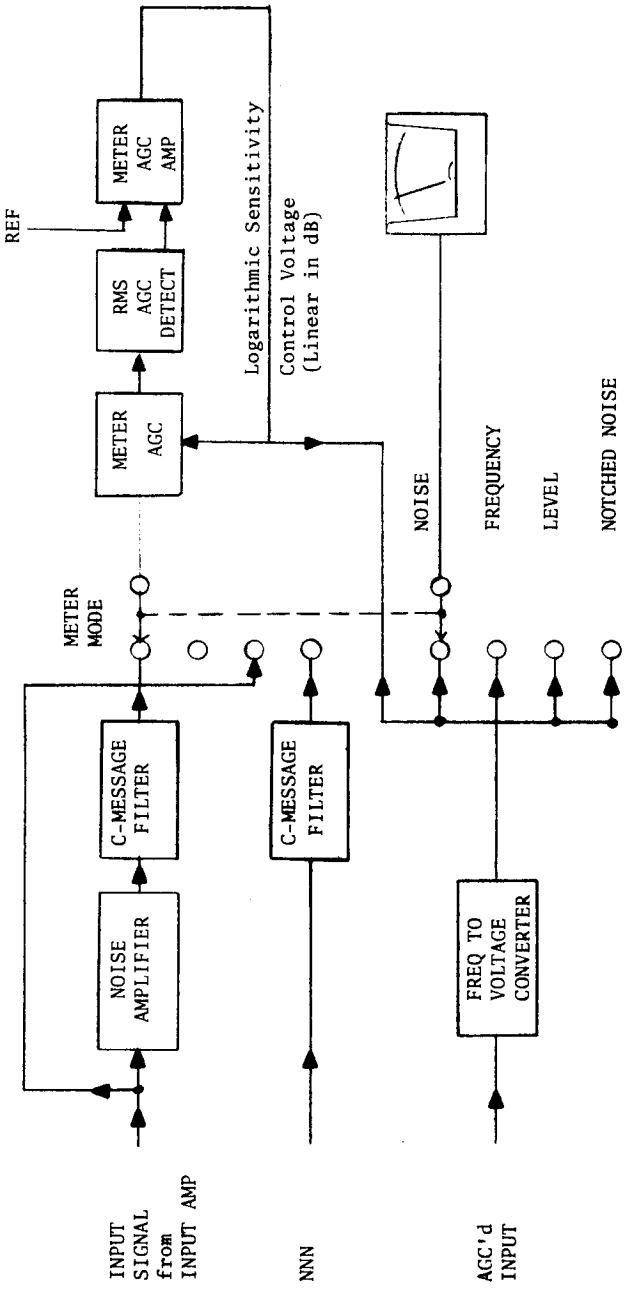


Figure 3-3 METER CIRCUITRY

accommodate weak signals and low noise signals, the maximum amplifier gain is sufficient to cause saturation for strong signals. This can be recognized, in operation, by the appearance of highly audible, and annoying, multiple harmonics.

3-21. OSCILLATOR

The oscillator is a Wein Bridge oscillator which is switch settable, by the OUTPUT switch, to 1004 Hz or 2713 Hz. Within the oscillator, a harmonic generator provides the second harmonic of the oscillator frequency. This is used in the 1004 Hz fundamental mode of the oscillator to generate 2008 Hz. In the upper (CCW) position of the OUTPUT switch, 2713 Hz is applied to the OUTPUT LEVEL potentiometer. In the next position, 1004 Hz is applied. In the third position, 1004 Hz plus 2008 Hz (at -16 dB) is applied. In the (CW) lower position, 2008 Hz is applied. The level is adjusted by the OUTPUT LEVEL pot.

3-22. METER CIRCUITRY (Figure 3-3)

Inputs to the meter circuit are the buffered Input Signal from the Input Amplifier, the Normalized Notched Noise (NNN) from the Difference Amplifier and the AGC'd input from the AGC Amplifier. The voltage to dB conversion required for three of the four meter modes is accomplished by the Meter AGC which has a logarithmic gain as a function of its Control Voltage. The Meter AGC output is rms detected and compared with a reference voltage. Any difference is amplified and causes the Meter AGC Control Voltage to change so as to null the input to the Meter AGC Amplifier. At null, the DC Control Voltage is proportional to the level in dB at the input.

3-23. In the LEVEL position of the METER MODE switch, the Input Signal is coupled directly to the Meter AGC which is scaled so that zero to full scale on the meter corresponds to a level range of from -44 to +10 dBm.

3-24. In the NOISE position of the METER MODE switch, the Input Signal is further amplified by the Noise Amplifier. It is then C-message filtered and coupled to the Meter AGC. With the added gain of the Noise Amplifier, the Meter AGC is scaled so that zero to full scale corresponds to a level range from 16 to 70 dBrnC.

3-25. In the NOTCHED NOISE position of the METER MODE switch, the NNN signal is coupled via a C-message filter to the Meter AGC. The scaling is such that Notched Noise is read relative to the received tone level over a range from -44 to +10 dB.

3-26. In the FREQUENCY position of the METER MODE switch, the AGC'd input is converted to a dc voltage by a Frequency to Voltage converter. The scaling is such that the meter spans the range from 300 to 3000 Hz.

OPERATION

4-1. INTRODUCTION

The PB-1C comprises four operating elements as follows:

Oscillator
Meter
Speaker
Phasor CRT

4-2. OSCILLATOR OPERATION

The oscillator output is available at the OUTPUT jack (310) as a balanced, 600 ohm, d-c blocked (up to 200 volts) voltage. The oscillator output level is controlled over the range from 0 to -30 dBm by the OUTPUT LEVEL potentiometer. Its frequency is selected by the four position OUTPUT switch as one of the following:

2713 Hz
1004 Hz
1004 Hz + 2008 Hz (2nd Harmonic), harmonic separation -16 dB
2008 Hz

The gain of the speaker amplifier is such that for high level inputs, near 0 dBm, the amplifier will saturate if the SPKR VOL control is set too high. This will be immediately obvious acoustically because obvious harmonics will be audible. This of course does not represent the true input. It is the result of including enough gain in the amplifier to make low level inputs clearly audible.

4-3. METER OPERATION

The panel meter, together with its mode switch, permits meter display of the Level & Frequency of an input tone, the Noise Level of a quiet input, or the Notched Noise of a nominally 1000 Hz test tone. Notched Noise reading is valid only if the DO NOT READ CRT light is extinguished. In the absence of any input the input AGC gain goes up, and if the METER MODE is in the FREQUENCY position, the needle will deflect to some arbitrary value in the vicinity of 2000 Hz. This is not a valid frequency reading.

Frequency is read on the upper scale which spans the range from 300 to 3000 Hz. The smallest division is 50 Hz. Accuracy is one percent of full scale. The unit is furnished trimmed for minimum error at 1000 Hz.

The center scale displays Level in dBm or Notched Noise in dB relative to the test tone. The range is from -44 to +10 dBm or dB. The smallest division is 1 dB. Accuracy is 1/2 dB. Both Level and Notched Noise are rms detected. Notched Noise is C-message weighted. For units of S/N 180, and above, the Notched Noise reading is attenuated by 10 dB when the NNE ATTEN switch is in the -10 dB, x 1/3.2 position.

The lower scale displays Noise Level in dBrnC. The range is from 16 to 70 dBrnC. The smallest division is 1 dB. Accuracy is 1/2 dB. Noise is rms detected and is C-message weighted.

4-4. SPEAKER OPERATION

The panel mounted speaker has two operating modes. In the INPUT position of the SPKR MODE switch, the INPUT jack is connected to the speaker via an audio amplifier, whose gain is controlled by the SPEAKER VOLUME potentiometer. In the NOTCH position of the SPKR MODE switch, the normalized notched noise is connected via the same audio amplifier. The notched noise is valid only if the input tone is within the frequency range (990 to 1030 Hz) and level range (+10 to -40 dBm) for which the PB-1C is capable of cancelling out the tone to form the notch. If this is not the case, the speaker output will be the difference between the input and the local oscillator with the input AGC'd to some indeterminate point. Thus if the DO NOT READ CRT light is on the acoustic output of the speaker in its NOTCH mode it is not only meaningless but may be painfully loud.

The NOTCH output for a proper input tone is highly useful. By listening to the impairments only, not masked by the much larger tone component of the input, individual impairment components can be recognized. A description of the acoustic outputs related to the impairments causing them is given in figure 12 through 29 of the Technical Bulletin following Section I.

4-5. PHASOR CRT OPERATION

a. The Bradley Telcom 2A/2B Line Simulator and Model TIG Trainer Box are most useful in familiarization procedures for PB-1C operation. The TIG-1 in particular, is easily used in a "self-training" manner. Data sheets describing these units are appendixed to this instruction book. These units are available either on a rental or purchase basis from ourselves or from the major telecommunications equipment rental companies.

b. A Facility Evaluation Report Form is included at the end of this section. This form represents a checklist for analyses of any voice-frequency facility by means of the PB-1C, as well as a convenient method of recording the data thus obtained.

c. PB-1C displays may be recorded photographically. The PB-1C settings for each photograph should be recorded, so that the photographed displays may be quantified at any subsequent time. If Polaroid photographs are made, the PB-1C control settings may be recorded on the back of each print.

d. A wide range of electrical outputs is available at front-panel output jacks. These electrical outputs may be recorded on external strip-chart recorders or tape recorders.

4-6. OPERATION

4-7. START-UP PROCEDURE

a. Connect power cable to 115 VAC, 60 Hz, single-phase power source.

b. Set Power switch to ON.

c. Check the CRT Vector Notch zero deflection position as follows:
   1. Set CRT MODE to VECTOR NOTCH, 20 to 300 Hz.
   2. Set SCALE MULT to -20 dB, X0.5.
   3. Patch the OUTPUT jack to the INPUT jack.
   4. Set oscillator OUTPUT to 1004 Hz position, observe that DO NOT READ CRT light is extinguished.
   5. Turn oscillator OUTPUT LEVEL full CW.
   6. Wait 10 minutes for warm up; then, if necessary, set VECTOR CRT ZEROS (VERT and HOR) as required to center spot.

d. Check the CRT HARMONIC zero deflections as follows:
   1. Set CRT MODE to HARMONIC, 2ND.
   2. Set SCALE MULT to -20 dB, X0.5.
   3. Patch the OUTPUT jack to the INPUT jack.
   4. Set oscillator OUTPUT to 1004 Hz position, observe that DO NOT READ CRT light is extinguished.
   5. Turn oscillator OUTPUT LEVEL full CW.
   6. Wait 20 minutes for warm up (the harmonic deflections are dc coupled and are therefore more temperature sensitive); then, if necessary, set HARMONIC CRT ZEROS (VERT and HOR) as required to center spot.
   7. Switch CRT MODE to HARMONIC, 3RD and check zero. There may be a small variation in position between the 2ND and 3RD position. The best zero adjustment splits this error around the center of the CRT.

4-8. VECTOR NOTCH MEASUREMENTS, 20 to 300 Hz AND UNFILTERED

a. Patch the received signal to the INPUT jack. Observe that DO NOT READ CRT light is extinguished. This signifies the presence of a valid input signal, i.e., between 990 and 1030 Hz and between +10 and -40 dBm. Select either 20 to 300 Hz or UNFILTERED operation with the CRT MODE switch.

b. When the MODE switch is set to VECTOR NOTCH, the in-phase component (NNN cos wt) of Normalized Notched Noise is displayed as a vertical deflection, and the quadrature component (NNN sin wt) is displayed as a horizontal deflection. The sensitivity of these deflections are controlled by the settings of the SCALE MULT switch.

c. In-phase or amplitude disturbances deflect the CRT spot vertically; an increase in amplitude deflects the spot upward, and a decrease in amplitude deflects the spot downward. Vertical deflections can be read against the CRT graticule vertical scale, which is calibrated in percent from -6% (at the bottom) through -4%, -2%, 0%, +2%, +4%, +6% (at the top). Phase or quadrature disturbances deflect the CRT spot horizontally; phase lead deflects the spot to the right, and phase lag deflects the spot to the left. Horizontal deflections can be read against the graticule horizontal scale, which is calibrated in degrees of arc, from -3^{o} (at the left) through -2^{o}, -1^{o}, (0^{o}), $+1^{o}$, $+2^{o}$, to $+3^{o}$ (at the right). Phase jitter is defined as a peak to peak value and is therefore read by adding the total horizontal excursion. For example, if the deflection extends from -2^{o} to $+2^{o}$, the jitter reading is 4^{o}. Note that although the vertical scale is calibrated in percent and the horizontal scale is calibrated in degrees of arc, the SCALE MULT switch selects the multiplier factors (X0.5, X1, X2, X5, and X10) that apply to both vertical and horizontal scales. When the SCALE MULT switch is at X1, vertical and horizontal deflections may be read directly. For other settings of the SCALE MULT switch, multiply the graticule vertical and horizontal readings by the scale multiplier factor indicated by the SCALE MULT switch setting. The deflection sensitivity is reduced by a factor of 3.2, i.e., x 1/3.2, when the NNE ATTEN switch is in the UP position.

d. Deflections in random directions may also be measured against polar scale circles that are calibrated in dB from -30 dB (the unnumbered smallest circle) through -20 dB, -16dB, -14 dB, -12 dB, and -10 dB (the largest circle). Deflections read against the polar scale circles must be added algebraically to the POLAR dB level (-20, -14, -8, 0, or +6 dB) indicated by the setting of the SCALE MULT switch. Thus, if the SCALE MULT switch is set to -8 dB, a disturbance that causes a radial deflection to the -14 dB circle has a level of (-8), +. (-14) = -22 dB with respect to the quiet tone. If the SCALE MULT switch is set to -20 dBm, a disturbance that causes a radial deflection to the -30 dB circle has a level of (-20) + (-30) = -50 dB below the quiet tone. The deflection sensitivity is reduced by 10 dB when the NNE ATTEN switch is in the UP position.

e. On PB-1C's bearing serial number 100 or higher either the horizontal deflection only, or the vertical deflection only, of the CRT display may be examined by means of the SINGLE AXIS switch.

4-9. DISTORTION MEASUREMENTS IN UNFILTERED VECTOR NOTCH MODE

a. Second and Third Harmonic Distortion can be measured in the UNFILTERED VECTOR NOTCH mode, as well as in the 2ND and 3RD HARMONIC modes described in Par. 4-10 below. Because harmonics of the test tone are coherent with that test tone, they form cloverleaf patterns that indicate the order of the harmonic. Pure Second Harmonic forms a four-lobe cloverleaf pattern; pure Third Harmonic forms a six-lobe pattern that is folded over into two nearly-coincident three lobe

cloverleaf patterns. These patterns may rotate continuously in the presence of frequency translation (if the distortion occurs before but not if the distortion occurs after the frequency translation), rotate through limited angles in the presence of low frequency jitter, or expand and contract in the presence of harmonic hits or multiple sources of harmonic. In the UNFILTERED VECTOR NOTCH mode, distortion levels in dB below quiet tone level are measured on the polar scales in the same way that random-direction radial deflections are measured, as described in Par. 4-8d.

4-10. DISTORTION MEASUREMENTS IN 2ND H and 3RD H MODES

a. The 2ND and 3RD HARMONIC positions of the CRT MODE switch select the second and third harmonic distortion components of the received tone for display and measurement. The deflection amplitude is a measure of the distortion magnitude, and the deflection angle is a measure of the phase intercept distortion of the channel. Since phase intercept distortion is an uncontrolled parameter, the deflection may be in any direction. It is therefore usually convenient to read the deflection against the circular (POLAR dB) scales. Note again that the POLAR dB markings of the SCALE switch indicate the number of dB to be added to (or subtracted from) the circle calibration. In the most sensitive scale position (-20 dB), the inner circle (-30 dB) corresponds to a separation of -50 dB; i.e., the harmonic level is 50 dB below the tone level.

b. The measurement is limited by the filter bandwidth, which is made narrow to keep the erratic spot motion induced by background noise below acceptable limits relative to the lowest harmonic distortion measurement threshold (50 dB below signal level). Where it is desired to study the phase intercept distortion, a harmonically rich signal can be transmitted (1004 Hz + 2008 Hz position of the oscillator OUTPUT switch). This raises the harmonic level above the normal noise level. Filter bandwidth can also be increased, by an optional internal modification to the PB-1.

4-11. PB-1C - MEASUREMENT TECHNIQUES

The PB-1C can be used to identify all of the following parameters:

Meter Noise
Notched Noise
Impulse Noise
SFI
Harmonics
Phase Jitter
Phase Hits
Gain Hits
Drop Outs
Frequency Offset
Low Frequency Phase Jitter

Following the parameter is a brief description of the display or meter reading. The scale multiplier must be taken into consideration when measuring the magnitude of the parameter on the CRT only.

a. NOTCHED NOISE

METER - The notched noise in dB relative to the input tone is provided when the METER MODE switch is in the NOTCHED NOISE position. The readings are in RMS terms and use the C-Message filter weighting. The center meter scale is read.

NOTE - Notched Noise reading valid only when DO NOT READ LIGHT is extinguished.

CRT - The visual presentation on the PB-1C can be related to the amount of noise present relative to the input signal. The value obtained is the peak reading, see Page 14 of Technical Bulletin following Section I.

SPEAKER - SPEAKER MODE to NOTCH adjust the SPKR VOL to desired level.

b. IMPULSE NOISE

METER - The meter is not used.

CRT - Monitor the CRT for impulse noise hits. The hits appear as random excursions on the scope. If impulse hits are suspected further test should be made in accordance with BSP's and the reading compared to specifications.

SPEAKER - Impulse hits can also be heard on the speaker with the SPEAKER MODE in NOTCH. An audible click or popping sound will occur in conjunction with the CRT display.

c. SFI

METER - SFI is included in the NOTCHED NOISE measurement.

CRT - The CRT can be used. As experience is gained in using the PB-1C, SFI can be diagnosed from the CRT display.

SPEAKER - With the SPEAKER MODE in NOTCH a single frequency can be heard. Further investigation is done with a spectrum analyzer to find the frequency and the level of that tone. A convenient output for this is the tip of the interconnect B jack which is the notched noise.

d. PHASE JITTER

METER - Not used for this test (a cursory look at the frequency stability might be advisable). Although the jitter sidebands are one component of the notched noise as read on the meter.

CRT - Those phase-related disturbances will tend to act or display in the horizontal plane.

1. The first test will be for jitter in the 20-300 Hz band.

   a. CRT MODE to VECTOR NOTCH 20-300.

   b. Adjust SCALE MULT to get a good presentation.

   c. Measure the amount of phase jitter from the scope. The SINGLE AXIS switch may be used to advantage in this determination.

      1. Note the excursion to the left, measured along the horizontal scale.

      2. Note the excursion to the right, measured along the horizontal scale.

      3. Add the two readings.

      4. Multiply this total by the SCALE MULT figure.

         i.e.
         ```
          1.4   left readings
          1.4   right readings
         ----
          2.8
          x 5   SCALE MULT
         ----
         14.0   degrees of Phase jitter
         ```

2. Repeat the above steps a through c with the CRT mode in VECTOR NOTCH UNFIL. This procedure will identify low frequency jitter.

NOTE: Noise, if high enough, will affect jitter reading. This is true for all jitter test equipment.

e. PHASE HITS

METER - Not used for this test.

CRT - A phase hit is displayed as a quick excursion along the horizontal plane.

1. CRT MODE to VECTOR NOTCH UNFIL. or 20 to 300 Hz.

2. Measure the furthest excursion to either the left or right on the horizontal scale.

3. Multiply this reading by the SCALE MULT to obtain the peak phase hit magnitude.

   i.e.
   ```
    2.0   left or right reading
   x 10   SCALE MULT
   ----
   20°    Phase Hit
   ```

SPEAKER - A phase hit can be heard on the speaker in the notch mode. A sonar or pinging sound denotes a phase hit. This sound will occur in conjunction with the CRT display.

f. GAIN HITS AND DROP OUTS

METER - Not used for this test.

CRT - A change in the amplitude of signal is displayed as excursions along the vertical plane. Gain Hits and Drop Outs will appear as quick excursions in the vertical plane.

SPEAKER - A sonar or pinging sound denotes a gain hit or drop out. The sound will occur in conjunction with the CRT display.

g. FREQUENCY

METER - A direct reading of the frequency can be made by switching the METER MODE to FREQUENCY Hz and reading the upper scale on the meter.

CRT - The CRT is not used to measure frequency, it can, however, identify frequency perturbations.

1. CRT MODE to 2nd HARMONIC.
2. Apply a harmonic rich tone (1004 + 2008) to the circuit under test.
3. Note the characteristic of the display. If a rotation of the display appears, the rate at which the display is rotating is the frequency offset.

   i.e. Display rotates at a rate of 3 revolutions per second. The frequency offset is 3 Hz.

h. HARMONICS

METER - Not used for this test, but the harmonics are one component of the notched noise as read on the meter.

CRT - The display of the harmonics is controlled by the CRT MODE selector. Either 2nd or 3rd order harmonics can be measured.

1. CRT MODE to 2nd HARMONIC
2. Assure 1004 Hz tone (harmonic free) is being used.
3. Measure the position of display on the polar or dB scales.

4. Add this reading to the SCALE MULT dB figure.

   i.e. -14 reading from CRT
   -20 SCALE MULT reading
   34 dB 2nd Harmonic

The total is expressed in dB is the ratio of the harmonic to the fundamental.

5. 3rd order harmonics can be read by using the 3rd HARMONIC position on the CRT MODE selector and repeating steps 1 - 4.

NOTE: Noise, if high enough, will affect harmonic readings by causing erratic spot motion. This can be averaged out visually.

4-12. INTERPRETATION OF PB-1C DISPLAYS

4-13. GENERAL

a. The illustrations on pages 8 through 11 of the Technical Bulletin at the end of Section I represent a catalog of PB-1C displays corresponding to various conditions. Those illustrations are extremely useful aids for analysis of disturbances, either by comparison with PB-1C displays or with Polaroid photographs of the displays. Under each illustration is a description of the conditions causing the display, as well as a description of the corresponding sound output, which is a valuable auxiliary aid in diagnosis.

b. The Bradley Telcom Model 2A/2B Line Simulator can be used to cause PB-1C displays equivalent to those caused by the facility under test. The impairments in that facility can then be determined from the 2A/2B control settings that cause the equivalent display. This technique is especially useful for analyzing displays that have not been cataloged previously.

c. With practice, the PB-1C operator can learn to analyze even complex displays directly, without recourse to the aids in a. and b. above.

4-14. ANALYSIS OF DISTURBANCES IN VECTOR NOTCH MODE

a. Figures 12 through 25 of the Technical Bulletin at the end of Section I represent PB-1C displays with the CRT MODE switch in one of the VECTOR NOTCH positions and with the SPEAKER MODE switch at NOTCH. The left hand photograph of each figure was taken at 20 to 300 Hz, and the right-hand photograph of each figure was taken at UNFILTERED. The 20 to 300 Hz filter provides VECTOR NOTCH displays compatible with conventional Bell System and CCITT Phase Jitter test sets and with the Bradley Telcom Model 75LMA Phase and Amplitude Jitter Set. However, this filter limits the disturbance bandwidths displayed to those in the sidebands 20 to 300 Hz below the test tone and 20 to 300 Hz above the test tone. In contrast, the UNFILTERED VECTOR NOTCH mode provides displays showing the entire spectrum of disturbances from 30 to 3500 Hz, with a notch bandwidth so narrow that all disturbance frequencies except those with ± 1 Hz of the test tone frequency may be observed.

b. In general, phase modulation causes essentially horizontal deflections, amplitude modulation causes vertical deflections, noise causes deflections at random angles, and SFI causes circular motions. If the VECTOR NOTCH pattern is much wider than it is high, phase jitter is predominant. If the pattern is higher than it is wide, amplitude jitter is predominant. If the display is equally large in

all directions, the problem is noise or SFI. In all cases, the background noise may be regarded as modulating the modulation disturbance; thus, PM plus noise produces a disturbance pattern in which the amount of PM can be estimated by subtracting the vertical deflection from the horizontal deflection.

c. An idea of the predominant jitter frequency can be obtained by operating CRT MODE switch. Sideband frequencies in the 20 to 300 Hz range will appear when the FILTER RANGE switch is set to 20 to 300 Hz. If there is a predominant single frequency in the modulation pattern, this can be heard on the speaker and its frequency estimated. For low-frequency jitter, the UNFILTERED VECTOR NOTCH mode is used. If a predominant SFI pattern can be seen in the UNFILTERED position but cannot be heard, it is likely to be power line related components which occur at a frequency at which the small speaker in the PB-1C does not have much response.

d. In the detection of modulation impairments by the PB-1C, the notched noise is translated downward in frequency by the amount of the test tone and is thus centered at dc with the lower sideband folded back onto the upper sideband. This is accomplished by an internal modulator which multiplies the notched noise by the reference tone. At the same time, the same modulator translates the notched noise up to twice the tone frequency, because the modulator produces the sum as well as the difference frequencies of its two inputs. In the 20 to 300 Hz position of the FILTER RANGE switch, the double-tone-frequency components are filtered out, so that only the dc-centered sidebands are displayed. In the UNFILTERED position, both the dc-centered and double-tone-frequency sidebands are displayed. Modulation impairments thus show up two ways in the UNFILTERED mode. This is really a reflection of the instrumentation used to reduce them to a display and not a picture of what is actually happening to the tip of the tone vector. It is useful because it 'flags' or calls attention to the modulation impairments allowing them to be observed even in the presence of a larger amount of noise.

e. In the UNFILTERED VECTOR NOTCH mode, phase modulation appears as two circles that are tangent to the vertical axis at the origin, and amplitude modulation appears as two circles that are tangent to the horizontal axis at the origin. Transient phase phenomena appear as one circle to the right or left of the vertical axis at the origin, and transient amplitude phenomena appear as one circle above or below the horizontal axis at the origin. Low-frequency modulation appears as circles that alternate from one side to the other of the tangent axis, growing and shrinking as they alternate. This process occurs at the jitter frequency. The oscillation frequency may be determined by counting the cycles which occur in a timed interval. The jitter amplitude may be measured by noticing the peak amplitude of the oscillatory motion. The oscillating figure is more or less distinctly delineated, depending on the relative magnitude of the low frequency jitter with respect to the remaining impairments, but the magnitude

of oscillation may always be accurately estimated because the pattern motion is distinct, i.e., the edge of the pattern moves by the jitter magnitude. The measurement of jitter frequency is important because all low frequency jitter meters (including the Bradley Telcom Model 75L, as well as the PB-1 and PB-1C), start to roll off at 3 Hz. However, since the jitter frequency can be observed, the curve below (Figure 4-1) can be used to correct the reading. Typical cases of low-frequency jitter observed with the PB-1C have displayed a jitter frequency of between 1 and 2 Hz and a corrected jitter magnitude in excess of 25 degrees.

f. Both Coincidence Hits and Impulses cause radial deflections in random directions. Coincidence Hits are generally slower than Impulses, so that noise may be generally seen on the Coincidence Hit, but not on the Impulse. In addition, Coincidence Hits generally cause a pinging sound, while Impulses generally cause a popping sound.

g. Narrow dropouts cause vertical deflections even though they may, if narrow enough, cause a popping sound very much like that of an impulse. Consistently vertical impulse-like transients (acoustically) are really brief gain hits. Similarly, consistently horizontal impulse-like transients are really brief phase hits.

h. FDM channels (e.g., L and N carriers) tend to have tone-correlated phase disturbances. FDM systems in which the demodulation reference is transmitted along the signal have failure modes in which low-frequency phase jitter predominates. FDM systems with an independent sync chain have predominant jitter in the 20 to 300 Hz passband. These latter systems may display some varying phase-intercept distortion (slow phase hit) or continuous small phase hits. Frequently these latter hits are brief in duration.

i. PCM systems (e.g., T-carriers) are characterized by noise-like disturbance patterns, which are actually complex Lissajous patterns in which the in-phase disturbance usually exceeds the quadrature disturbance. T-carrier noise patterns may have peculiar systematic shapes which vary quite noticeably with tone frequency as it affects the sampling frequency foldback products. The acoustic output has a characteristic easily identifiable sound like that of gears grinding.

4-15. DISTORTION ANALYSIS IN UNFILTERED VECTOR NOTCH MODE

a. Figure 26 through 29 of the Technical Bulletin at the end of Section I show Second and Third Harmonic Distortion in the UNFILTERED VECTOR NOTCH mode. Such distortion is visible in the UNFILTERED VECTOR NOTCH mode, but is out of the passband of the 20 to 300 Hz filter.

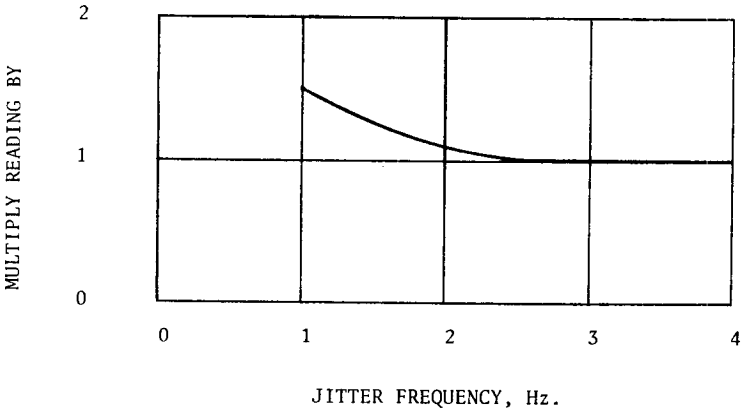


Figure 4-1 Correction For Jitter at Low Frequencies

b. Because harmonics of the test tone are coherent with that test tone, they form cloverleaf patterns that indicate the order of the harmonic. Pure Second Harmonic forms a four-lobe cloverleaf pattern; pure Third Harmonic forms a six-lobe cloverleaf pattern that is folded to make two nearly-coincident three-lobe cloverleaf patterns. Continuously rotating patterns indicate that frequency translation is occurring after the distortion. Rotation of the pattern through limited angles indicates low-frequency jitter. Expanding and contracting patterns indicate harmonic hits.

4-16. HARMONIC DISTORTION ANALYSIS IN THE 2ND H AND 3RD H MODES

a. The 2ND H and 3RD H positions of the MODE switch select the second and third harmonic distortion components of the received tone for display and measurement. Figure 31 in the Technical Bulletin is a typical 2ND or 3RD HARMONIC display. The deflection amplitude is a measure of the distortion magnitude, and the deflection angle is a measure of the phase intercept distortion of the channel. Since phase intercept distortion is an uncontrolled parameter, the deflection may be in any direction.

b. When frequency translation is present, the phase intercept distortion angle changes continuously at a constant rate and the spot moves in a circular path, as shown in Figure 31B of the Technical Bulletin. The impairment location causing it is shown in Figure 30. Note that at the Receive Terminal, the frequency of distortion content $k_T \cos (2wt + st)$, differs from twice the frequency of the fundamental, $\cos 2(wt + st)$ by the amount st. This is the equivalent of an SFI input at a beat frequency of st.

c. When second harmonic distortion, $k_R \cos (2wt + 2st)$ is introduced at the receive terminal, after the frequency translation, it is distortion of the received frequency; it is thus exactly double the received frequency and produces a stationary spot. In Figure 31C, note that the circle radius (k_T) corresponds to the distortion which occurs ahead of the frequency translation; the offset (k_R) of the center of the circle corresponds to the distortion which has occurred after the frequency translation; and the rate at which the circle is traversed by the spot is a measure of the frequency of translation. The foregoing analysis may be extended to third harmonic distortion.

d. There may be multiple frequency translation sources as well as other phenomena which cause variations in the phase intercept distortion angle. Phase hits cause intermittent angular motion of the spot. Phase modulation causes oscillatory angular motion of the spot. Filters limit the display bandwidth in the harmonic modes so that only low frequency jitter can be thus observed. There may also be harmonic amplitude hits, usually involving PCM carrier, which cause radial motion of the spot. Large irregular or jagged circles encountered in PCM systems are an indication that the compandor is not functioning properly. Depending upon its magnitude, this phenomena

renders a facility incapable of passing data. This particular problem is not observable with conventional test equipment because the filtering involved in reducing the phenomena to a meter reading severly attenuates the impairments. There are normally multiple distortion sources although in a trouble situation, usually one will predominate. These phenomena may occur at any voice appearance in the transmission path, with unpredictable phase intercept distortion between their point of generation and the final output. The result is spot motion in random directions. The operational significance of the above is that if the distortion spot displays high mobility it is an indication that the channel will have trouble passing data.

4-17. PHASE INTERCEPT DISTORTION, See Figure 32 of Technical Bulletin

a. The time delay suffered by any frequency component passing thru a transmission medium is the slope of the line joining that point on the curve with the origin on a phase vs. frequency plot. One condition required for undistorted transmission of a complex wave shape is that the phase vs. frequency curve (plotted in linear units, and extrapolated down to DC) be a straight line passing through the origin. This is the response corresponding to a pure time delay. The slope of this line is the time delay, t. Dimensionally, $\phi/w = t$; Radians/(Rad/Sec) = Sec. Intuitively there is no time domain wave-shape distortion because all frequency components have the same time delay and therefore arrive in the same relative phase at the far end as they leave at the launching end.

b. Note that a perfectly linear phase vs. frequency curve (zero envelope delay distortion) is not a sufficient condition for low base-band distortion because, referring to Figure 32 of the Technical Bulletin, then the component of frequency w_1 has a time delay ϕ_1/w_1 which is entirely different from that of the w_2 component, ϕ_2/w_2. This distortion is a result of the angle at the extrapolated intersection of the phase vs. frequency curve with zero frequency. This is known as the phase intercept distortion. It is an uncontrolled parameter in most communications systems.

c. The angular displacement of the spot for either second or third harmonic distortion measurement is a measure of the phase intercept distortion. In the mechanization of the instrument, the received tone, $\cos (wt + \phi_w)$ is tracked. It is then doubled, i.e., $\cos (2wt + 2\phi_w)$. The phase and amplitude of the second harmonic $\cos (2wt + \phi_{2w})$ is plotted with respect to the double frequency tone as a reference. Referring to Figure 33 of the Technical Bulletin, which is a phase vs. frequency plot, the phase difference between $\cos (2wt + 2\phi_w)$ and $\cos (2wt + \phi_{2w})$ is $(2\phi_w - \phi_{2w})$. This is the deflection angle of the harmonic distortion spot. It is also the phase intercept distortion based on measurement at frequencies w and 2w. A similar observation is true with respect to the third harmonic.

d. Angular motion of the harmonic 'spot' corresponds to changes in phase intercept distortion. This motion will always be along an arc of some circle for a given distortion source and the phase intercept distortion due to that source. However, a multiplicity of distortion sources may exist in a transmission channel relative to a multiplicity of phase intercept distortion sources. The case of frequency translation described above is commonly encountered.

e. The measurement is limited by the filter bandwidth. This must be narrow to keep the erratic spot motion induced by background noise below acceptable limits relative to the lowest harmonic distortion measurement threshold (50 dB below signal level). Where it is desired to study the phase intercept distortion a harmonically rich signal can be transmitted (oscillator OUTPUT switch in 1004 Hz + 2008 Hz position). This raises the harmonic level above the noise level. The presence of a highly mobile harmonic spot when an FDM system is probed in this way is an indication that the primary frequency supply is in trouble. This phenomena, which can only be observed in the phasor domain, is data-inimical. It renders modems (as opposed to limited distance modems or line drivers) incapable of compensating for the phase intercept distortion angle which is the only reason for their existence in the first place.

4-18. CHECKLIST- The following two pages provide a checklist for PB-1C Phasor Domain observations.

PB-1C FACILITY EVALUATION REPORT BY _____ DATE _____

FROM -

VIA -

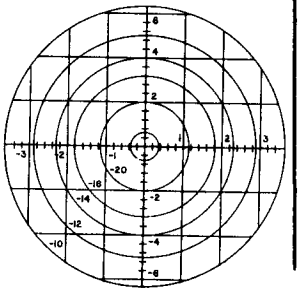
TO -

Received Tone Level - ____ dBm Frequency - ____ Hz

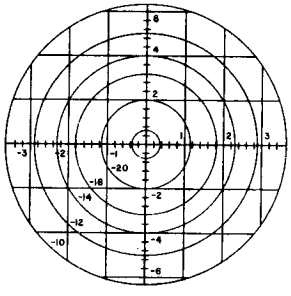
MODE - VECTOR NOTCH, Steady State Characterization

DISPLAY FILTER	20 to 300 Hz	UNFILTERED
Max. Horizontal Excursion	____ degrees	____ degrees
Max. Vertical Excursion	____ percent	____ percent
Max. Radial Excursion	____ dB	____ dB

Adjacent graticule drawings may be used or sketch display pattern, or scope photos may be attached.



SCALE X __



SCALE X __

Predominant Impairment - If several impairments are present, indicate relative magnitude.

Noise	____	____
Phase Jitter	____	____
Low Frequency Phase Jitter		____ amplitude
		____ frequency
Amplitude Jitter	____	____
SFI	____	____
Harmonic Distortion	____	____

Decrease received tone level 10 dB and remark on any changes in above.

MODE - VECTOR NOTCH, Transient Characteristics

Observation interval ____minutes.

Phase Hits ___hits over ___Degrees

Gain Hits ___hits over ___Percent

Impulse Hits ___hits over ___dB

Use the SPEAKER in the NOTCH position to assist in identifying hits. Note difference between modulation hit "ping" and impulse noise "pop".

HARMONIC MODES	2nd	3rd
Max. Excursion	____ dB	____ dB
Min. Excursion (closest point to origin)	____ dB	____ dB
Frequency Translation	____ Hz	____ Hz
Circle Diameter	____ dB	____ dB
Circle Offset	____ dB	____ dB

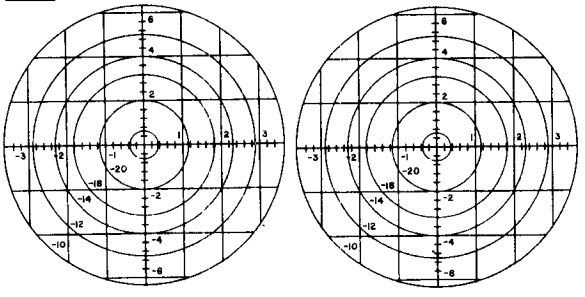
Spot Mobility in ____2nd or ____3rd mode (check one)

Moves ____inches in ____seconds at ____dB SCALE MULT setting

Oscillatory - from ____ to ____o'clock in ____seconds

Radial - ____dB in ____seconds

Adjacent graticule drawings may be used to sketch display pattern, or scope photos may be attached



SCALE __ dB SCALE __ dB

Decrease tone level 10 dB from nominal and remark on any changes in above.

ACCOUSTIC (NOTCHED NOISE)	Yes	No
Noise hiss	_____	_____
Crosstalk	_____	_____
Single tones audible	_____	_____
Multiple tones audible	_____	_____

Switch SPEAKER switch between INPUT and NOTCH. Audible tones in NOTCH position are higher __, lower __, or surrounding __ test tone frequency. Note PCM, FDM, and copper have distinctive accoustic signatures. Comment on audible presence of modulation hits__, impulse hits__, harmonic hits__.

ALIGNMENT PROCEDURES

5-1. GENERAL

a. The alignment procedure described in this section should be performed only by personnel familiar with the operation of the PB-1C VF Line Analyzer and with the appearance of its displays.

b. See paragraph 5-7 for correct alignment sequence.

c. Perform alignment only with equipment that meets the specifications given in Paragraph 5-2.

5-2. EQUIPMENT REQUIRED FOR ALIGNMENT

a. Oscillator # 1: frequency range, 300 to 3000 Hz; output level range, -40 dBm to +10 dBm; output impedance, 600 ohms ± 2% balanced; phase jitter, less than 0.1^{o}; amplitude jitter, less than 0.1%; total distortion, less than 1% (-40 dB). Frequencies must be settable within 0.1% and output levels must be settable within 0.2 dB. The TONE FREQUENCY Oscillator of the Bradley Telcom Model 2A/2B Line Simulator meets these specifications.

b. Oscillator # 2: identical to Oscillator # 1. The MODULATION FREQUENCY Oscillator of the Model 2A/2B Line Simulator meets these specifications.

c. Oscillator # 3: is required only for alignment of second harmonic and third harmonic modes of the PB-1C. Specifications are: output frequency range, 300 to 3300 Hz; output level, settable to 0 dBm; output impedance, 600 ohms ± 2% balanced; phase jitter, less than 0.1^{o}; amplitude jitter less than 0.1%; second harmonic distortion less than 0.1% (-60 dB); third harmonic distortion less than 0.1% (-60 dB). The Bradley Telcom Model PB-0 and the PB-0R oscillator, or the PB-1C oscillator meet these specifications.

d. Frequency Counter: capable of measuring frequency to within 1 Hz.

e. High-Impedance DC Voltmeter: input impedance. 20,000 Ω/V minimum.

f. Level Meter: +10 to -44 dBm, accurate to 0.2 dBm.

g. AM Source: source capable of providing 990 to 1030 Hz, 0 dBm (600 ohm), tone, amplitude modulated by at least 10% at a frequency between 100 and 200 Hz. Bradley Telcom Model 2A/2B Line Simulator is capable of providing this signal.

h. Miscellaneous patch cords, leads, card extender, rubber glove, tools, etc., as required.

5-3. NOTES ON USE OF TEST OSCILLATORS

a. Some PB-1C alignment procedures employ Oscillator #1 as a source of test tones at specified levels (usually 0 dBm) and Oscillator #2 as a source of single frequency interference (SFI) tones, usually at level of 10% (-20 dB) of the test tone level.

b. If the TONE FREQUENCY oscillator in the 2A/2B Line Simulator is used as Oscillator #1, to provide the test tone, and the MODULATION FREQUENCY oscillator is used as Oscillator #2, to provide the SFI tone, the SINGLE INTERFERENCE level control can be set directly to percent SFI with respect to the OUTPUT LEVEL setting of the 2A/2B. SINGLE FREQUENCY INTERFERENCE level settings of 10% will then give SFI levels of -20 dB with respect to the OUTPUT LEVEL setting. Furthermore, the two tones are added internally in the 2A/2B Line Simulator, and their sum appears as a single 600 ohm output. If this output is patched to the PB-1C INPUT jack, and the 2A/2B Simulator and the PB-1C Analyzer will be properly matched, then the output levels of the two oscillators will be correct.

c. If Oscillator #1 and #2 are separate units, and their outputs are added by paralleling at the PB-1C input jacks, mismatch may occur, because the load impedance seen by either oscillator is equal to the output impedance of the PB-1C. Thus, if the output impedances of the oscillators and the input impedance of the PB-1C are each 600 ohms, then each oscillator will see a mismatched lead of 300 ohms instead of a matched load of 600 ohms; and the resulting mismatch will cause the output levels of both oscillators to be in error with respect to the settings of their level controls. This is not objectionable as long as the tester takes this into account.

5-4. SELF-CHECKING CAPABILITIES

a. The availability of an oscillator in the PB-1C with multiple frequencies and with a capability of furnishing a second harmonic enriched output provides a number of self-check capabilities.

b. FREQUENCY READINGS: Patch the PB-1C oscillator OUTPUT jack to the PB-1C INPUT jack. Set the METER MODE to FREQUENCY, Hz and switch the oscillator OUTPUT frequency at 2713 and 1004 Hz. Observe that the meter reading agrees with the frequency setting of the oscillator. The frequency meter typically reads high at mid scale so the 2008 Hz frequency will typically read 20 Hz higher.

c. LEVEL: Set the METER MODE switch to LEVEL. Set the oscillator OUTPUT frequency to 1004 Hz. Patch the OUTPUT jack to the INPUT jack and vary the OUTPUT LEVEL setting. As a minimum it should be possible to vary the level readings between -30 and 0 dBm.

d. NOISE: With the same set up as for LEVEL above, set the METER MODE switch to LEVEL. Adjust the oscillator OUTPUT LEVEL to -30 dBm (with 1004 Hz frequency setting). Switch the METER MODE to the NOISE position and observe a reading of 60 dBrnc $\pm$ ½.

e. NOTCHED NOISE: Patch the oscillator OUTPUT to the INPUT jack. Set the OUTPUT frequency selection for 1004 + 2008 Hz. Place the METER MODE switch in NOTCHED NOISE position and observe a reading of approximately -16 dB. Note the nominal is slightly lower than -16 dB because of the C message filter weighting.

f. CRT CALIBRATION: It is also possible to cross check the CRT sensitivity against the Notched Noise meter reading in the second harmonic and in the vector notch unfiltered mode using the oscillator output harmonically enriched. With the same excitation and connections as for NOTCHED NOISE above, observe the CRT deflection with the CRT mode switch in the second harmonic position. It should be the same as the Notched Noise meter reading $\pm\frac{1}{2}$ dB and nominally -16 dB. Also observe the CRT pattern in the vector notch unfiltered mode. The average value of the four peaks should fall within $\frac{1}{2}$ dB of the circle corresponding to the Notched Noise reading.

g. GAIN HIT ACTION: With the connections as for Notched Noise but with the oscillator in the 1004 Hz mode, put the CRT mode switch in the Vector Notch Unfiltered position. Turn the oscillator level control and observe the vertical displacement of the CRT with level changes. Increasing level moves the spot upward and spreads it to a circle. Decreasing level moves the spot downward and also generates a circle. The same action can be viewed in the 20 - 300 Hz filter position but the level central must be turned quickly to see a vertical line going upward or downward depending upon the sense of the level change.

5-5. REMOVAL AND REPLACEMENT OF PB-1C COVER

a. To remove cover, loosen and remove eight screws on top of unit and lift off top cover. To replace cover, first line up front center hold and start screw. Then push cover forward and into its seat. Then insert the seven remaining screws.

5-6. IDENTIFICATION OF CIRCUIT BOARDS

The following physical description applies to units bearing serial numbers 1 to 99.

NOTE: For units bearing Serial Number 100 and above, see Paragraph 5-13, page 5-10.

See Figure 5-1 for top view of the PB-1C. This figure identifies circuit board locations. Four of the five plug in cards, i.e., all but the output card, are retained by card guides fixed to the base of the can. The guide spacing is unique to each individual board. If a board is not retained by the card guides it is plugged in the wrong place. Also note the position of the component side of the boards on Figure 5-1. Boards must not be plugged in reversed. This is prevented by keying inserts in the connector. If, as a convenience, these inserts are removed during maintenance, they should be replaced.

With regard to the output card, to insure that the CRT zero pots, which are mounted on this card, will align with the holes in the panel, the top front corner of the card is fastened to a panel bracket with a 6/32 screw. To remove the card the screw must be removed and this screw must be replaced when the card is reinserted.

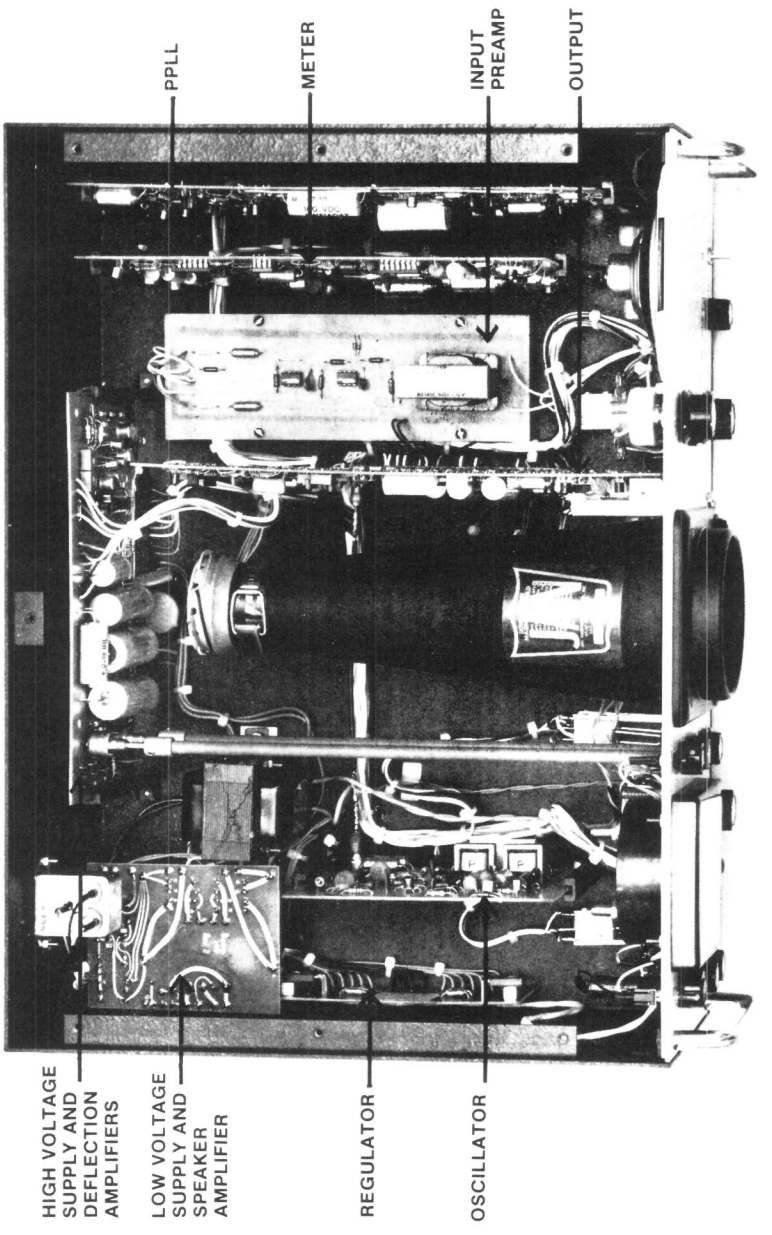


Figure 5-1 BOARD LOCATIONS, S/N 1 TO 99

a. LOW VOLTAGE SUPPLY AND SPEAKER AMPLIFIER: The Low Voltage Rectifier and Speaker Amplifier card is mounted directly on the low voltage transformer. The speaker amplifier is driven by the unregulated dc supply to isolate it from the Main Phase Lock Loop electronics.

b. REGULATOR CARD: The Low Voltage Regulators which are mounted to the base on heat conducting standoff, accepts the positive and negative unregulated dc supplies and converts them to +12 and -12 volts output. The tolerance on these supplies is ±½ volts. This is essentially the tolerance of the 7812 voltage regulators used.

c. INPUT PREAMP: The Input Preamp is fix-mounted to the base of the unit. It comprises a balanced input transformer and a first and a second amplifier stage. The second stage is used to boost the input signal level for low level noise measurements. For tone inputs above a -20 dBm, the output of the second stage (pin 6 of rear op amp) is a clipped wave due to saturation. This is not a malfunction.

d. HIGH VOLTAGE CARD: Contains the high voltage CRT power supplies and the CRT deflection amplifier. The CRT accelerating potential is obtained by voltage doubling the output of a 500 volt power transformer. The secondary wires from this high voltage transformer (Stancor P8173)can be as much as 1100 volts off ground. The maximum difference potential in the unit is 1500 VDC. These voltages are confined to the high voltage transformer leads and to that section of the High Voltage card to the left (viewed from the front) of the high voltage card. The deflection amplifier, on the right side of the card, has a +320 volt power supply. If for any reason it is necessary to rotate the CRT, by releasing and resetting the clamp, it is essential that a rubber glove be used in case contact should accidentally be made with any of high voltage points. Also the large 0.22 uf high voltage capacitors hold a charge for a few minutes after power is removed. They should be momentarily shorted with a wire or clip lead routinely before touching the card during maintenance.

e. OSCILLATOR CARD: Contains a three frequency oscillator.

f. METER CARD: Contains an rms dector and logarithmizing AC to DC converter, for Level, Noise, and Notched Noise reading, a C-message filter, and a Frequency to dc voltage converter.

g. PPLL CARD: Contains the notch noise generating circuitry.

h. OUTPUT CARD: Contains the display phase lock loop, horizontal and vertical deflection multipliers, and the display filters.

5-7. ADJUSTMENT HIERARCHY

There are no adjustments on the Low Voltage Rectifier and Speaker Amplifier card, the Low Voltage Regulator, and the Input Amplifier cards. Adjustments are provided on the Oscillator, High Voltage, PPLL, Meter and the Output cards.

Adjustments on the Oscillator, High Voltage, and PPLL cards are each independent of the adjustments of all other cards. With the exception of the notched noise scaling adjustment, the Meter card adjustment, too, is independent of the adjustments of all other cards. The Meter card notched noise scaling adjustment is dependent on the presence of a properly operating PPLL card. The Output card adjustments require that the PPLL card and the High Voltage card be functioning.

5-8. PPLL CARD ALIGNMENT (see Figure 5-2)

There are three potentiometers on the PPLL card. These are not particularly critical and are dependent on the characteristics of several FETS on the card which are not closely controlled in manufacture but which are extremely stable and long-lived components. It is therefore not recommended that these potentiometers be adjusted. Potentiometers are used rather than trim resistors are used as a manufacturing convenience. Nevertheless, for the irresistably curious, the criteria for their adjustment is given below.

The setting of P1 controls the relative transient response of the tracking loops, being set so that the recovery time is equal to magnitude (in dB) gain hits is the same at high and low signal levels. This can be "eyeballed" but is most accurately done by a rather time consuming plot of the A.G.C. error gradient. If the potentiometer is accidentally turned, reset it by inserting 2 or 3 dB gain hits at 0 dBm and at -30 dBm signal levels while observing the CRT in either VECTOR NOTCH mode. Set P1 so that the hit dynamics appear as close as can be observed to being identical. P1 may also affect the generation of distortion in the A.G.C. Circuit and if readjustment is attempted, the notch should be checked for harmonic distortion.

P2 and P3 adjust the A.G.C. and Phase Lock Loop gain respectively. They are set using an SFI input of -30 dB which can be varied $\pm$ 20 Hz around the test tone (1004 $\pm$ 20 Hz). Adjust P2 and P3, alternating between the adjustments, so that the circle observed in the VECTOR NOTCH 20 to 300 Hz mode remains circular within 10% as it drops to a amplitude of ½ as the difference frequency between test tone and SFI tone is reduced from either direction, i.e., above or below.

5-9. OSCILLATOR CARD ALIGNMENT (see Figure 5-2)

a. Use a frequency counter to monitor the OUTPUT of the oscillator. Select the OUTPUT frequency of 1004 Hz and raise the OUTPUT LEVEL to the maximum. If the frequency is more than ½ Hz off, adjust P1, which is the only potentiometer on the card, to 1004 Hz frequency reading. Select output frequency of 2713 Hz and observe that the output is 2713 Hz $\pm$ 3 Hz.

5-10. HIGH VOLTAGE CARD (see Figure 5-2)

The following adjustments are required only if a satisfactory spot cannot be obtained with the FOCUS and INTENSITY controls, or if the spot is not in the zero position when the XY IN (310) inputs are grounded. The frame of all 310 jacks on the panel is a convenient ground point.

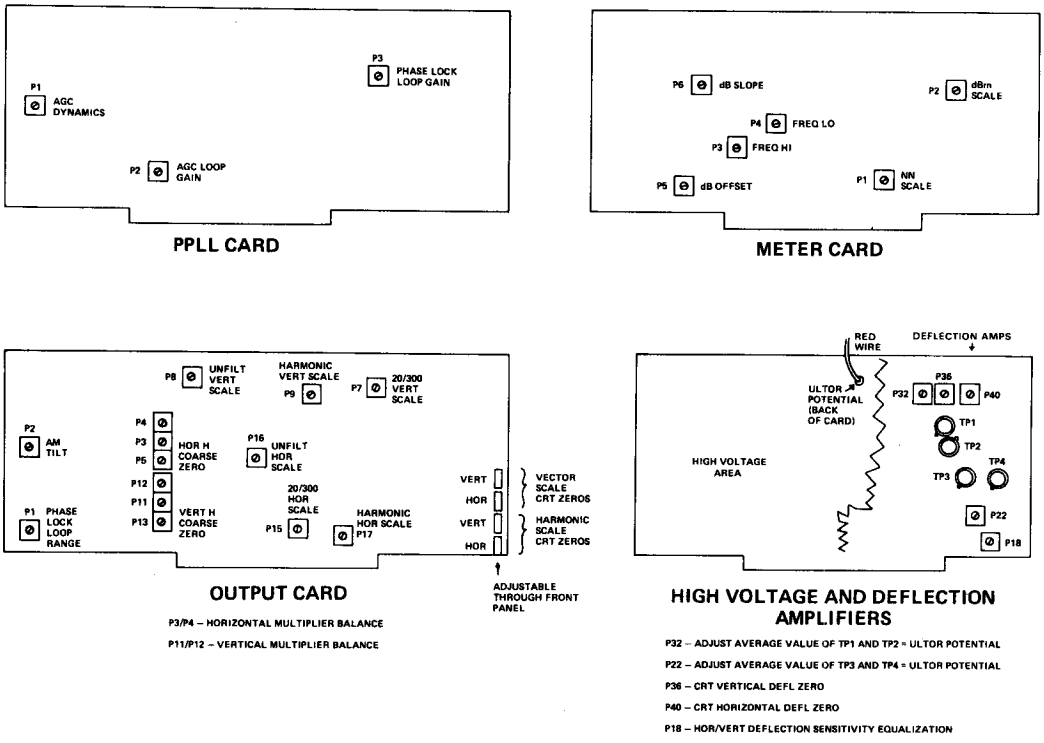


Figure 5-2. ADJUSTMENT LOCATIONS

a. Insert a 310 cord into the XY IN jack. Short the tip and the ring to ground. Using a voltmeter, monitor the "ULTOR" potential which should be 90 ± 10VDC with respect to ground.

b. Locate TP1 through TP4 (Figure 5-2), the cases of four MJ421 transistors. Adjust P36 so that the DC voltages are equal to the ultor potential, Similarly, adjust R40 so that the DC voltages are equal to the ultor potential.

c. With the shorting cord still in the XY IN jack, turn the INTENSITY pot, P1, until a spot appears on the CRT screen. Focus the spot using P2. the FOCUS pot. Then, by readjusting R36 and R40, center the spot on the crosshairs of the PB-1C graticule.

d. Set the PB-1C scale mult, switch to the +6 position. Unground the ring of the XY IN jack and attach it to the plus terminal of a 1.5 volt battery. Ground the minus terminal. Note that an ohmmeter typically includes such a battery and the ohmmeter terminals can be used for this purpose. The spot should deflect about halfway down the CRT screen. If the deflection is not in the downward direction, release the CRT clamp and (using rubber glove) rotate the tube so that the deflection direction is correct. Ground the ring again and connect the plus end of the battery to the tip of the XY IN jack. Use R18 to equalize this horizontal deflection. Recheck zeroing of spot and repeat until the gains are equal and the spot is centered.

e. With the ring still grounded, apply an AC signal to the Tip, and rotate the tube, using the rubber glove, to obtain a straight horizontal line.

f. Turn INTENSITY pot counterclockwise again, to prevent burning a spot in the center of the screen.

5-11. METER CARD ALIGNMENT (Figure 5-2)

a. LEVEL SCALE: Allow 15 minute warm up. Adjust if any level reading error exceeds ¼ dB. To adjust, place meter card on extender. Using Oscillator # 1 patch 1000 Hz tone to INPUT jack. Place METER MODE switch in LEVEL position. Observe Level reading while varying input level between -30 and 0 dBm. P5 and P6 control the LEVEL scale. Although the adjustments interact somewhat, P6 controls the slope, i.e., scale deflection between the -30 and 0 reading while the P5 shifts the scale deflection interval upward or downward. Adjust P6 so that a 30 dB input level change produces a net scale deflection of 30 dB. Then, with 0 dBm input, adjust P5 so that the reading is 0 dBm ± 0.1. Go back and forth resetting the potentiometers as necessary to achieve 0.1 dB agreement between input and level reading at 0 dBm and at -30 dBm. Check that the level reading at -15 dBm for another convenient intermediate point, is correct to within ¼ dB.

b. FREQUENCY SCALE: Adjust only if at 1000 Hz or 2700 Hz

exceeds 25 Hz. Allow 15 minute warm up. To adjust place card on extender. Use Oscillator # 1 or Oscillator OUTPUT from PB-1C patched to PB-1C INPUT. Place METER MODE in FREQUENCY position. Switch input frequency between 1004 and 2713 Hz while observing frequency reading. P3 and P4 control the high and the low end scale reading respectively but with considerable interaction. Adjust P3 and P4 so that the readings at 1004 Hz and 2713 Hz are correct within 5 Hz. At mid scale, near 1700 Hz, reading will then typically be high by 25 Hz. This is not a malfunction, it is inherent in the circuit.

c. NOTCHED NOISE SCALE: Adjust only if the error exceeds ½ dB. Allow 15 minute warm up. Place card on extender. Make certain that LEVEL scale is properly adjusted (see above). Patch Oscillator # 1 at 1000 Hz and Oscillator # 2 at -20 dB (relative to Oscillator #1) and 1200 Hz frequency to PB-1C INPUT. Place METER MODE in NOTCHED NOISE and observe reading. Set P1 for reading of -20.2 dB. The slight offset from -20 is to account for the C-message filter weighting.

d. NOISE SCALE: Adjust only if error exceeds ½ dB. Allow 15 minute warm up. Place card on extender. Make certain that LEVEL scale is properly adjusted (see above). Set PB-1C oscillator to 1004 Hz and patch its OUTPUT to the INPUT jack. Set OUTPUT level to -30 dBm as measured with the METER MODE switch in the LEVEL position. Switch METER MODE to NOISE position and observe reading of 60 dBRnc. Adjust P2 for correct reading.

5-12. OUTPUT CARD ALIGNMENT (see Figure 5-2)

a. The Output Card contains 18 potentiometers. Four of these are the CRT zero pots accessible via front panel screw driver holes when the card is mounted in position.

P1 is the display phase lock loop range potentiometer. It is a FET dependent adjustment which is normally set only at manufacture. It is experimentally adjusted so that the Display Phase Lock Loop will lock over a frequency range of at least 990 to 1030 Hz in all four CRT MODE switch positions. There is no criteria other than this.

b. The AM TILT adjustment P2 is set with the CRT MODE in the VECTOR NOTCH 20 to 300 Hz position and an amplitude modulated input signal with a modulation frequency nominally between 100 and 200 Hz. So that the deflection is purely vertical, this is carried out after the tube alignment under High Voltage Card (paragraph 5-10) and compensates for minor circuit time delays.

c. Potentiometers P5 and P13 are the multiplier DC zeros. These are set in either harmonic mode. Center the panel harmonic zero pots and adjust P4 and P13 to center the spot while monitoring oscillators 3 at the PB-1C INPUT jack. Use the maximum SCALE MULT position.

d. MULTIPLIER BALANCES: The display multipliers each have two balanced potentiometers, P3 and P4 for the horizontal multiplier, P11 and P12 for the vertical. Using Oscillator 1 and Oscillator 2 input a 1000 Hz test tone and -20 dB of 1200 Hz SFI. Adjust all four balance potentiometers so that the disc observed is homogeneous at the edges.

e. SCALING: The VECTOR NOTCH unfiltered scaling adjustments, P8 vertical and P16 horizontal, are adjusted with the same input as the multiplier balance above. Adjust P8 and P16 so the disc observed is circular and of the correct diameter (fills the -20 dB graticule circle with a scale sensitivity in 0, x 5). Note: The VECTOR NOTCH zero adjustments must be properly set or the circle will be offset.

f. VECTOR NOTCH 20 to 300 Hz scaling adjustments are P7 vertical and P15 horizontal. These are adjusted with the same input as VECTOR NOTCH UNFILTERED above after the UNFILTERED MODE is set. The setting of P8 and P16 affect those of P7 and P15, thus procedure e. above must be carried out first. Place the CRT MODE switch in VECTOR NOTCH 20 to 300 Hz position and set P7 and P15 so that the circle observed falls on the -20 dB graticule circle.

g. HARMONIC: Both second and third harmonic sensitivity are set by common adjustments, P9 vertical, and P17 horizontal. Use the same set up as for VECTOR NOTCH, UNFILTERED above but change the Oscillator 2 frequency so that the SFI tone is within 3 Hz of the second harmonic of the tone frequency. Observe that the spot traverses a circle. If the frequency difference between twice the frequency of Oscillator #1 and Oscillator #2 is greater than 3 Hz, the circle diameter will diminish. Adjust P9 and P17 only for frequency difference within 3 Hz or less.

5-11 e. above must be set first because it affects the sensitivity of P9 and P17 adjustment.

5-13 IDENTIFICATION OF CIRCUIT BOARDS, SERIAL NUMBER 100 AND UP

See Figure 5-3 for a chassis view of units bearing Serial Number 100 and higher. The figure identifies circuit board locations. The plug-in cards are retained by brackets attached to the can or to the panel (output card). If a board does not mate with the brackets, it is plugged in the wrong place or is plugged in backward. The mother board mounts the line to low voltage transformer, the low voltage power supply (including regulator), the speaker amplifier, the input preamp, and the oscillator. The oscillator frequency adjustment pot (see Paragraph 5-9) is located on the mother board.

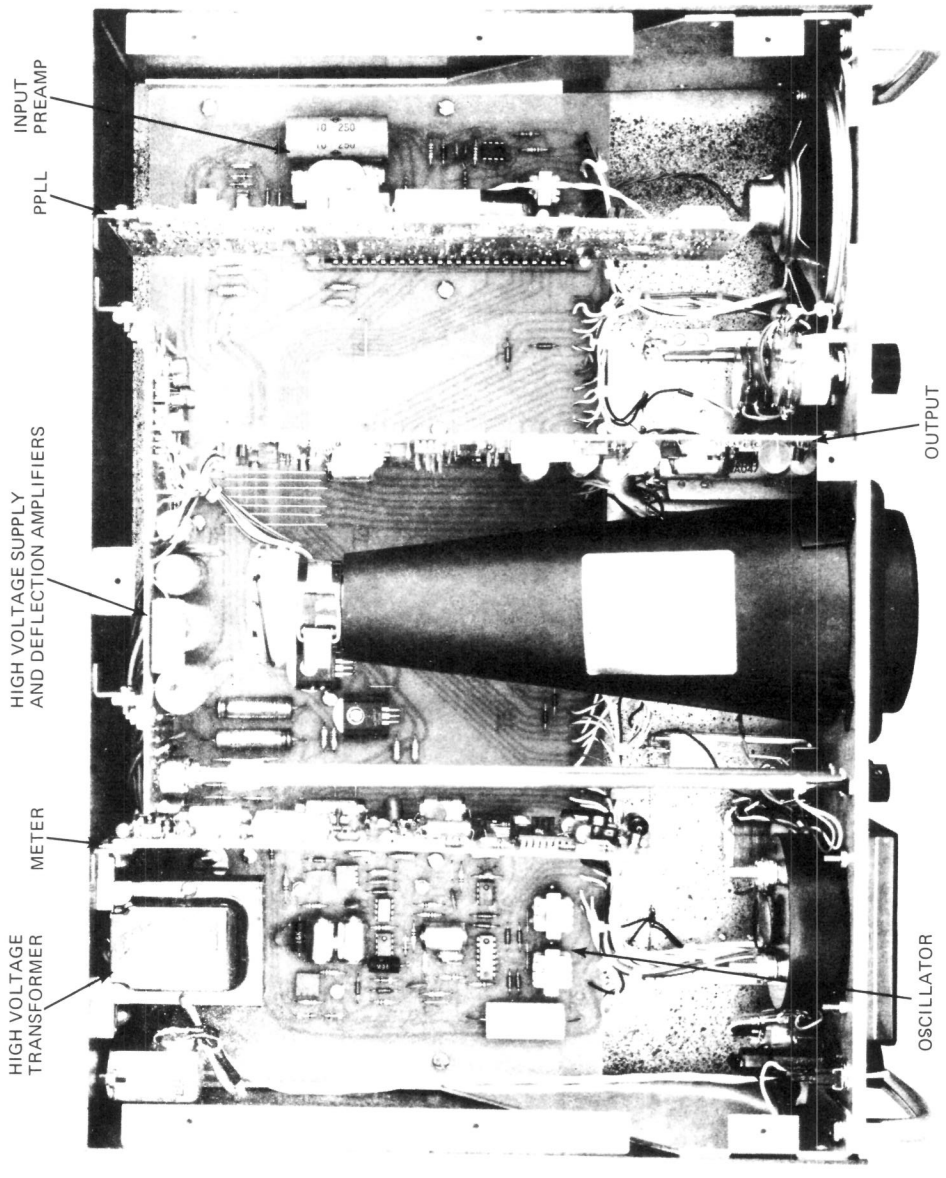


Figure 5-3 PB-1C BOARD LOCATION, S/N 100 and HIGHER