Data Services Transmission Requirements and Data Test Sets

Bell System

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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. Where a practice has been abridged, it is noted accordingly under the practice number or in the introduction portion of the practice. For information not contained in this manual, refer to the standard BSP files.

The FMP consists of four 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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DATA SERVICES TRANSMISSION REQUIREMENTS AND VOICE BANDWIDTH DATA TEST SETS

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PART I

DATA-PHONE SERVICE

DATA SYSTEMS—"DATA-PHONE"® SERVICE AND DATA ACCESS ARRANGEMENTS ON DIRECT DISTANCE DIALING NETWORK OVERALL DATA TRANSMISSION TEST REQUIREMENTS

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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 equally to DATA-PHONE service and Data Access Arrangements (DAA) unless otherwise specified. There are no specific requirements for inductively or acoustically coupled DAA.♦

1.02 This section is reissued for the following reasons:

- To include DAA information throughout this section
- To update BSP references in 7.01
- To include reference to 914-type data test set in 11.03
- To include a reference section
- To change the upper test frequency to 2800 Hz
- To change the holding tone to a −13 dBm0.

1.03 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 either end 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; ie, 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.

1.04 In order to test Bell System DATA-PHONE services, a number of 904-type data test centers (DTC) have been installed in various locations in the Bell System. The data test centers are used in conjunction with local and toll test centers. ➧The two types of voiceband data test centers in operation are the 904A or C and the 904B or D. The 904A and C data test centers are designed for local testing and are capable of testing data sets which have a remote test feature. The remote test feature allows the data set to be tested from a DTC through the operation of a test key on the data set by the attendant. This permits a data set to be tested without telephone company personnel at the station. The 904B or D data test center must always be associated with a 904A or 904C DTC. The 904B or D DTC contains several types of data test sets and other test equipment, which enable it to make dynamic tests (end-to-end error tests) of data sets.➦ (In other words, the DTC is a "presumed good" data set.) It is most useful for testing the interface of the data set (which is not tested by the 904A-type tests) and for quick demonstrations to the customer and/or business machine personnel that the data set is operational. However, since the DTC is somewhere in the middle of the network and may not be in the routing taken by the customer's call, sending data to a DTC is not always a conclusive test. If the results are good, no information is gained as to whether data service is satisfactory to the particular location the customer is calling. If the tests are bad, the fault may be due either to facilities between the DTC and the customer or to the data sets, indicating that further analysis is needed. Section 314-205-300 provides additional information on the overall transmission maintenance procedures.

1.05 ➧The Data Access Arrangement provides a service through which a customer may connect his data set (modem) to the switched telecommunications network. Since a non-Bell System modem is used with DAA, the error rate performance cannot be specified. The DAA consists of a Bell System data coupler and, when necessary, a telephone. This arrangement provides signal level limiting, loop isolation, a loop-holding path for dc supervision, and hazardous voltage protection. The Bell System retains the responsibility for network control signaling features. However, with automatic DAAs, the customer's business machine may generate tone address signals or control the generation of dc dial pulses.➦

2. OPERATION OF THE DDD NETWORK

2.01 The DDD network consists of a large number of trunks which interconnect long distance switching offices. This network serves, with a few exceptions, all of the telephones in the United States and Canada. Since data calls are routed from city to city via the DDD network, it may be helpful to review briefly the general structure of the DDD network.

2.02 Central offices where the customer data lines are terminated for the purposes of interconnection to other offices are called end offices and are designated class 5 offices. The class 5 offices are connected by trunking facilities to higher ranking offices (lower class number). The class 5 office does not necessarily have to terminate in a class 4 office. Depending upon location, it may home on any higher ranking office (any lower class number) from a class 4 to a class 1. High-usage trunks may be provided between offices of any class. The needs of direct distance dialing are met by switching and trunking arrangements that employ the principle of Automatic Alternate Routing to provide rapid and accurate connections while making efficient use of the telephone plant. With Automatic Alternate Routing, a data call which encounters an "all trunks busy" condition on the first high-usage route tested is automatically and rapidly "route advanced" and offered in sequence to one or more alternate routes for completion. The overall tests of a data service should be made during the normal working hours in order to determine if there are any variations in error rate or in general performance under alternate routing conditions.

2.03 During the busy-hour period, the overflow traffic is more likely to be routed through alternate routes. For each call, there is a network of final routes which are last choice routes and are engineered on a low-delay basis. On the average, no more than a small fraction of the calls offered to this final trunk group during the busy-hour period will find all trunks busy. Within the United States, the maximum number of trunks in tandem will not exceed a total of nine, ie, seven trunks from a class 4 office to a class 4 office, plus one trunk on each end to a class 5 office. The probability of a call traversing all nine final trunk routes is estimated to be only a few calls out of millions. Most calls are completed on direct or first alternate trunk routes between offices; relatively few switch through more than two intermediate (intertoll) trunks in tandem.

2.04 Part of the DDD network is operated on a 4-wire basis and the remainder on a 2-wire basis. It would be advantageous to operate all trunks in the DDD network at a zero loss, making the total transmission loss independent of the number of trunks used in a connection between two stations. If the whole system operated on a 4-wire basis subset to subset, it would be possible to keep the losses close to zero. However, with the interconnection of 2- and 4-wire facilities, problems of balance, echo, singing, noise, and crosstalk require circuits to be operated at definite minimum losses. The application of the above considerations to an individual trunk depends upon the facilities involved, length of the circuit, and accuracy with which the various adjustments at the terminals and intermediate points have been made and held. An important feature of analog transmission systems is that the adjustment of a component made at any one point will have a reaction 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.

2.05 Most of the trunks on the DDD network are designed to operate on a via net loss (VNL) basis. VNL is defined as the lowest loss in dB at which it is possible to operate an intermediate trunk facility in a multitrunk DDD connection, considering limitations of echo, crosstalk, noise, singing, and office balance on the overall connection. VNL design provides the lowest practical loss at which a trunk can be operated regardless of the number of trunks in tandem in the connection. ♦More information about VNL is contained in Section 851-300-100 entitled Transmission Design Consideration and Objectives, Switched Special Services and PBX Services.♦

3. TRANSMISSION ASPECTS OF DATA SERVICE

3.01 ♦The data subscriber line should meet the objectives shown in Section 314-205-501 (Data Systems—DATA-PHONE® Service and Data Access Arrangements on Direct Distance Dialing Network—Test Requirements for Subscriber, Foreign Exchange, and Remote Exchange Lines).♦

3.02 Voice transmission and data transmission, while they are similar in basic elements such as means of switching and circuit design, differ somewhat in transmission requirements. 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

(c) Return loss

(d) Message circuit noise

(e) Impulse noise

(f) Envelope delay distortion

(g) Frequency shift

(h) Nonlinearities

(i) Phase jitter (incidental FM)

(j) Hits—amplitude and phase

(k) Dropouts—microwave fading.

These items are covered in more detail in Parts 4 through 11 of this section.

3.03 Several of the parameters listed above are primarily controlled by voice requirements. These include overall circuit loss, return loss, and message circuit noise. Of the remaining parameters, data requirements are usually controlling. In general, voice telephone service can tolerate greater transmission impairments than data service. For example, if the customers have difficulty with transmission during a telephone conversation, they will either compensate for the difficulty by talking louder or repeat the part of the conversation that has been missed. Under the same conditions, the data set is at a disadvantage since it can only transmit at a predetermined level and frequency. The data set has no way of determining if errors or reduction of signal level have occurred during transmission. (Of course, error detection capability may be provided in some instances.) Impulse noise, except in extreme conditions, has little effect upon voice transmission since the duration of the impulse noise peaks involved are often too short to be recognized by man. Impulse noise is a serious problem in voice-frequency data transmission, in which the data signals are measured in milliseconds or less. Envelope delay does not have a serious effect upon voice transmission because the human ear is relatively insensitive to differences in delay at different frequencies. Modern carrier and loaded facilities have better envelope delay performance than the older types. Carrier frequency error does not seriously affect voice transmission in most instances. For data transmission, more than a 10-Hz deviation from the normal carrier frequency may degrade a data circuit to the point at which the data being sent is unintelligible.

3.04 The performance of a data set generally deteriorates after the operating limits are exceeded. For example, after the attenuation distortion (frequency response) limit has been reached in data set 202C, 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. Prudent and careful application of adjustments to each section in the overall connection will increase the reliability of the service.

4. MAXIMUM TRANSMITTING LEVEL AND OVERALL CIRCUIT LOSS

4.01 The maximum practical transmitting level of data sets is limited by crosstalk in multipair cable facilities and by the maximum level that a steady tone or combination of tones which may be applied to a carrier terminal unit without overloading. Most DATA-PHONE data sets have been designed so that the maximum transmitting level will not exceed one milliwatt in 900 ohms. ♦In DAA, the couplers are designed to limit, when necessary, the signal power delivered by the customer-provided data modem.♦ In connection with initial installation tests (see Section 314-205-501), the loop insertion loss is measured and recorded for the data loop. The maximum sending level for the telephone company-provided data set involved should be set so as not to exceed ♦−12 dBm at the main frame appearance of the subscriber line at the class 5 office furnishing dial tone to this line. This will correspond to a maximum data signaling power of −13 dBm0 on toll carrier facilities.♦ The transmit level will be selected by the engineering department and the proper option shown on the circuit layout card or line card. This can be verified by dialing the milliwatt supply from the customer's premises and subtracting the transmission measuring set reading from −12 dBm. In regard to some types of DATA-PHONE data sets such as the 400 series, more than one tone is sent simultaneously. The −12 dBm figure represents the total power of all tones transmitted simultaneously. In order to keep receiving levels within requirements, the data set level should be set so it will be received at the serving central 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.

4.02 The maximum permissible overall circuit loss between data sets depends upon the DDD connection and the type, sensitivity, and operating frequencies of the data set. The receive level of data sets ranges from +2 dBm to −53 dBm. The exact maximum loss that a particular data set can tolerate may be calculated by subtracting the maximum transmitting level from the minimum receive level. At this time, all DATA-PHONE data sets can tolerate an overall loss of 36 dB at 1000 Hz and 48 dB at 2800 Hz. ♦Although the slope requirements are based on loss measurements at frequencies of 1000 and 2800 Hz, the test oscillator should be offset by about 4 Hz to obtain stable measurements over T carrier.♦

4.03 With the many improvements in DDD network losses over the past few years, overall loss is not considered to be a major cause of trouble. Under present design, the maximum overall circuit 1000-Hz loss should not exceed 37 dB. This includes the local loops and toll connecting trunks at each end plus seven intertoll trunks in the connection. If problems arise, they usually can be traced to improperly lined-up trunks in the network.

5. ATTENUATION FREQUENCY DISTORTION

5.01 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. Some DATA-PHONE data sets that operate in the higher bit range [above 300 bits per second (bps)] can tolerate more attenuation frequency distortion by the use of the compromise equalizer. With low-speed (under 300 bps) narrow band data sets, such as the 100-type data set, attenuation frequency distortion is less limiting because of the narrow bandwidth.

5.02 For the entire station-to-station connection through the DDD network, the attenuation frequency (slope) should not exceed 15 dB between 1000 Hz and 2800 Hz for satisfactory operation of data sets. For high-speed data transmission, the loop between the serving central office and the customer location should measure no more than 3.0-dB maximum difference between the 1000-Hz loss and the 2800-Hz loss. The maximum difference on the connection over the DDD network, end office to end office, should not exceed 9 dB between 1000 Hz and 2800 Hz.

5.03 The attenuation frequency characteristic of connections on the message network varies from call to call. On a built-up connection, the facility is affected at higher frequencies due to the effect of capacitance in office wiring. When tests of a data service reveal instances of high distortion measurements accompanied by an excessive number of errors, overall loss-frequency measurements should be made station-to-station. (The connection should be "held" in order to make the measurements.) If these measurements indicate that there is an attenuation difference, the circuit should be measured at each loop. Both loops should meet the maximum objective and if this objective cannot be met, each link should be tested to determine the source of the trouble. ▶See Section 660-405-300 for additional information on trouble sectionalization and clearing methods to be applied to trunks in the DDD network when used for data services. Section 660-101-305 provides information on the local testroom procedures followed by the plant service center when handling data service complaints. It also contains the overall maintenance plan for DDD data service.◀

5.04 The attenuation frequency characteristic also defines the bandwidth of the transmission facilities. DATA-PHONE and DAA services are operated on frequencies as low as approximately 300 Hz and as high as approximately 3000 Hz. Modern transmission facilities provide sufficient bandwidth to accommodate these frequencies; however, obsolete types of facilities (such as H-172 loading) may prevent satisfactory data transmission and a substitute must be provided.

6. RETURN LOSS REQUIREMENTS

6.01 Return loss requirements for data sets are determined by listener echo (echo heard by the listener). Listener echo is limiting for data sets because the receiving data set on a connection will interpret the data received through the echo path as interference. Most of the data sets in use at this time will not tolerate listener echo ▶delayed more than one-third the baud interval and at a power◀ closer than 12 dB to the received signal level. Return losses at each 2-wire to 4-wire point in the DDD network will affect listener echo. At 2-wire switching points, the return losses, in turn, are affected by office balance. Voice requirements for return loss and echo on the DDD network provide an adequate margin for data service.

6.02 Bell Telephone Laboratories studies on return loss requirements indicate that the 12-dB first listener echo requirement for data sets is valid but can be met without special loop treatment. Therefore, there is no longer a specific return loss requirement for data service loops. Return loss is an important parameter, especially to high-speed data transmission, but the troubles are usually isolated to trunks, improperly installed E-type repeaters, or poorly balanced hybrids rather than the loop facilities.

7. MESSAGE CIRCUIT NOISE

7.01 Message circuit noise is ▶the noise on a channel in the absence of a signal. Message circuit noise is of lesser importance in data service than in voice service. If normal voice circuit noise objectives are met, then data transmission noise objectives will be automatically met. Message circuit noise objectives for voice may be found in the following sections:

- 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 Tests—PBX Central Office Trunks, Off-Premises Station Lines and Tie Trunks Having Access to the Direct Distance Dialing Network

- 660-403-500—Message Circuit Noise Measurements on Message Trunks—Requirements
- 660-500-500—Transmission Testing of Message Trunks at Locations Other Than Testboards—General Information.◆

7.02 Message circuit noise will not be a problem if a 24-dB signal-to-C-notched noise ratio is maintained throughout the connection.

8. IMPULSE NOISE

8.01 Impulse noise hits are a primary source of errors in data transmission. If impulse noise hits of sufficient magnitude occur during data transmission, they can seriously degrade the error rate of the data transmission system. ***Impulse noise measurements should be made on every loop that is to be used for the transmission of data signals at 300 bps or greater.*** 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.

8.02 Impulse noise exhibits some level variation with the time of day. It was previously believed this variation was great enough to warrant measurements only during the busy hour. Recent studies show this effect to be less severe, and it is now 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.

8.03 Previously, it was recommended that transmission level corrections be made at 1700 Hz, which was selected because it was near the center of the spectrum of high-speed voiceband data transmission. This is no longer considered necessary on trunks because the difference between the 1000-Hz and 1700-Hz loss is small on trunks but must be taken into account on loops. An average of the 1000- and 2800-Hz loss is used since nonloaded facilities are encountered.

8.04 The impulse noise objectives for trunks and facilities are given in Table A. The objectives given in this table are average levels where one-half of the trunks in the trunk group or one-half of the facilities in a facility group exhibit five or less counts in 5 minutes.

8.05 A trunk group is defined as all of the trunks between two offices, A and B, for any given purpose and under the same maintenance control. A facility group is defined as all of the facilities in a given routing with common design. For example, the 12 channels in an N1 system would be included in a group. Where specific trouble investigation is in process, only those facilities under investigation are included in the facility group. For example, if seven of the 24 channels in an ON1 system are used in a trunk group A-B where high-impulse levels have been noted, only those seven channels enter into the computations.

8.06 Where compandored facilities are encountered, a ◆−13 dBm0 holding tone is used in setting the objectives. This stabilizes the expandor loss at 9.0 dB.◆

8.07 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.◆

9. ENVELOPE DELAY DISTORTION

9.01 Envelope delay distortion 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. Voice transmission performance is not affected to the same degree by envelope delay distortion as data transmission. The amount of envelope delay distortion that will be found on a voice-frequency facility depends upon the type and, in the case of cable, the length of the facility. Carrier system distortions are affected by the type of carrier and the multiplex arrangement encountered.

9.02 Envelope delay distortion (EDD) is usually expressed as the maximum variation of the envelope delay characteristic within a particular frequency band. This measurement is usually

→ TABLE A ←

TRUNK AND FACILITY IMPULSE NOISE OBJECTIVES

TOLL CONNECTING TRUNKS AND INTERTOLL TRUNKS			
LENGTH (MILES)	TYPE TRUNK		
	Note (1)	Note (2)	Note (3)
0 through 60	54 dBrnc0*	66 dBrnc0*	58 dBrnc0*
61 through 125	54 dBrnc0*	66 dBrnc0*	58 dBrnc0*
126 through 250	54 dBrnc0*	66 dBrnc0*	59 dBrnc0*
251 through 500		66 dBrnc0*	59 dBrnc0*
501 through 1000		66 dBrnc0*	59 dBrnc0*
1001 through 2000		66 dBrnc0*	61 dBrnc0*
Over 2000		66 dBrnc0*	64 dBrnc0*
TOLL CONNECTING FACILITIES AND INTERTOLL FACILITIES			
LENGTH (MILES)	TYPE FACILITY		
	Note (1)	Note (2)	Note (3)
0 through 60	51 dBrnc0*	64 dBrnc0*	55 dBrnc0*
61 through 125	51 dBrnc0*	64 dBrnc0*	55 dBrnc0*
126 through 250	51 dBrnc0*	64 dBrnc0*	56 dBrnc0*
251 through 500		64 dBrnc0*	56 dBrnc0*
501 through 1000		64 dBrnc0*	56 dBrnc0*
1001 through 2000		64 dBrnc0*	58 dBrnc0*
Over 2000		64 dBrnc0*	61 dBrnc0*

Note (1): Voice frequency only.

Note (2): Compandored carrier or mixed compandored and noncompandored facilities with - 13 dBm0 holding tone.

Note (3): Noncompandored carrier.

* Limits are given for measurements made with instruments equipped with "C" Message (C) weighting filter. If measurements are made with instruments equipped with voiceband (VB) weighting filter, add one dB to the objective.

expressed as microseconds over the band of interest. Data sets vary in their tolerance to envelope delay distortion, depending upon the type of modulation and the bit rate. Low-speed DATA-PHONE data sets can tolerate a greater amount of delay distortion than the higher speed data sets. 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 attenuation frequency distortion 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 noise may also have a strong effect on P/AR readings.⬅ Table B shows the expected readings for acceptable and unacceptable conditions. If envelope delay measuring equipment is available at the station ends of the overall connection suspected of having excessive envelope delay distortion, direct measurements should be made. If this equipment is not available, consult the Data Technical Support personnel through normal lines of organization for advice. The end-to-end envelope delay distortion should be compared with the requirements of the data set involved. ➧The maximum overall envelope delay distortion requirements for satisfactory error performance for data sets 201A and 202-type are shown in Table C of this section. List 3 and List

4 of data set 203-type are designed for DDD operation. Error performance is not specified, but some insight into the performance that can be expected per field trial (see Technical Reference, Data Set 203-Type, June 1970) is as follows. The performance was equal to or better than 10^{-5} errors per bit for 95 percent of the calls at 1800 bps (2-level). A 10^{-4} error or better error rate was obtained on 84 percent of all calls and an error rate better than 10^{-5} errors per bit on 62 percent of all calls at 3600 bps (4-level). Error performance for 4800 bps is approximately equal to that at 3600 bps. In the case of a customer-provided modem, the requirements should be the same as for an equivalent bit rate Bell System data set.◆

TABLE B

P/AR READINGS

CONNECTION IS	PAR READING
Acceptable	Above 50
Unacceptable	Below 50

9.03 As with other transmission aspects of the switched message network, the amount of envelope delay distortion varies from call to call, depending upon the number and type of carrier links and the length and type of voice-frequency links in the connection. Compromise or adaptive automatic equalization is used in the higher speed data sets to make operation on the switched message network possible. In connection with the installation or maintenance testing of DATA-PHONE data sets, it is important to verify that the compromise attenuation and delay equalizers have been properly connected at the data set location. The options which cover the equalizers for the particular data set involved are specified on the circuit order, line card, or other records associated with the data service.

9.04 On the overall connection, as the envelope delay distortion objectives for given frequencies are approached or exceeded, the operation of the data set will become more marginal. This may result in a malfunction or complete failure of the data set.

→ TABLE C ←

MAXIMUM ENVELOPE DELAY DISTORTION REQUIRED FOR SATISFACTORY ERROR PERFORMANCE

DATA SET (SEE NOTE)	FREQUENCY	MAX EDD
201A	1150-2300 Hz	500 μs
	1000-2500 Hz	900 μs
	800-2700 Hz	1750 μs
202 - Type	1200-2200 Hz	1050 μs
	1000-2500 Hz	1500 μs
	800-2600 Hz	2000 μs

Note: All data sets used in connection with DATA-PHONE service should have the compromise equalization option connected (see 9.03).

9.05 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. The RX line will have to meet the requirements per Section 314-205-501.

9.06 When remote exchange lines of any type, including wide area telephone service (WATS) lines, are used for data service, their design should first be reviewed by personnel responsible for circuit design to ensure that the envelope delay distortion will not exceed the limits for the type of data sets involved. RX lines to class 4 or higher offices will include the distortion of a toll connecting trunk in computing objectives. If the envelope delay distortion exceeds 300 microseconds between 1000 and 2400 Hz, the line should be delay-equalized to meet the 300-microsecond objective. WATS design will be identical to RX design if other than the local office is used as a serving office. If the local office is used, the normal loop objectives apply. Information about delay equalizers may be found in Sections 314-820-100, -103, and -104.

10. FREQUENCY SHIFT

10.01 Frequency shift (sometimes called frequency offset) beyond the capabilities of the data 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, or envelope delay, the possibility of frequency shift should be investigated.

10.02 Under normal circumstances, frequency shift will have little effect upon voice transmission. With data service, deviations in frequency of more than ±10 Hz may cause distortion of a data signal. The modulated data signal of the DATA-PHONE data set is transmitted as a tone or combination of tones which have been calibrated to precise frequencies. At the receiving end of the facility, the signal is demodulated by the receiving data set in order to recover the data. If the frequencies of the transmitted tones are changed as they traverse the facility, the frequency-sensitive circuits in the receiving data sets will not receive the tones at the optimum points, thus resulting in a distortion of the data signal and an increase in the number of errors received. 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.

10.03 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.

10.04 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.

10.05 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.

10.06 In the event that all specified requirements have been met and unsatisfactory service is experienced, the trouble may be caused by either phase jitter, harmonic distortion, or single-tone interference. Normally, it is not expected that the plant department will be required to make these tests. However, if advised by Data Technical Support personnel, these parameters should be checked.

11. EVALUATING DATA TRANSMISSION AND TROUBLE INVESTIGATION

11.01 ***In all instances, facilities used for data transmission should meet normal voice-frequency objectives prior to their consideration for use on data services.*** The additional requirements described in Parts 4 through 10 of this section should then be applied to the facilities, as required, in order to accommodate the more stringent objectives of data transmission.

11.02 On a connection over the DDD network, the effects of such items as overall loss, attenuation frequency distortion, envelope delay, 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.

11.03 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 901-, 902-, and 903-type data test sets or a 914-type data test set.♦

11.04 An analysis of possible results of the circuit evaluation test is shown in Table D. The result of the tests may be used as a guide for locating transmission difficulties encountered with data services.

TABLE D

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)	
High distortion and high error rate	Distortion reading is high and steady.	Attenuation Frequency Distortion Message Circuit Noise Return Loss Envelope Delay Distortion	(Part 5) (Part 7) (Part 6) (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 Message Circuit Noise	(Part 8) (Part 7)
High distortion and high error rate	Distortion reading may shift gradually.	Frequency Shift	(Part 10)

12. REFERENCES

12.01 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	J94027A and B Par Meter Generator and Receiver, Description, Operation, and Maintenance
107-100-100	♦901A and 901B Data Test Sets—Identification and Operation♦
107-101-100	914-Type Data Test Sets, Description and Operation
107-200-100	903A and 903B Data Test Sets, Description and Operation
107-300-100	902A and 902B Data Test Sets, Identification and Operation
314-205-300	Data Systems—DATA-PHONE® Service on Direct Distance Dialing Network, Overall Transmission Maintenance Procedures
314-205-501	Data Systems—DATA-PHONE® Service and Data Access Arrangements on Direct Distance Dialing Network—Test Requirements for Subscribers, Foreign Exchange, and Remote Exchange Lines
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
590-010-300	Data Systems—DATA-PHONE® Service on Direct Distance Dialing Network—Overall Field Force Maintenance Procedures
660-101-305	Data Systems—DATA-PHONE® Service on Direct Distance Dialing Network—Plant Service Center Handling Customer Trouble Reports
660-405-300	♦Data Systems—DATA-PHONE® Service and Data Access Arrangements Using the Switched Telecommunication Network, Toll Testroom Trouble Clearing Procedures♦
851-300-100	♦Transmission Design Consideration and Objectives, Switched Special Services and PBX Services.♦

NOTES

DATA SYSTEMS—"DATA-PHONE"® SERVICE AND DATA ACCESS ARRANGEMENTS ON DIRECT DISTANCE DIALING NETWORK— TEST REQUIREMENTS FOR SUBSCRIBER, FOREIGN EXCHANGE, AND REMOTE EXCHANGE LINES

CONTENTS PAGE

1. GENERAL

1.01 This section describes the transmission test requirements on subscriber, remote exchange, and foreign exchange lines used for data transmission on the switched telecommunication network (DDD). Information in this section applies equally to DATA-PHONE service and data access arrangements (DAA) unless otherwise specified.

1.02 This section is reissued as follows:

- To revise Fig. 1 to show maximum signal level at serving central office
- To update listing of standard voiceband data sets for DATA-PHONE service in Table B
- To include DAA information throughout the section
- To include reference to the 6H and 6HR impulse counters
- To include reference to the 6F and 6FR voiceband noise measuring sets
- To include information on the 497G weighting network
- To correct BSP references
- To add a reference section.

1.03 The tests described in this section are made between the serving office (the central office furnishing dial tone) and the data set location unless otherwise specified.

READ

➧***Test requirements in this section are specified at 1000 Hz and 2800 Hz. However, in actual testing, the signal should be offset by 4 Hz to avoid quantizing problems in T-carrier systems.***

1.04 Data access arrangements are provided for customers using non-Bell System data modems. When the requirements for DAA differ from those provided for data sets, they will be specified in this section. DAAs are also referred to as data couplers.➧

1.05 For the purposes of this section, the term "loop" is used to define the over-all subscriber line from the data set location to the serving central office. When the first central office is ***not*** the serving office for the line (RX or FX lines), the "loop" will consist of the local loop plus an interoffice facility. The interoffice facility may use metallic pairs or carrier-derived channels (see Fig. 1).

1.06 The ***local loop*** is the facility from the customer's premises to the main frame of the local serving office. ➧The loops are normally 2-wire instead of 4-wire because the lower cost of 2-wire loops outweighs the improved transmission performance of 4-wire loops.➧

1.07 Due to serving office or local trunking problems, it will be necessary from time to time to serve a data subscriber from other than his normal office. This type of service is provided by a remote exchange (RX) line. End-to-end error tests (possible only with Bell System modems) should be made prior to taking this action to determine whether an actual service problem exists.

1.08 The RX line should be served from an office which eliminates part of the normal DDD routing. Each line should be individually designed and the distortion of the bypassed trunk added to the normal loop requirements to determine the parameters of the RX line.

1.09 Objectives for RX lines include the distortion of a toll connecting trunk. ***If the envelope delay distortion exceeds 300 microseconds between 1000 and 2400 Hz, the RX line must be delay equalized to meet the 300-microsecond objective.*** ➧Information about delay equalizers may be found in Sections 314-820-10Z.➧

1.10 A foreign exchange (FX) line provides service between the customer's premises and a remote central office in ***another area*** other than the central office which normally would serve that customer's location.

1.11 FX lines pose a difficult problem from an engineering design and plant maintenance point of view insofar as noise and envelope delay distortion are concerned. It is difficult to design an FX line that may be hundreds of miles long to data transmission loop design criteria. Equalization and noise requirements make this impracticable. However, data service via foreign exchange access should be successful for calls within a 200-mile radius of the serving office if the design criteria are met. ➧If the customer desires, he may order conditioned FX lines (C-conditioning).

1.12 Wide Area Telephone Service (WATS) lines will be designed to the same objectives as RX lines if the local office is not used as a serving office. If the local office is used, the normal loop objectives apply.➧

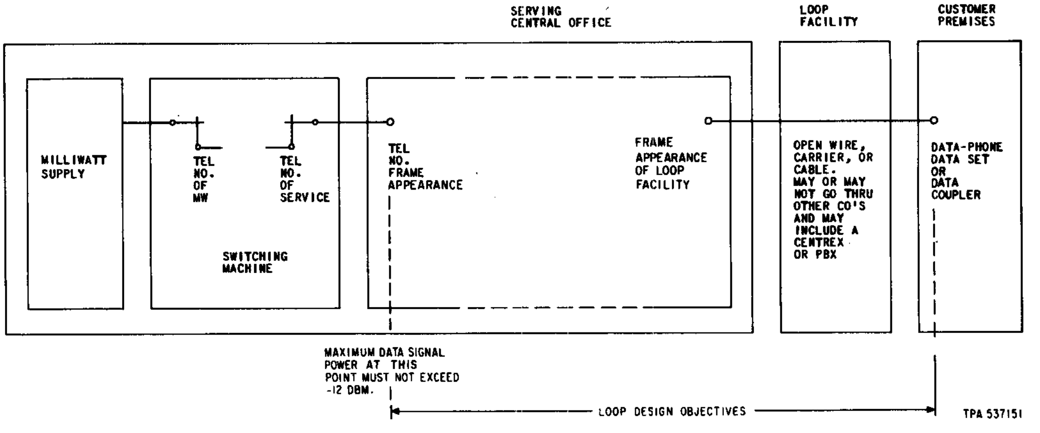

Fig. 1—➧DATA-PHONE Loop Layout➧

2. PRESERVICE LOOP TESTING

2.01 Upon receipt of assignment information concerning the installation of a data service, the plant service center should test all subscriber cable conductors involved for opens, short circuits, crosses, leakages, and grounds. These tests should be made on the subscriber cable pair from the central office to the data set location. Measurements of dc conductor resistance, using a battery voltage not exceeding 6 volts, should be made on all subscriber pairs to determine any possible error in plant records, high resistance, or other conductor faults (see AB22.077.2). When these measurements are made, the meter being used should be observed carefully in order to detect any variations. If needle variation occurs, it indicates that a possible trouble condition could exist; therefore, a different cable pair should be assigned. Where interoffice physical plant facilities (RX or FX loops) are involved, cable acceptance tests should be made if this has not been done previously. For information concerning cable acceptance tests, see Sections 330-300-5ZZ.

2.02 ♦Installation measurements (Table A) to be made are determined by the type of data set (Table B) and the loop (local loop, RX, or FX line) being installed. Tables C and D list the parameters and objectives for local loop, RX, and FX lines.

♦ TABLE A ♦

INSTALLATION MEASUREMENTS

PARAMETER	DATA SET OR DAA	
	TYPE I	TYPES II AND III
Insertion Loss 1000 Hz	Yes	Yes
Attenuation Distortion (Slope)	No	Yes
Impulse Noise*	No	Yes
Message Circuit Noise	Yes	Yes
Envelope Delay Distortion	No	Yes

*TLP corrections are to be made using the average of the 1000-Hz and 2800-Hz AML readings.

TABLE B

DATA SETS USED WITH DATA-PHONE SERVICE

TYPE I (BELOW 300 BPS)	TYPE II (300 TO 2400 BPS)	TYPE III (ABOVE 2400 BPS)
101	201	203
103	202	
113	402	
401	602	
403		
603		

TABLE C

LOCAL LOOP OBJECTIVES

PARAMETER	DATA SET TYPE I	DATA SET TYPES II AND III
Maximum Insertion Loss in dB		
1000 Hz	10.0 dB	10.0 dB
2800 Hz	Not Critical	13.0 dB
Maximum Slope	Not Critical*	3.0 dB
Impulse Noise — no more than 15 counts in 15 minutes at:		
Noncompandored or compandored facilities with —13 dBm0 holding tone	59 dBrnc0†	59 dBrnc0†
Message Circuit Noise — Meet voice objectives using 3-Type NMS:		
Noise Metallic	20 or less dBrn	20 or less dBrn
Envelope Delay Distortion		
1000 to 2400 Hz	Not Critical	100 Microseconds
Transmitting Level at Serving Central Office in dBm	—12	—12

* While no limit is specified, loop treatment is recommended if the slope exceeds 9 dB.

† If voiceband weighting is used, increase all objectives by 1 dB.

2.03 For DAA, the installation measurements (Table A) to be made should be determined by the design engineer from the type of data modem information provided by the customer and specified on the service order. When no information is available on the modem, Type III requirements should be specified. The following guidelines should be used when limited information is available about the customer modem:

(1) For all analog modems, Type III requirements should be specified.

(2) For all other modems, requirements based on the speed of modem (same as for DATA-PHONE service) should be specified.

(3) If the type of modem is known to be similar to a Bell System DATA-PHONE data set, use the requirements for that particular data set.◆

2.04 During trouble investigation, additional measurements may be needed to verify the transmission parameters given in Tables C and D.

3. ◆DATA ACCESS ARRANGEMENTS

3.01 The DAA may be telephone line powered or require a dc power supply at the customer's premises which is either customer- or telephone company-supplied.

3.02 Test access points for the loop will be tip and ring on the line side of the DAA.◆

TABLE D

REMOTE EXCHANGE AND FOREIGN EXCHANGE LINE LIMITS

PARAMETERS	RX, WATS TO CLASS 5 OFFICE FOR DATA SETS*		RX, WATS TO CLASS 4 OR EQUIVALENT FOR DATA SETS*		FX FOR DATA SETS	
	TYPE I	TYPES II & III	TYPE I	TYPES II & III	TYPE I	TYPES II & III
Attenuation Distortion 1000 to 2800 Hz	7 dB	5 dB	8 dB	5 dB	8 dB	6 dB
Envelope Delay Distortion 1000 to 2400 Hz	Not Critical	300 μs	Not Critical	300 μs	Not Critical	600 μs
Maximum Insertion Loss 1000 Hz	10 dB				8.5 dB	
Impulse Noise — No more than 15 counts in 15 minutes at: †	68 dBrnc0					

* Served from other than the normal local office. Requirements include equivalent distortions of one toll connecting trunk.

† Use a −13 dBm0 holding tone if compandored carrier is used.

4. IMPULSE NOISE MEASUREMENTS

4.01 Impulse noise measurements should be made on loops that are to be used at data transmission speeds above 300 bps. Impulse noise requirements are stated in terms of a maximum of 15 counts in 15 minutes above the specified threshold requirement. Circuits which exceed this number of counts are likely to have degraded error performance.

4.02 Figure 2 gives the procedure for making impulse noise measurements. Impulse noise measurements on the loop should always be made at the data set location using a 6-type impulse counter (Sections 103-6YY-ZZZ). When a "dial-up" quiet termination is available, it should be used to terminate the central office end of the loop before starting impulse noise measurements. ➧In No. 1 crossbar, step-by-step, and electronic switching system (ESS) offices with joint holding features, the "quiet termination" may go off-hook and on-hook periodically.➧ This is done to release the test line after the calling party hangs up. Impulse hits are usually observed on the 6-type counter due to this action. In this situation, do not use the "dial-up" termination. The impulse noise objectives are one count per minute, and the test line can create as many as 12 counts per minute. ➧The tests should be made by dialing up a test line in the serving central office or by application of a termination to a test shoe which may be connected at the main distribution frame appearance of the subscriber line.➧

4.03 ***Where compandored or unknown facilities are involved, the measurements should be made using a ➧−13 dBm0 holding tone at 2800 Hz.➧*** This stabilizes the compandor action at a level which simulates the working environment (data level). Impulse noise measurements are then referred to the "zero transmission level point" for comparison with the circuit objectives. The test procedure using a −13 dBm0 holding tone is given in Part 9 of this section.

4.04 General tests of loops used in connection with data transmission indicate that switching machines can introduce impulse noise on these circuits. Where impulse noise measurements exceed the requirements shown in Table C for the station loop, the noise may be on the outside plant facilities or in the serving office. ➧For a minimum of central office impulse noise, an electronic switching system

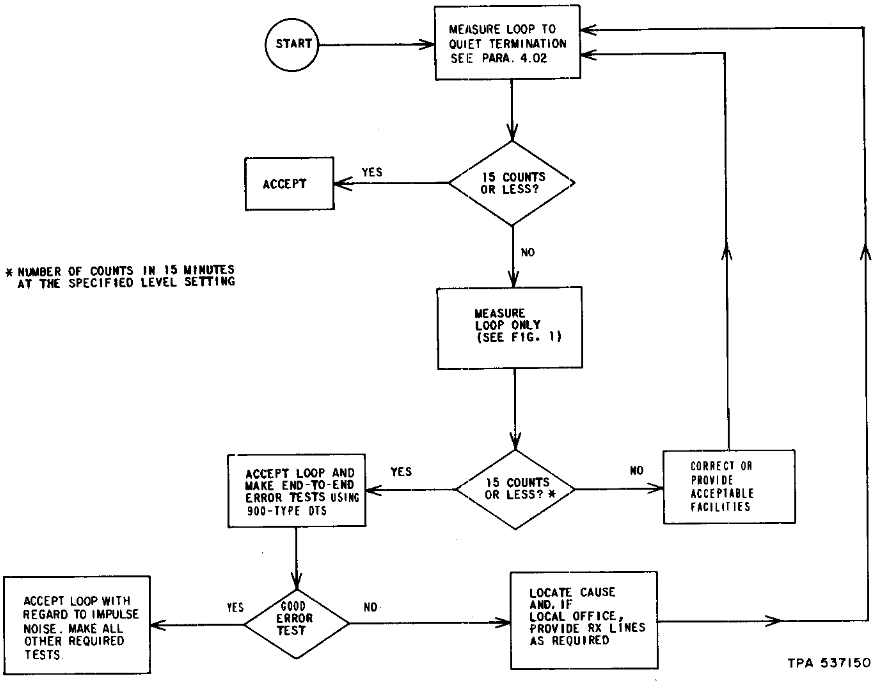

Fig. 2—Procedure for Impulse Noise Objectives

or a No. 5 crossbar office is the most desirable type of office to use as a serving office.◆ The next best would be a "known-quiet" step-by-step office. ◆Step-by-step offices equipped with rotary-out-trunk switches may produce impulse noise at an unacceptable level. These offices should be tested as specified in EL 1379—PL 2510.◆ The use of a panel office as a serving office for data services should be avoided, with the exception of low-speed data systems which are relatively insensitive to impulse noise. If impulse noise measurements exceed the objectives, this information should be forwarded to the Engineering Department responsible for the installation.

5. MESSAGE CIRCUIT NOISE REQUIREMENTS

5.01 Message circuit noise requirements for data service are the same as those for voice communication. ◆Requirements and detailed procedures for making measurements are covered in Section 311-100-501 for station loops, Section 311-100-500 for central office PBX trunks and tie trunks, and Section 314-410-500 for C-type conditioned FX lines. Sections 103-611-1ZZ cover the use of 3-type noise measuring sets.◆

6. INSERTION LOSS

6.01 ◆The loop should meet its 1000-Hz expected measured loss (EML) requirements as specified on the Service Order or Detail Work Sheet with a variation of no more than ±1 dB. If the EML does not appear on the circuit layout card, consult the engineering group responsible when analyzing trouble on the circuits. The maximum allowable insertion loss (loss between serving central office and data set or DAA) for data services is 10 dB at 1000 Hz. This does not include the insertion loss of the DAA. The maximum insertion loss including the DAA (measured to the data set side of the DAA) is 12 dB at 1000 Hz. See Table D for RX and FX line requirements.

7. ATTENUATION FREQUENCY DISTORTION REQUIREMENTS

7.01 The attenuation frequency distortion of the loop may be determined by measuring the loss of the loop at 2800 Hz and calculating the loss deviation from the measured 1000-Hz loss. There is no attenuation frequency distortion requirement for Type I data sets on local loops. For Types II and III data sets, the 2800-Hz loss deviation should not vary more than ±3 dB from the 1000-Hz loss or more than ±2 dB from the 2800-Hz loss shown on the circuit layout card. The maximum allowable 2800-Hz insertion loss for Type II and III data sets on local loops is 13 dB. A loop checker should not be used as erroneous readings may result. The loop checker looks at a much broader response than the 3-dB limit from 1000 Hz to 2800 Hz.◆

8. ENVELOPE DELAY DISTORTION

8.01 The maximum envelope delay distortion for Types II and III data sets (above 300 bps) is 100 microseconds for the 1000- to 2400-Hz band. There is no requirement for Type I data sets (below 300 bps). See Table D for RX and FX lines.

9. HOLDING TONE FOR IMPULSE NOISE MEASUREMENTS

9.01 This procedure involves the use of a "holding tone" of −13 dBm0 applied at the far end (central office) of a circuit and a tone-rejecting filter at the input to the 6-type impulse noise measuring set at the near end (customer) of the circuit. The holding tone establishes the loss of the compandor at a level which simulates the working environment.

9.02 Since the attenuator in the 6A impulse noise counters cannot always be adjusted to the desired attenuation, allowance for this limitation is made in the following tests by providing both the desired level settings and the suggested attenuator settings if the actual setting cannot be used. In addition, when making impulse noise measurements, the level settings must be adjusted up by 1 dB if voiceband weighting is used as opposed to C-message weighting. The C-message filter attenuates impulse noise 1 dB more than the voiceband filter.

9.03 The following is a step-by-step procedure for making impulse noise measurements. Figure 3 shows the test setup.

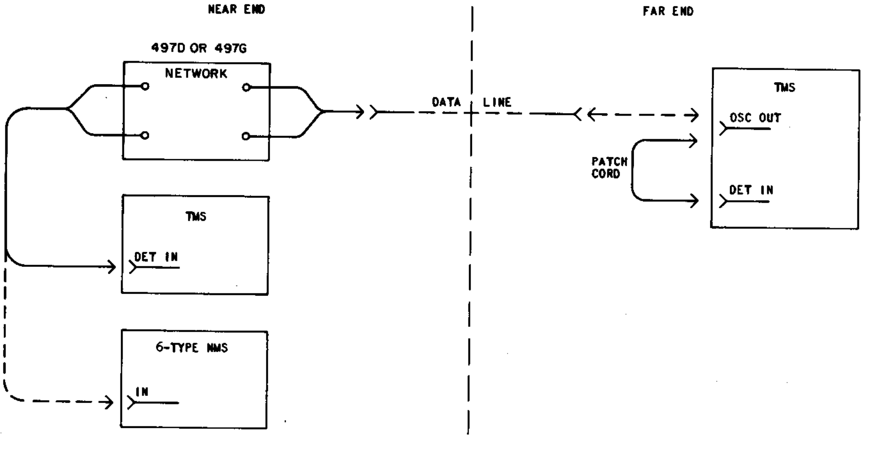

Fig. 3—Typical Arrangement for Providing Holding Tone

STEP	PROCEDURE
	Far End
1a	If compandored facilities are not involved, connect a termination to the circuit at the central office and proceed with Step 4.
1b	If compandored facilities are to be measured, connect the oscillator output on the transmission measuring set (TMS) to the detector input of the TMS and adjust the oscillator frequency to approximately 2800 Hz, if the 497G network is used, or approximately 2750 Hz if the 497D network is used.
2b	Adjust the oscillator output level to −13 dBm.
3b	Connect the oscillator output to the data line, thus terminating the data line for impulse noise measurements.
	Near End
4	Connect the 6F or 6H impulse noise test set to the line at the same test access point used for 1000-Hz loss measurement.
5	Determine the threshold setting in dBrnc0 from Table C or D.
6	Add the average of the measured 1000-Hz and 2800-Hz loss from the threshold setting in dBrnc0 to obtain the corrected threshold setting in dBrnc0 for the test point.
7	Adjust the impulse noise counter threshold setting to the corrected threshold setting and record the counts over a 15-minute period.
8	For more information on impulse noise test sets, refer to Sections 103-6YY-ZZZ.
	Example: The impulse noise is to be measured on a local loop. The threshold requirement from Table C is 59 dBrnc0. The 1000-Hz test tone from the central office measures −7.3 dBm and the 2800-Hz test tone measures −8.5 dBm. The average of these losses is (−7.3) + (−8.5)/2 = −7.9 dB. The corrected impulse noise threshold is 59 + (−7.9) = 51.1 dBrnc. If the 6F is used, set the FUNCTION switch to TERM 600—900 Ω and the DBRN switches to 21 dBrn (an additional 30-dB attenuation is provided in the first counter circuit to provide a threshold setting of 51 dBrnc).

10. REFERENCES

10.01 Bell System Practices covering the various equipment associated with data service are as follows:

SECTION	TITLE
AB22.077.2	Transmission Design Objectives for DATA-PHONE® Service and Data Access Arrangements Provided Over Station Loops, Remote Exchange Lines, Foreign Exchange Lines, and Wide Area Telephone Service Lines
103-611-100	J94003A and B Noise Measuring Set
103-611-101	J94003C Noise Measuring Set
103-611-102	J94003CR Noise Measuring Set
103-620-100	J94006A (6A) Impulse Counter, Description, Operation, and Maintenance
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
314-205-500	Data Systems—DATA-PHONE® Service and Data Access Arrangements on Direct Distance Dialing Network, Overall Data Transmission Test Requirements
314-410-500	Voice Bandwidth Private Line Data Circuits, Tests and Requirements
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
330-300-500	Completion Tests of Exchange-Area Cables Introduction
330-300-501	Completion Tests of Exchange-Area Cables Apparatus, Records, and Forms
330-300-502	Completion Tests of Exchange-Area Cables Preparation
330-300-503	Completion Tests of Exchange-Area Cables Testing
330-300-504	Completion Tests of Exchange-Area Cables Analysis and Reports
590-010-300	Data Systems—DATA-PHONE® Service on Direct Distance Dialing Network—Overall Field Force Maintenance Procedures
668-010-300	Data Systems—DATA-PHONE® Service on Direct Distance Dialing Network, Data Test Center, Trouble Analysis Procedure
590-103-1ZZ	Data Couplers
598-080-ZZZ	Data Auxiliary Set 828C.

NOTES

PART II

VOICE BANDWIDTH PRIVATE LINE DATA CIRCUITS

VOICE BANDWIDTH PRIVATE LINE DATA CIRCUITS

DESCRIPTION

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LIST OF TABLES AND FIGURES

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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 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 Engineering information is contained in Section AB27.350 and the associated point sections. 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.

1.03 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 1000-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. When customer-provided modems (CPM) or multiplexers terminate the channel, protective arrangements may be required as covered in Part 3 of this section.

1.04 Although operation of these services is basically 2-point, certain multipoint and switched arrangements are also used. One-way, half-duplex, and full-duplex data 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. ABBREVIATIONS AND COMMON TERMS

2.01 This part provides abbreviations used in voice bandwidth data service and circuit terminology that are generally encountered. In addition, definitions of unique terms are given.

A. Abbreviations

2.02 A listing of common abbreviations that may be encountered are as follows:

- BIT—Binary Digit
- CCO—Circuit Control Office
- CCSA—Common Control Switching Arrangement
- CDT—Communications Display Terminal
- CLRC—Circuit Layout Record Card
- CO—Central Office
- COAM—Customer Owned and Maintained (this term is now outdated)
- CRT—Cathode Ray Tube
- CSTC—Central Serving Test Center
- DAS—Data Auxiliary Set
- DATEC—Data Technical Support Team
- DDD—Direct Distance Dialing

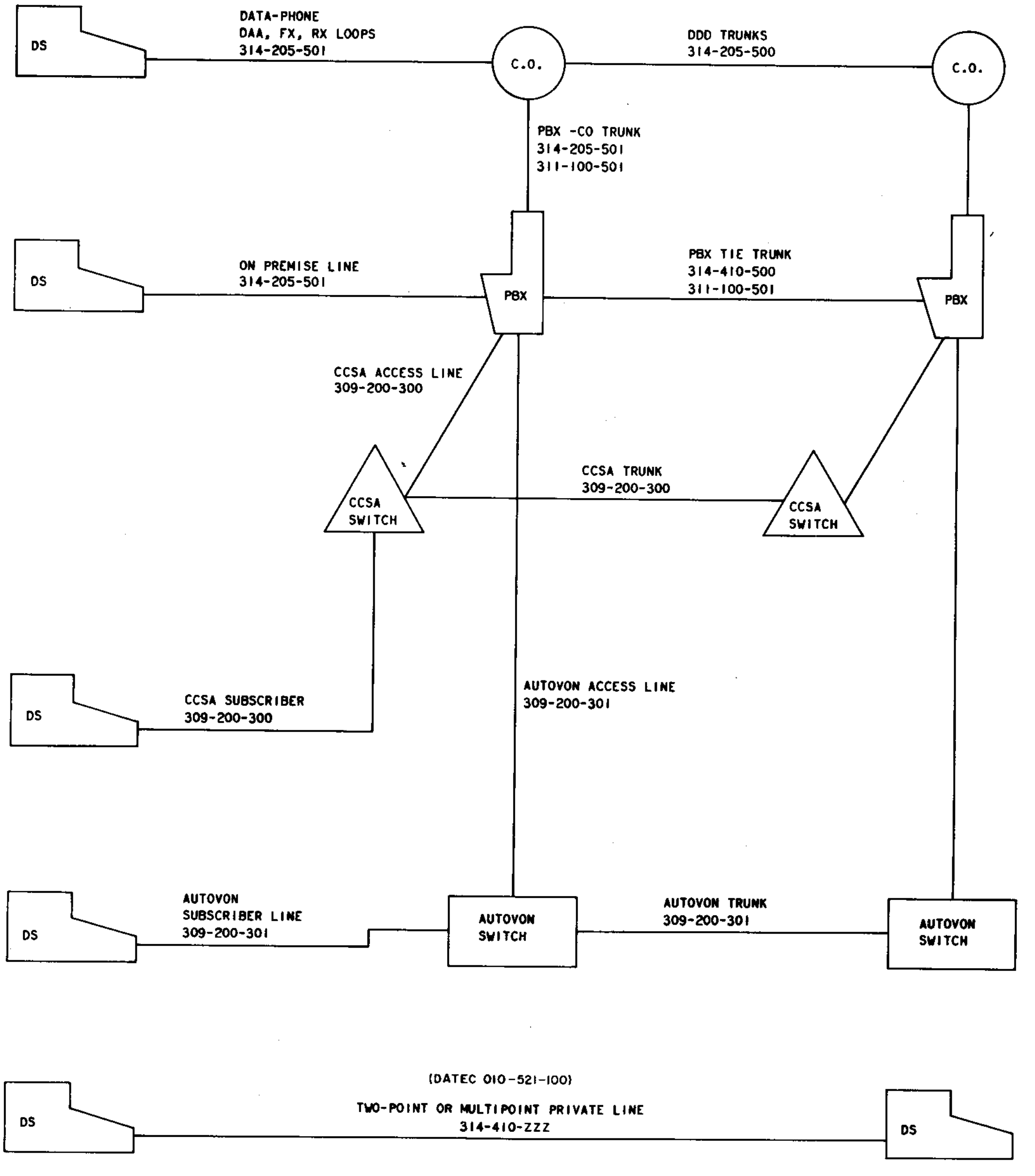


Fig. 1—Reference for Voiceband Data Transmission

- DS—Data Set
- DTS—Data Test Set
- IXC—Interexchange Channel
- LC—Local Channel
- MODEM—Modulator-Demodulator (Data Set)
- PBX—Private Branch Exchange (Switchboard—Manual or Automatic)
- SCAN—Switched Circuit Automatic Networks
- SSN—Switched Service Network
- TELCO—Telephone Company
- TCN—Telecommunications Network
- TMS—Transmission Measuring Set
- TTY—Teletypewriter.

B. Common Terms

2.03 Definitions of common terms are as follows:

(a) ***Baud***—A unit of signaling speed derived from the duration of the shortest signaling element. The speed in bauds is equal to the number of signaling elements or symbols per second.

(b) ***Bell System Technical References***—A reference source providing interface information to designers and manufacturers of business machines, communications systems, and terminal equipment. The subjects covered include data set interface specifications, data sytems and terminals, data connecting arrangements, and various transmission channels and services.

Note: Bell System organizations may order Technical References by using Form SD-1.80.80 and addressing it as follows:

Western Electric Co., Inc.

Indiana Publication Center

P.O. Box 26205

Indianapolis, Indiana 46226

The DATEC support team maintains a file of Technical References and can be used as a source for this type of information.

(c) ***Benchmark Measurements***—These are measurements made on a looped-back or one-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 recorded for later reference purposes.

(d) ***Bridge***—A device used to interconect more than two middle and/or end links on multipoint circuits.

(e) ***Customer-Provided Equipment (CPE)***—Any equipment provided by the customer and connecting to the telephone company line. Both CPM and CPT are considered CPE and may be designated as CPE.

(f) ***Customer-Provided Modem (CPM)***—Customer-provided data set.

(g) ***Customer-Provided Terminal (CPT)***—Customer-provided terminal equipment at the data station. Generally, this is equipment located on the customer side of the telephone company modem interface and wholly provided by the data customer. Examples of CPT are digital computers, communication controllers, card and paper tape readers and punches, and magnetic tape readers and recorders.

(h) ***Data Test Center (DTC)***—An office responsible for remote testing of data sets. Access to this office may be gained through a dedicated line or DDD facilities.

(i) ***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 (see Fig. 2).

(j) ***Equal-Level Loop-Back***—A circuit arrangement interconnecting the receive and transmit paths and correcting for any differences in

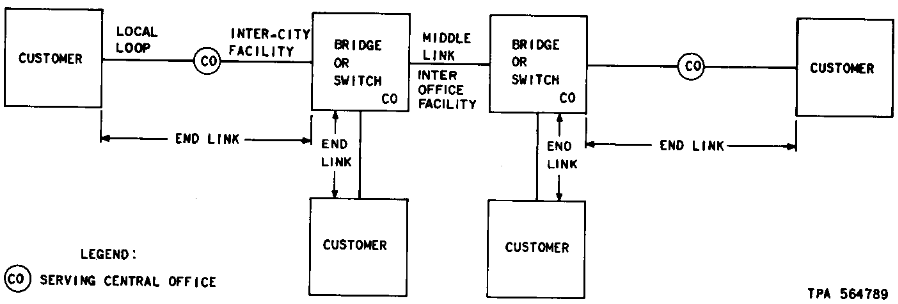


Fig. 2—End Link and Middle Link Definition

transmission level point (TLP) at the point of connection. The simplest way to accomplish this is to interconnect two identical TLPs, for example, at −3 and −3. To interconnect a −3 TLP receive point with a +13 TLP transmit point, an amplifier with 16 dB of gain would be required in the loop-back path. This ensures that signals on the line are maintained at standard data level during loop-back tests when data level is applied toward the customer station.

(k) ***Full-Duplex Operation***—The transmission of signals in both directions simultaneously.

(l) ***Half-Duplex Operation***—The transmission of signals in either direction on an alternate (not simultaneous) basis.

(m) ***Local Channel***—The transmission facility between the customer premises and the serving test center (STC). Refer to the definition of STC.

(n) ***Middle Link***—The facility 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. (Refer to Fig. 2.)

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

(o) ***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.

(p) ***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.

(q) ***Plant Service Center (PSC)***—The designated location to receive data service reports, whether local repair service, special service reports, data test center, etc. The PSC is responsible for handling, controlling, and clearing all trouble reports on special services, but often finds it necessary and advantageous to request the assistance of more specialized groups.

(r) ***Protective Arrangement***—An equipment arrangement provided by the telephone company through which a customer may connect his communications equipment (such as a modem) to a private line channel which will not access the switched message network.

(s) ***Serving Test Center (STC)***—A designated office responsible for testing transmission facilities, station equipment, and apparatus, in response to a customer report either taken directly or received from another office. It is also responsible for maintaining circuit records on those circuits for which it is designated an STC. If a PCO has not been designated, the STC is also responsible for coordinating maintenance activities, maintaining circuit layout record cards, and circuit history records.

(t) *TLP (Transmission Level Point)*—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.

Transmission Level Point (TLP)—General Definition and Use for Private Line Data Channel Design

2.04 The following is intended to clarify the term transmission level point (TLP). An understanding of TLP is necessary before making measurements on PL data circuits.

(a) 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 compare this power to the power present at other points in the channel. Figure 3 illustrates the relationship between TLPs and test tone power in dBm for a simple 2-point 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.

(b) Describing this power is similar to the problem of trying to describe the height of a mountain. In order 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.

(c) The standard reference point for measuring power in 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.

(d) With the establishment 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. An example of a −13 dBm0 signal is shown in Fig. 3 for test signals on a typical 2-point private line data channel.

(e) 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 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 +5 TLP would be +5 −13 = −8 dBm. If this −13 dBm0 signal were measured with a TMS at the +5 TLP, the meter would indicate −8 dBm. Similarly, if a −13 dBm0 signal were measured

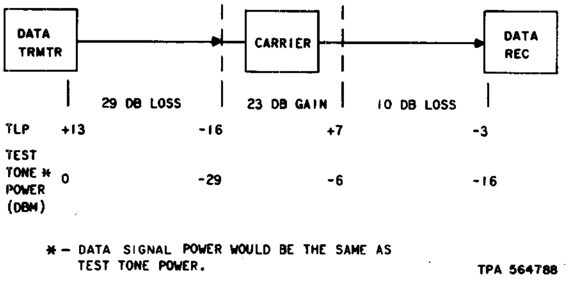


Fig. 3—Relationship Between TLP and Test Tone Power

at the −3 TLP, the meter would indicate −16 dBm [(−13) + (−3) = (−16)].

Note: The numeric value of the TLP does not describe the power present at that point any more than the elevation of a mountaintop above sea level describes how high the mountain rises above the plains which surround it. In order 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 of the mountain itself. In order to know the power present at a 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 at the 0 TLP (with the notation 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 at the 0 TLP is −29 + 16 = −13 or a −13 dBm0 signal. 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 added to the power at the −16 TLP.

(f) Use of the 0 TLP reference also permits transmission objectives and measured results to be stated independently of any specific TLP. For example, the end-to-end impulse noise threshold objective is 71 dBrnc0. Knowing this, 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 threshold, which is 68 dBrnc. For measurements at the +7 TLP DEMOD OUT jack, 7 dB should be added to the objective to determine the absolute threshold which is 78 dBrnc. Similarly, if a channel was designed for 0 dB net loss and 0 dBm transmit power and −13 dBm0 design, the receiver is a +13 TLP, and 13 dB should be added to the relative objective to obtain the absolute setting, which is 84 dBrnc.

3. APPLICATION OF PROTECTIVE ARRANGEMENTS

3.01 Protective arrangements may be required for voiceband private line channels where the channels connect to CPE and do not access the switched message network. The regulations regarding the application of protective arrangements are as follows:

(a) Protection against potentially hazardous voltages and longitudinal imbalance will be provided by the Telephone Company on the customer premises on interstate services installed on or after May 15, 1973.

(b) Existing stations on interstate services installed prior to May 15, 1973 will not be retrofitted with protective arrangements.

(c) Protection against excessive signal power level on interstate services and some intrastate services will be accomplished by the Telephone Company at the central office by surveillance, rather than by equipment on the customer premises. Where excessive signal power is detected, the Telephone Company may provide signal power limiting devices on the customer premises or at the central office.

(d) Interstate voicegrade channels connected to customer-provided equipment that applies ringing below 300 Hz are exempt from protection at this time, although protective criteria for signal power level (other than ringing) will apply in this instance.

(e) Some private line services furnished for specified customers or purposes are exempt from these requirements. This includes certain circuits furnished to the U.S. Army, U.S. Navy, U.S. Air Force, National Aeronautics and Space Administration, power companies, pipeline companies, railroad companies, air common carriers, U.S. Government departments and agencies, and the Communications Satellite Corporation, which meet the provision stipulated in Section 2.6.3 of F.C.C. Tariff No. 260 and comparable sections in the intrastate tariffs. Local practices should be consulted regarding the proper application of protective arrangements for private lines provided under intrastate tariffs.

3.02 Where the customer transmits signals in the band from 300 to 3000 Hz, protection against potentially hazardous voltages and longitudinal imbalance can be provided by one of the following:

- 31B voice coupler
- Protected repeat coil

- J53050D-1, L1 interconnecting unit
- Data auxiliary set 828A
- V4 repeater.

Where private line voice circuits also provide signaling leads to the customer, the signaling leads should also be protected by the following means:

(a) The J53050C-1, L3 interconnecting unit (for contact closure signaling)

(b) The J53050C-1, L2 interconnecting unit (for E and M lead signaling).

Where the customer has equipment that transmits signals in the band from 300 to 3000 Hz, and in addition, makes use of dc continuity where it is available, this protection can be achieved by means of the 119A interconnecting unit.

3.03 Signal power limiting can be achieved by use of the F-58122 automatic gain control (AGC) amplifier or a 1000A or 1000B data coupler. The 1000A or B data coupler can be installed on the customer premises, while the F-58122 AGC amplifier can be installed either at the customer premises or the central office.

3.04 General information on the above protective arrangement equipment may be found in Part 4 of this section. Additional information may be found in ELs 1172, 1540, 2333, and 2415. Copies of these ELs should be kept by each DATEC representative.

4. STATION ARRANGEMENTS

A. General

4.01 Data auxiliary set (DAS) 828A provides a standard station arrangement for 4-wire private line circuits that terminate in either 2-wire or 4-wire telephone company or customer-provided equipment (CPE). Other types of station equipment may be specified and are generally similar in function to DAS 828A. Hazardous voltage protection and preservation of longitudinal balance are required in most new station installations involving CPE. The provision of in-band signal power limiting within the station arrangement is not generally required under interstate tariffs but may be required under some intrastate tariffs. When in-band signal power limiting is not provided, surveillance techniques will be employed to assure signal power level compliance to the minimum protective criteria. The CLRC should indicate the type of station equipment to be used to provide protection against potentially hazardous voltages and longitudinal imbalance, and if also required, in-band signal power limiting.

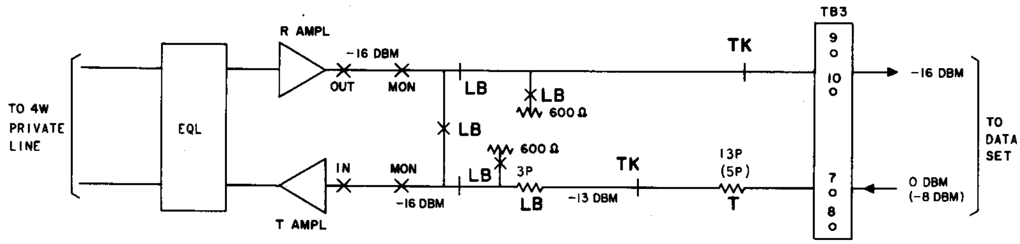
B. Customer Station Interface Levels

4.02 The current standard transmit power at the data set interface is 0 dBm (+13 TLP). This design is used for those data sets which can transmit at 0 dBm. Older CPE data sets which cannot transmit at 0 dBm may interface at a +5 TLP and transmit at −8 dBm. The standard receiver power at the data set interface is −16 dBm (−3 TLP) in all cases. Nonstandard interface levels may be negotiated by the customer and are to be indicated on the CLRC. In all cases the channel is designed on a −13 dBm0 basis (the data power is 13 dB below the TLP). Typical arrangements showing the DAS 828A using these designs are shown in Fig. 4, 5, 6, and 7.

4.03 Field experience shows that a polling operation in combination with a high noise environment causes problems in certain older Bell System data sets due to AGC operation. Since these sets have good sensitivity, a −16 dBm received level is not required. If the received signal power and noise power are reduced with a pad, the AGC range may be properly centered and the modem performance improved. The basic channel design should not be changed from a 16-dB net loss. Instead, a pad may be added at the data set receive input and considered part of the data set. For polling applications where split or 2-wire bridges are used and the master station uses the continuous carrier option, the referenced pads are needed only at the master station receiver and are not required at the outlying stations. Data sets 202D and 202R generally require a 16-dB pad as shown in Fig. 8. The new family of data sets (201C, 202T, 208A, and 209A) are designed to operate at a data power of −16 dBm. Thus, no pad is to be used. If these sets replace an older set requiring a pad, the pad must be removed.

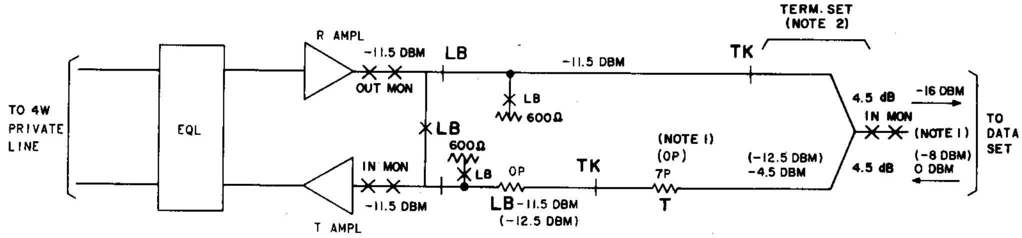
C. Data Auxiliary Set 828A

4.04 Descriptive information on this apparatus is given in Section 598-080-100. The DAS



NOTE:
FOR +5 TLP TRANSMIT, CORRESPONDING TO -8 DBM,
THE T PAD VALUE WOULD BE 5DB, AS SHOWN IN PARENTHESES.

Fig. 4—Circuit Design for Data Only, 4-Wire Data Set



NOTES:
1. VALUES FOR +5 TLP TRANSMIT ARE IN PARENTHESES.
2. SI SCREW AND COMP NET SCREW MUST BE DOWN IN ALL CASES.

TPA 570145

Fig. 5—Circuit Design for Data Only, 2-Wire Data Set

provides amplification or attenuation in transmit and receive pairs, equalization (in receive line), and line facility loop-back of a 4-wire private line data channel. The DAS 828A can provide equal-level loop-back for testing.

4.05 DAS 828A or the standard V4 repeater mountings equipped with 227-type amplifiers provide adequate protection against hazardous voltage and longitudinal imbalance. Isolation of dc and of longitudinal surges is also provided.

4.06 If 849-type networks are used in lieu of a 227-type amplifiers, adequate protection may not be assured. Arrangements for providing this protection when 849-type networks are used are covered in EL 2333. The use of 227-type amplifiers is the preferred arrangement when signal power limiting is not required. The F-58122 AGC amplifier may be used in place of the 227-type amplifier when signal power limiting is required in addition to hazardous voltage and longitudinal balance protection.

4.07 Loop-back capability in the DAS can be actuated on a local or remote basis. The loop-back circuit is operated by direct current sent over the simplex leads from a remote point, except

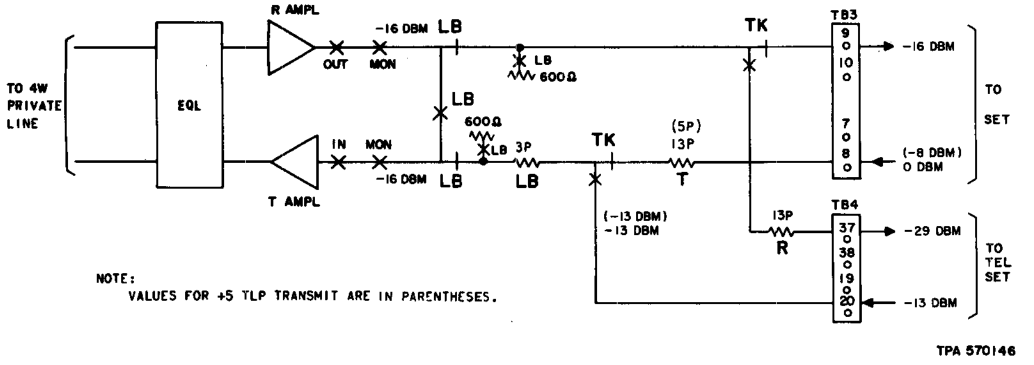


Fig. 6—Circuit Design for Data/Voice, 4-Wire Data Set

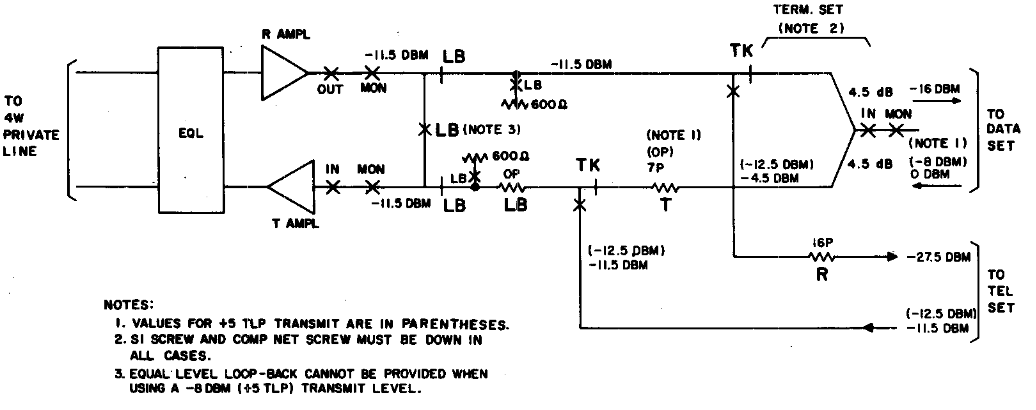


Fig. 7—Circuit Design for Data/Voice, 2-Wire Data Set

where the simplex leads are used for 20- Hz signaling, or by applying direct current from a locally operated key and power supply. The 44A1 data unit can be plugged into the term set socket in order to provide a tone-operated loop-back capability.

4.08 A 1B terminating set is usually provided when a 2-wire data set is used. The typical screw settings for the 1B terminating set when it is used as part of the DAS 828A are shown in Fig. 9. In this case, the 44A1 data unit must be mounted external to the DAS 828A if tone-operated loop-back is required.

D. Data Auxiliary Set 828C

4.09 This DAS provides transmission capability over the DDD network for one 4-wire voiceband data circuit using two DDD connections. The primary function of this apparatus is to furnish a backup facility for a 4-wire private line data channel.

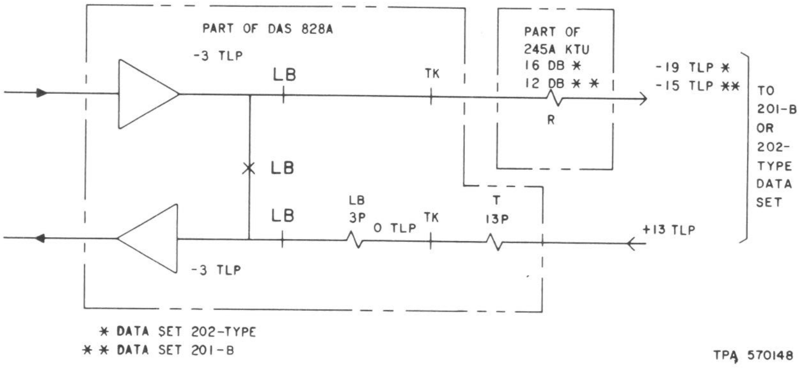


Fig. 8—Station Arrangement Suggested at Master Station for Polling Applications

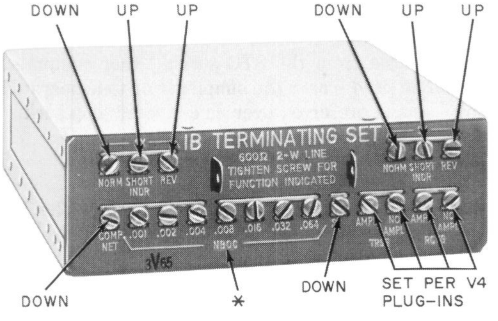


Fig. 9—1B Terminating Set—Screw Settings

4.10 DAS 828C is designed specifically to work along with DAS 828A, but may be used with other private line termination arrangements. It is for use only with Bell System data sets. More descriptive information on DAS 828C is given in Section 598-080-101.

E. F-58122 Amplifier

4.11 The F-58122 AGC amplifier can be used to replace 227-type amplifier in DAS 828A or the V4 repeater where in-band signal power limiting is required. Additional descriptive informaton is given in Section 332-104-103. Adjustment procedures for the amplifier are given in Section 332-104-503 (V4 repeater) or 598-080-500 (DAS 828A).

F. 1000A and 1000B Data Couplers

4.12 Both the 1000A and 1000B couplers provide protection from hazardous voltage, longitudinal imbalance and excessive inband signal power. The basis for selection between the two is whether dc power is available from the line.

4.13 The 1000A data coupler is a line-powered protection unit that restricts the customer signals automatically to a prescribed maximum average signal power ranging from 0 dBm to −10 dBm in 1-dB steps. This unit has a 1.8-dB insertion loss at 1000 Hz that must be included in the end-to-end channel loss. This loss must be considered when making circuit tests.

4.14 The 1000B data coupler performs the same function as the 1000A in restricting the output signal. However, the signal level can only be set for either 0 dBm or −8 dBm. In addition, the 1000B data coupler has an internal dc power supply power unit that requires 117-volt 60-Hz power from a local source. The insertion loss is 1.6 dB at 1000 Hz, which must be included in the end-to-end channel loss.

4.15 Both types of data coupler contain a 2800-Hz test oscillator that is actuated by a slide switch on the coupler by the user or telephone company employee. The oscillator tone level is high enough to activate the level control circuit which in turn reduces the test tone to the proper output level and verifies the limiting action of the coupler. The test tone also provides a preliminary transmission test of the facility by comparing the received level at the test center with previous measurements. More descriptive information on the data couplers is given in Sections 590-103-103 and 590-103-108.

G. 31B Voice Coupler

4.16 The 31B voice coupler is suitable for use as a protection device on the following types of private line circuits:

- Voice private lines without telco-provided channel signaling
- Data private lines that do not require signal power limiting on the customer premises.

The 31B voice coupler provides a compact, inexpensive means of obtaining protection against hazardous voltages which might originate in customer equipment, and of ensuring longitudinal balance regardless of the degree of balance (to ground) of the customer equipment. It also provides isolation between the customer equipment and the line with an adequate insulation breakdown rating to protect the customer terminals from longitudinal surges. The insertion loss of the 31B voice coupler is 0.7 dB. More descriptive information on this coupler is given in Sections 463-331-103 and 463-331-104.

H. Protected Repeat Coil

4.17 The protected repeat coil provides the same functions as the 31B voice coupler, with the added function of providing access to the simplex path of the transmission facilities when required for telephone company use. Typically, 120-U or -W type coils are used; however, if the channel requirements specify low values of delay distortion, the 117G-type repeat coil is used. Insertion losses for the repeat coil in combination with the protective resistor are about 0.7 dB for the 120-type and 0.9 dB for the 177-type.

4.18 The J53050D, L1 interconnecting unit contains 4 sets of protected repeat coils on a 23-inch panel for protecting four 4-wire transmission circuits. It is covered by CD- and SD-1E-207-01 and is described in Section 463-360-101.

I. Loop-Back Arrangements

4.19 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).

4.20 A dc activated loop-back arrangement is satisfactory in those cases where the dc 4-wire simplex path from the STC (or equivalent) is available to the customer location. The simplex path should have a resistance of less than 800 ohms and should not be required for signaling or other purposes.

4.21 A tone-operated loop-back arrangement should be provided when dc loop-back operation is not possible from the STC serving that customer. It can be used where the simplicity of tone-operated loop-back is preferred over dc activated loop-back.

Remote Loop-Back Arrangements

4.22 A dc operated arrangement allows the PL circuit to be looped back remotely from a dc access point, such as a central office or testing center. The loop-back (LB) relay, located at the customer station, is operated by applying 48-volt dc central office battery and ground over the 4-wire simplex path. For DAS 828A-L1, a minimum of 30 mA is required to operate the LB relay. Under this condition, a maximum of 800 ohms simplex resistance is specified. This corresponds to two 1600-ohm 2-wire local loops. When using the DAS 828A-L1/2, the 4-wire simplex path is used for signaling and is not available for remote dc loop-back activation.

4.23 The tone-operated arrangement utilizes the 44A1 data unit to operate the LB relay. This data unit is a 2713-Hz tone detector and can be plugged into the term set socket of the DAS 828A. More descriptive information is given in Section 590-100-131.

4.24 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 1 second. The 406A tone generator will be 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.

5. SIGNALING ARRANGEMENTS

5.01 20-Hz manual ringdown signaling is customarily used on private line data circuits when alternate voice capability is required. The DAS 828A provides this capability at the customer station.

5.02 A D1B ringdown converter (SD-56163-01) may be used at the serving central office to convert the 20-Hz signaling into E and M signaling. The converter may be connected directly to carrier channels such as N1, ON, or T carrier using D1, D2, or D3 channel banks, which provide an out-of-band E and M signaling capability. The D1B converter is connected to a single frequency (SF) unit with E and M signaling capability for use over channels which do not have a self-contained signaling capability.

5.03 A typical 20-Hz station arrangement using DAS 828A is shown in Fig. 10. A simplified schematic diagram of the D1B converter is shown in Fig. 11.

5.04 Operation of the ringdown signaling is as follows:

(1) The customer places the DAS 828A in the talk mode and pushes the RING key on the associated key set. A 20-Hz signal is transmitted over the 4-wire simplex path while the key is depressed.

(2) The D1B detects the 20-Hz signal on the 4-wire simplex path and operates the A relay (Fig. 11) causing −48 volt battery to be removed from and ground to be placed on the M lead (on-hook condition).

(3) If the D1B is connected to an SF unit, the ground on the M lead causes the SF unit to transmit a 2600-Hz tone on the channel. The tone is applied momentarily at a −8 dBm0 level, followed by a steady −20 dBm0 level (−36 dBm at a −16 TLP) for as long as the 20-Hz signal is detected by the D1B.

(4) The SF unit at the distant end, upon detection of a 2600-Hz tone (with no significant energy outside the 2450-2750 Hz band), removes ground from and places an open on the E lead (on-hook condition).

(5) The open on the E lead causes the R relay in the associated D1B to release, causing 20 Hz to be placed on the 4-wire simplex path toward the station as long as the open remains on the E lead.

(6) The ringer at the station is activated by the 20-Hz signal. The DAS 828A may be in the data, talk, or loop-back mode and receive the ringing signal. The ringing signal stops when the calling customer releases the RING key; going off-hook at the called station does not halt the ringing signal.

5.05 The resistance of the simplex path between the DAS 828A and the D1B should not exceed 5000 ohms. If a metallic circuit is available between two data stations and the simplex resistance between data stations does not exceed 5000 ohms, the stations can ring each other directly without the need for auxiliary signaling equipment. The station ringers should be set in the low notch position for long loops.

5.06 The ringing voltage transmitted by either the DAS 828A or the D1B should be 105 volts at a frequency of 20 Hz. The D1B can detect a ringing voltage as low as 15 volts. The station ringer should operate on ringing signals of 50 volts or more, as measured across the ringer.

5.07 The sensitivity of an SF unit to the received 2600-Hz signal varies with the type of SF unit being used. In general, received SF tone levels lower than −19 dBm at a +7 TLP may prevent the SF unit from recognizing an on-hook (ringing) signal. Very high level noise or crosstalk may also cause the SF unit to fail to recognize an on-hook signal because of the guard action in the unit.

5.08 If the transmitted data signal has energy in the 2450- to 2750-Hz band which is greater than the energy in a 800- to 2450-Hz band, the SF unit may falsely recognize this as an on-hook signal

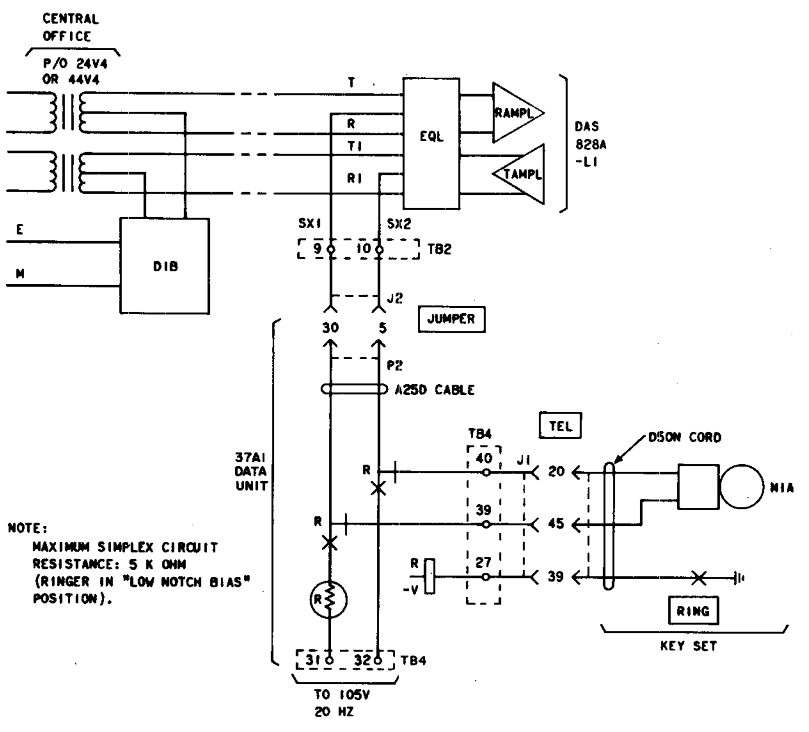


Fig. 10—Typical 20-Hz Ringdown Circuit For Private Line Data Station

and transmit a 20-Hz ringing tone to the customer station. In this case, it may be necessary for the customer to make a choice as to whether the CPE data set can be modified or substituted to remove this energy, or whether the Telco signaling arrangements should be removed. This matter should be treated as a trouble condition and referred to DATEC via lines of supervision.

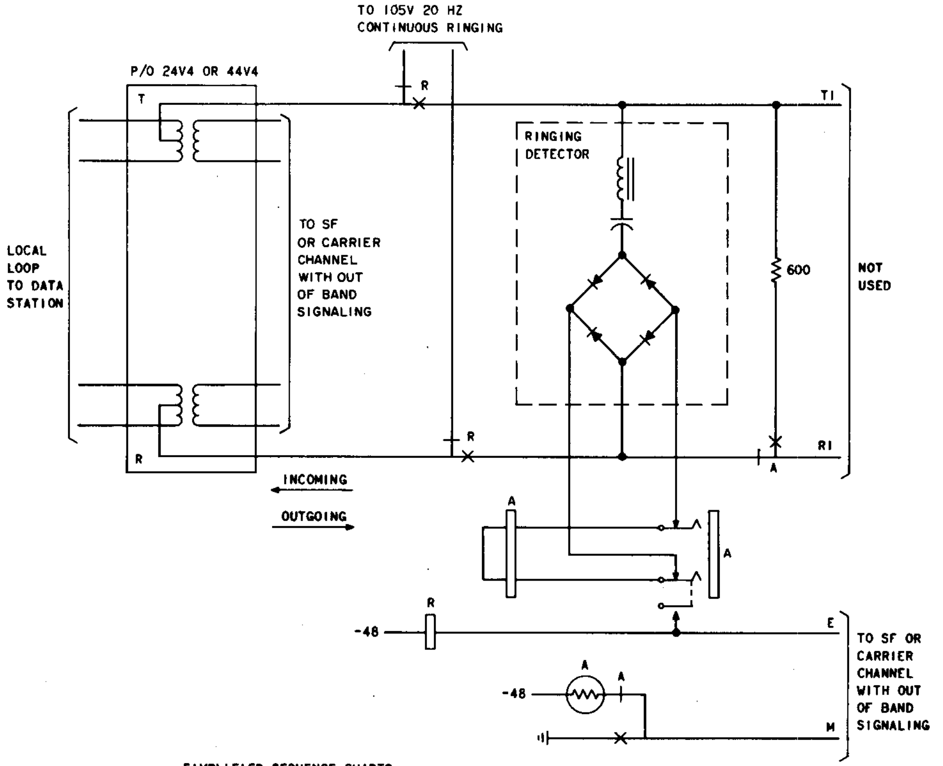
Note: Bell System data sets do not create this trouble condition and are compatible with SF signaling.

5.09 A trouble condition which may be very irritating to the customer is a steady ring. There is no way for the customer to stop the ring other than to hold his RING key depressed. In such a case, open both pairs towards the station receiving the ring to temporarily halt transmission of the 20-Hz signal to the customer. This condition is commonly caused when the E lead between the SF unit and the D1B is opened, usually at the frame.

6. CIRCUIT CONDITIONING

6.01 FCC Tariff No. 260 provides for a basic voicegrade channel (2001, 3002) and five types of C conditioning. These are designated as follows.

- 2001, 3002—Basic channel
- C1
- C2



SIMPLIFIED SEQUENCE CHARTS

IDLE CIRCUIT: NO 20 HZ FROM TIE TRUNK CIRCUIT, A RELAY RELEASES BAT ON M LEAD; GRD ON E LEAD, R RELAY OPERATED, NO 20 HZ TOWARD TIE TRUNK CIRCUIT.

SC1: INCOMING CALL
INCOMING RING IS OPEN E LEAD

R	
DURATION OF OPEN E LEAD	20 HZ RINGING CONNECTED ACROSS T AND R

SC2: OUTGOING CALL
OUTGOING RING IS 20 HZ T-R FROM TIE TRUNK CIRCUIT

A	
DURATION OF 20 HZ T-R	GRD ON M LEAD 600 TERMINATION T1-R1

TALKING CONDITIONS ARE IDENTICAL TO IDLE CIRCUIT CONDITIONS

Fig. 11—Simplified Schematic for D1B Ringdown Converter

- C3—Used only for switched circuits such as CCSA or SCAN
- C4
- C5—Used only for 2-point circuits.

6.02 These grades of conditioning are used to indicate the tightness of limits applied to circuit parameters of attenuation distortion and delay distortion. These are classified as bandwidth parameters and are covered more fully in Part 8 of this section.

6.03 The primary 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. The interface parameters and facility parameters (given in Part 8) are not affected by the grade of conditioning selected.

6.04 C3 conditioning is restricted to switched services networks only. Information on this type of conditioning is given in Section 309-200-301.

6.05 The requirements for attenuation distortion and envelope delay distortion for the various grades of C conditioning are given in Section 314-410-500.

7. CIRCUIT CONFIGURATIONS

7.01 The basic circuit configurations for private line data service are as follows:

(a) 2-Point

(b) Multipoint

(c) Central Office Relay Switched

(d) Customer Premises Switched

(e) Overseas

Combinations of these configurations may appear in a single private line circuit. When certain combinations are used, the error performance rate may be met using various forms or grades of C conditioning.

7.02 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 require more than 1500 feet of cable from the distributing arrangement. Refer to Fig. 12. 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 same end link and are not considered as constituting separate links. If more than 1500 feet of cable is required to interconnect a station with the local distributing arrangement, that station should be served by a separate end link from a central office bridge as shown in the lower portion of Fig. 12.

Intraexchange circuits may be subject to fewer restrictions, depending on local practice.

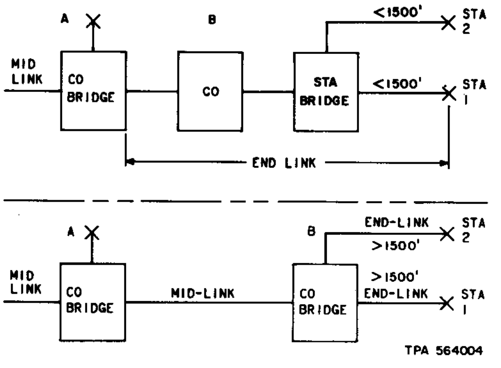


Fig. 12—Circuit Conversion of End Link to Midlink

A. 2-Point Circuits

7.03 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. C5 conditioning can be ordered only on 2-point circuits. Some C5 circuits have more than one station per exchange, but only one can be connected at a time. A given station may communicate only with a particular designated station in the distant exchange. No trouble report will be accepted or testing done for combinations of stations other than those specified by the service order.

B. Multipoint Circuits

7.04 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. 13 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. 3-point operation is similar, with Station D omitted.

7.05 Figure 14 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 further than 1500 feet of 22-gauge wire apart.

C. Central Office Relay Switched Circuits

7.06 Figure 15 shows a configuration utilizing a maximum of three central office switches that are allowed under the interstate tariff. The circuit may be unconditioned or have C1 or C2 conditioning between all pairs of stations.

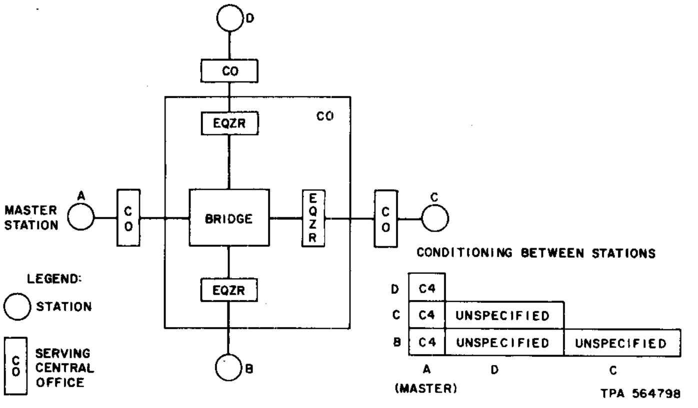


Fig. 13—4-Point Arrangement

D. Customer Premises Switched Circuits

7.07 Figure 16 shows a customer premises switched connection. This arrangement is permissible; however, no overall conditioning can be guaranteed.

7.08 The overall connection may be arranged to approximate the response of a basic channel or a C2 conditioned channel by conditioning each individual channel as specified in Section 314-410-300. Only the individual channel should be measured; never the overall connection.

7.09 It will not necessarily be possible to meet the end-to-end facility parameter requirements (as given in 8.01) on the overall connection, since it may include more local and short haul facilities in tandem than normal.

E. Overseas Circuits

7.10 Information on overseas circuits is given in Section 314-410-103.

8. CATEGORIES OF TRANSMISSION PARAMETERS

8.01 The circuit transmission requirements are divided into the following categories:

- Interface parameters
- Bandwidth parameters
- Facility parameters.

Table A shows the various parameters that apply to these categories.

8.02 The interface parameter specifications are influenced by two considerations: electrical protection of the telephone network and its operating personnel, and standardization of private line network design arrangements. The interface parameter specifications may be changed in unusual situations to accommodate unique customer requirements. These changes will be specified either by special tariff or "special assembly" provisions.

8.03 The bandwidth parameters are an indication of the usable bandwidth of a channel. Some of these parameters are specified by tariff. They are normally controlled by means of facility selection and equalizer selection and adjustment.

8.04 The facility parameters listed in Table A represent potential impairments to a data signal that can be caused by typical telephone transmission equipment. The facility parameter limits specified in Section 314-410-500 are common to all standard voiceband data circuits, regardless of the conditioning used. Tighter limits for C-notched noise and nonlinear distortion, as specified in Section 314-410-105, may be obtained by means of facility selection when the circuit is ordered with the high performance data option (HPDO).

IP

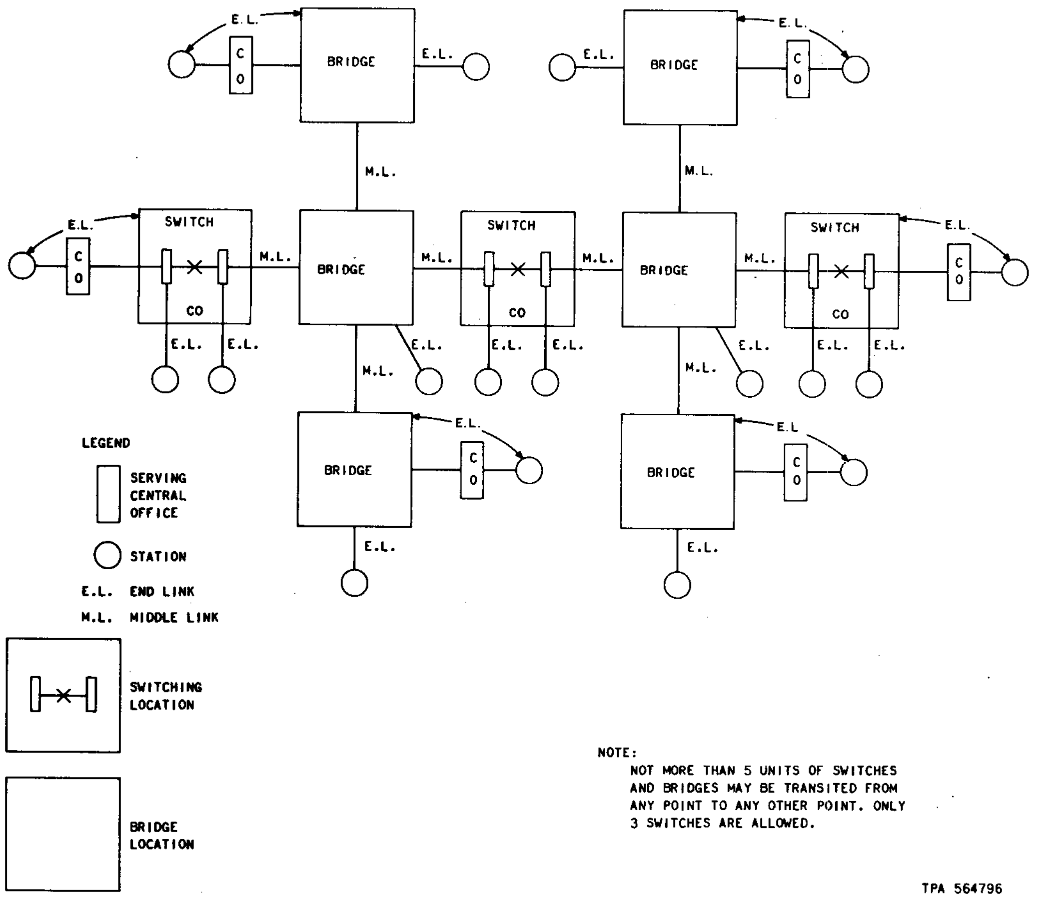


Fig. 14—Combined Central Office Switched Multipoint Circuit

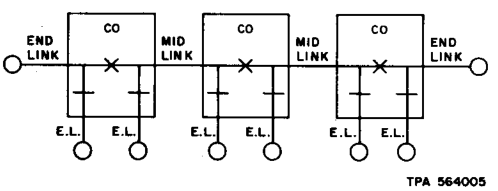


Fig. 15—Interstate Central Office Relay Switched Configuration

9. SYSTEMS AND ASSEMBLIES

9.01 This part defines and discusses the terms "Systems" and "Assemblies" These are defined as follows:

(a) ***Data Transmission Systems***—A service where Bell System data sets are used with the recommended channel conditioning as specified in Section 314-410-101. In such systems the operating speed of the data set, conditioning on the channel, and the configuration of the circuit

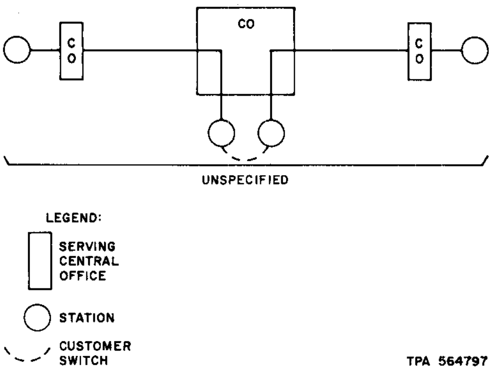


Fig. 16—Customer Switching Arrangement

are compatible and provide a satisfactory level of performance as defined in Bell System Practices and Technical References.

(b) ***Data Transmission Assemblies***—Services that do not meet the requirements as defined for data systems are called data transmission assemblies. These assemblies are tariffed arrangements of facilities, equipment, and allowable interconnections that a customer may lease. No level of data performance (error rate) is specified for the overall data assembly.

9.02 Included in the category of data transmission systems are those cases where Bell System

TABLE A

CATEGORIES OF TRANSMISSION PARAMETERS

INTERFACE PARAMETERS	BANDWIDTH PARAMETERS	FACILITY PARAMETERS
Terminal Impedance Transmitted Data Signal Power Transmitted Test Signal Power Received 1000-Hz Test Tone Power In-Band Signal Power Out-of-Band Signal Power Longitudinal Balance	Frequency Response (Attenuation Distortion) Envelope Delay Distortion Peak-to-Average Ratio (P/AR)	1000-Hz Loss Variation Message Circuit Noise (C-Message Noise) C-Notched Noise Impulse Noise Single Frequency Interference Frequency Shift Phase Jitter Nonlinear Distortion Echo* Phase Hits Gain Hits (Dropouts) Return Loss*

*Echo and Return Loss may also be considered as interface parameters in some circumstances.

data sets are used with the recommended conditioning in the following network configurations:

- 2-point channels
- Multipoint channels meeting certain design criteria as specified in 7.04
- Up to four 2-point channels in tandem when arranged for central office switching (see 7.06)
- CCSA networks
- Foreign exchange (FX) channels used to dial a switched telecommunications network connection to a point within 200 airline miles of the FX central office.
- Tandem tie trunk connections between on-premises PBX stations. For Bell System 201-type and 202-type modems, up to two tie trunks can be in the connection, provided the length of the overall connection does not exceed 4000 miles, and the tie trunks are appropriately C-conditioned. For Bell System 203-type and 208-type modems, performance will be supported over a single tie trunk. No data performance will be supported from modems attached to off-premises stations or between modems connected together by an off-network call.

9.03 Some examples of data transmission assemblies are as follows:

- Private lines or tie lines using Bell System data sets but with less than recommended grades of conditioning
- DDD from tie lines or tandem tie lines and off-network CCSA operation
- Access to CCSA from satelite or tributary PBXs or from off-premises PBX extensions to DDD or CCSA.

9.04 Any Bell System services which are interconnected with customer-provided devices such as multiplexers and data processing devices are treated overall as a data transmission assembly although each individual Bell System service may be treated as a data transmission system.

10. REFERENCES

10.01 The following documents provide additional descriptive information on facilities and equipment associated with private line voiceband data service.

NUMBER	TITLE
AT&T PUB 41003	Analog Parameters Affecting Voiceband Data Transmission—Description of Parameters—October 1971
AT&T PUB 41004	Data Communications Using Voiceband Private Line Channels—October 1973
AT&T PUB 41009	Transmission Parameters Affecting Voiceband Data Transmission — Measuring Techniques—January 1972
EL 1172	Application of Protection to Voicegrade Private Line Data Channels Which Connect to Customer-Provided Equipment
EL 1540	Application of Protection to Voicegrade Private Line Data Channels Which Connect to Customer-Provided Equipment
EL 2333	Application of Protection to Voicegrade Private Line Channels Which Connect to Customer-Provided Equipment
EL 2415	Application of Protection to Voicegrade Private Line Channels Which Connect to Customer-Provided Equipment

SECTION	TITLE
AB 27.350	Private Line Data Circuits—Voice Bandwidth—General Design Information
AB27.425.01	DATA-PHONE Service—Analysis of Transmission Factors
010-521-100	Data Technical (DATEC) Support

SECTION	TITLE
309-200-301	Switched Services Networks Using Central Office Switching Machines—AUTOVON—Service Maintenance
Division 310	Non-Switched Special Services System
Division 311	Switched Special Services System
314-016-125	TWX Service—Attenuation Equalization Arrangements and Adjustments—Using 44V4 Repeaters
314-410-101	Voice Bandwidth Private Line Data Circuits—Transmission Requirements of Bell System Data Sets
314-410-103	Voice Bandwidth Private Line Data Circuits—Overseas Circuits
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
314-821-100	Data Systems—Central Office—406A Tone Generator—Description
332-104-103	V4 Telephone Repeater—F58122 AGC Amplifier
332-104-503	V4 Telephone Repeater—F58122 AGC Amplifier—Tests and Adjustments
463-331-103	Voice Connecting Arrangement CD4—31B Voice Coupler
463-331-104	Voice Connecting Arrangement CDX—Using 31B Voice Couplers
590-103-103	1000A Data Coupler—Description, Installation, Maintenance, and Tests
590-103-108	1000B Data Coupler—Description, Installation, Maintenance, and Tests
598-080-100	Data Auxiliary Set 828A—Description and Operation
598-080-101	Data Auxiliary Set 828C—Description and Operation
660-200-301	Special Services—Protection and Safeguarding

VOICE BANDWIDTH PRIVATE LINE DATA CIRCUITS

TRANSMISSION REQUIREMENTS OF BELL SYSTEM DATA SETS

CONTENTS PAGE

1. GENERAL

1.01 This section provides current information on the characteristics of Bell System data sets.

1.02 The information in this section was previously contained in Appendix A of Section 314-410-500. This section represents a change from current requirements as follows:

- Provides information on new data sets
- Deletes information on data sets that have been rated MD.

2. TRANSMISSION REQUIREMENTS OF BELL SYSTEM DATA SETS

2.01 This part lists the characteristics and transmission requirements of voice bandwidth data sets currently used in the Bell System.

A. **Data Sets 103F- and 108-Types**

Data Input and Output: Serial, nonsynchronous

Bit Rate: Up to 300 bps

Type of Modulation: Frequency shift

Operating Frequencies:
M = Mark S = Space

F1:	S =	1070
	M =	1270
F2:	S =	2025
	M =	2225

Transmit Level: DS 103F-type: 0 to −14 dBm adjustable
DS 108-type: −6 to −26 dBm adjustable

Maximum Receive Sensitivity: DS 103F-type: −45 dBm
DS 108-type: −40 dBm

Input or Output Impedance: 600 or 900 ohms

Attenuation and Delay Distortion Equalizer: Not required

Recommended Conditioning: Basic channel

BSP References: Data Set 103F-Type
590-001-104 — Reference Guide
591-019-100 — Description

Data Set 108-Type
590-001-107 — Reference Guide
591-023-100 — Description

B. Data Sets 201A- and B-Types

Data Input and Output: Serial, synchronous

Bit Rate: DS 201A: 2000 bps
DS 201B: 2400 bps

Type of Modulation: Differential 4-phase

Operating Frequencies:
M = Mark S = Space

	DS 201A	DS 201B
MM	2125-1125	2550-1350
MS	1375-2375	1650-2850
SM	1875-875	2250-1050
SS	1625-2625	750-1950

Transmit Level: 201A3, A4 or 201B3, B4: 0 to —8 dBm adjustable in 2-dB steps (external pad is required for —12 dBm transmit level)

201A- or B-List Type: 0 to —12 dBm adjustable in 1-dB steps.

Maximum Receive Sensitivity: —42 dBm with equalizer
—50 dBm w/o equalizer

Input or Output Impedance: 600 or 900 ohms

Attenuation and Delay Distortion Equalizer: The single compromise equalizer is not used except if DDD backup is specified. If DDD backup is specified. DS 201C is recommended in lieu of DS 201B. Otherwise, the single compromise equalizer is used regardless of the private line conditioning specified on the service order.

Recommended Conditioning: DS 201A: Basic channel
DS 201B: See Note 1.

Note 1: Recommended conditioning DS 201B:

(1) C4 conditioning — not sensitive to codes, no problems expected.

(2) C2 conditioning — the following code restrictions apply:

- Repeated "1010. ." — no degradation up to 50 bits. Increasing degradation beyond 40 bits up to 80 bits, at which point the clock reaches its maximum excursion.
- Clock drift may be considered linear on a one-for-one basis. That is, to recenter the clock would require 1 dibit (2 bits) of any pattern other than "1010. ." for every dibit of "1010. . ."
- No degradation in data performance will occur if in any message the number of weak bits (repeated "1010. .") does not exceed the number of strong bits (any other pattern). The successive number of weak bits should not exceed 40.

No restriction is placed on the number of steady 0s or 1s that may be transmitted.

(3) Basic channel — a channel just meeting the 3002 basic limits on attenuation distortion and envelope delay distortion (primarily the EDD) will not be adequate to provide supportable error performance with DS 201B. The channel must meet C2 or C4 conditioning limits, as indicated above, for performance to be supported.

Note 2: Both the attenuation and delay sections of the compromise equalizer are contained in a single physical unit and are so arranged that the sections cannot be split.

BSP References: Data Set 201A and B-Types
590-002-100 — Reference Guide
592-011-100 — Description

C. Data Set 201C

Data Input and Output: Serial, synchronous

Bit Rate: 2400 bps

Type of Modulation: Differential 4-phase

Operating Frequencies:
MM = 2550-1350
MS = 1650-2850
SM = 2250-1050
SS = 750-1950

Transmit Level: 0 to −15 dBm adjustable in 1-dB steps (DDD)
0 dBm nominal (private line)

Maximum Receive Sensitivity: to −44 dBm (DDD)
−16 dBm ±7 dB (private line)

Input or Output Impedance: 900 ohms (DDD)
600 ohms (private line)

Attenuation and Delay Distortion Equalizer: A single compromise equalizer for both amplitude and distortion (equalizer should be installed in all applications using basic channels)

Recommended Conditioning: Basic channel (see note)

Note: The code sensitivity experienced with DS 201C is less than that of DS 201B. The degradation is most pronounced for a repeated 1010 pattern. Repetitions of any dibit codes which persist for less than 100 bits will not cause a serious performance degradation.

BSP References: Data Set 201C
592-029-100 — Description

D. Data Sets 202C-, D-, E-, and R-Types

Data Input and Output: Serial, nonsynchronous

Bit Rate: Up to 1800 bps

Type of Modulation: Frequency shift

Operating Frequencies:	DS 202C and D: M = 1200 S = 2200
M = Mark S = Space	DS 202E and R: M = 1300 S = 2100

Transmit Level: 0 to −12 dBm adjustable by potentiometer

Maximum Receive Sensitivity:	DS 202C and D:	−40 dBm
	DS 202R:	−42 dBm

Input or Output Impedances: 600 or 900 ohms (nominally 600 ohms for DS 202R)

Attenuation and Delay Distortion Equalizer: An amplitude equalizer and a delay equalizer are provided as an option in DS 202C and D

Maximum Attenuation Distortion Before Amplitude Equalizer In Set Is To Be Used: 3 dB 1200-2200 Hz (no equalizer in DS 202E and R)

Maximum Envelope Delay Distortion	500 μsec	1000-2600 Hz (no equalizer in DS 202E and R)
Before Delay Equalizer In Set Is	1500 μsec	600-2600 Hz
To Be Used:	3000 μsec	500-3000 Hz

Note: Either the attenuator or delay equalizer may be used separately or together as needed.

Recommended Conditioning:	0-1200 bps basic channel
	1200-1400 bps C1 conditioning
	1400-1800 bps C2 conditioning

BSP References:

Data Set 202C-Type
590-002-102 — Reference Guide
592-015-100 — Description

Data Set 202D-Type
590-002-103 — Reference Guide
592-016-100 — Description

Data Set 202E-Type
590-002-104 — Reference Guide
592-018-100 — Description

Data Set 202R-Type
590-002-108 — Reference Guide
592-025-100 — Description

E. Data Set 202T

Data Set Input and Output: Serial, nonsynchronous

Bit Rate: Up to 1800 bps

Type of Modulation: Frequency shift

Operating Frequencies: M = 1200
M = Mark S = Space S = 2200

Transmit Level: 0 dBm (nominal)

Maximum Receive Sensitivity: —16 ±7 dB

Input or Output Impedance: 600 ohms

Attenuation and Delay Distortion Equalizer: A single compromise equalizer for both amplitude and delay distortion (equalizer should be installed all the time)

Recommended Conditioning: 0-1400 bps basic channel
1400-1800 bps C2 conditioning

BSP References: Data Set 202T
592-031-100 — Description

F. **Data Sets 203A-, B-, and C-Types**

Data Input and Output: Serial, synchronous

Bit Rate: Speed option

	BIT RATE IN BPS		
LIST NO.	2-LEVEL	4-LEVEL	8-LEVEL*
2 and 4	2400	4800	7200
3	1800	3600	5400
5	3200	6400	9600
6	3600	7200	10,800
7	Provides a 150-bps auxiliary channel		

*May result in degraded performance. Refer to Section 592-019-100.

Type of Modulation: Vestigial sideband multilevel amplitude modulation (two, four, or eight levels)

Data Set Carrier and Pilot Frequencies (Hz):

LIST NO.	LOWER PILOT	CARRIER	UPPER PILOT
2	500	2300	2900
3	700	2200	2700
4	700	2300	2700
5	400	2400	2900
6	401	2543	2900

Auxiliary Channel Frequencies for List 7 (Hz):

MARK	SPACE	FREQUENCY SPECTRUM
450	375	300-525

Transmit Level: 0 to −15 dBm adjustable in 1-dB steps

Receive Sensitivity: −10 to −44 dBm

Input and Output Impedance: 600 or 900 ohms

Attenuation and Delay Distortion Equalizer: Adaptive, automatic equalizer

Recommended Conditioning: C2 conditioning for 4- or 8-level operation for all list options. This does not ensure successful operation. See * under Bit Rate table.

BSP References: Data Sets 203A-, B-, and C-types
590-002-107 — Reference Guide
592-019-100 — Description

G. **Data Sets 208A- and B-Types**

Data Input and Output: Serial, synchronous

Bit Rate: 4800 bps

Type of Modulation: Differential phase shift keying

Transmit Level: 208A (private line): 0 dBm nominal
208B (DDD): 0 to −15 dBm adjustable in 1-dB steps

Maximum Receive Sensitivity: 208A (private line): −16 dBm ±7 dB
208B (DDD): to −42 dBm

Input and Output Impedance: 208A: 600 ohms
208B: 900 ohms

Attenuation and Delay Distortion Equalizer: 208A: Choice of four compromise equalizer settings in addition to an adaptive automatic equalizer
208B: Compromise equalizer always in and an adaptive automatic equalizer

Recommended Conditioning: 208A: Basic channel

BSP References: Data Set 208A
590-002-110 — Reference Guide
592-027-100 — Description

Data Set 208B
592-030-100 — Description

H. Data Set 401J

Data Input and Output: Parallel, nonsynchronous receiver

Character Rate: 0 to 20 characters per second

Type of Modulation: 2 out of 8
3 out of 14

Operating Frequencies:

GROUP A	GROUP B	GROUP C
600-rest	1098-rest	1950-rest
697	1209	2050
770	1336	2150
852	1447	2250
941	1633	

Transmit Level: −3 to −12 dBm adjustable for answerback tones

Maximum Receive Sensitivity: −48 dBm for Groups A and B
−53 dBm for Group C

Input and Output Impedance: Nominal 900 ohms

Attenuation and Delay Distortion Equalizer: Not required

Recommended Conditioning: Basic channel

BSP References: Data Set 401J
590-004-103 — Reference Guide
594-018-100 — Description

I. Data Sets 402C- and D-Types

Data Input and Output: Parallel, nonsynchronous

Character Rate: Up to 75 characters per second

Type of Modulation: Frequency shifts in narrow bands

Operating Frequencies:
M = Mark S = Space

CHANNEL	MARK	SPACE
1	730	800
2	900	970
3	1070	1140
4	1240	1310
Timing	1410	1480
5	1580	1650
6	1750	1820
7	1920	1990
8	2090	2160

Transmit Level: −1 to −12 dBm total power adjustable

Receive Sensitivity: −9 to −39 dBm total power

Input and Output Impedance: 600 or 900 ohms

Attenuation and Delay Distortion Equalizer: None provided

Maximum Attenuation Distortion: 7 dB 1000-2100 Hz
3 dB 700-1000 Hz

Maximum Envelope Delay Distortion: 750-2200 Hz 1500 μsec

Recommended Conditioning: Basic channel

BSP References: Data Set 402C
590-004-104 — Reference Guide
594-019-100 — Description

Data Set 402D
590-004-105 — Reference Guide
594-020-100 — Description

J. Data Sets 403D- and E-Types

Data Input and Output: Parallel, nonsynchronous receiver

Character Rate: 0 to 10 characters per second

Type of Modulation: 2 out of 8

Operating Frequencies:

GROUP A	GROUP B
697	1209
770	1336
852	1477
941	1623

Transmit Level: −3 to −12 dBm adjustable for answerback tones

Receive Sensitivity: +2 to −39 dBm total power

Input and Output Impedances: 600 or 900 ohms

Attenuation and Delay Distortion Equalizer: Not required

Maximum Attenuation Distortion: 4 dB 1000-1600 Hz
3 dB 700-1000 Hz

Maximum Envelope Delay Distortion: 700-1600 Hz 2500 μsec

Recommended Conditioning: Basic channel

BSP References: Data Set 403D
590-004-106 — Reference Guide
594-025-100 — Description

Data Set 403E
594-026-100 — Description

K. **Data Set 407A**

Data Input and Output: Parallel, nonsynchronous receiver

Character Rate: 0 to 10 characters per second

Type of Modulation: 2 out of 8

Operating Frequencies:

GROUP A	GROUP B
697	1209
770	1336
852	1477
941	1623

Transmit Level: −3 dBm, −7 dBm, or −12 dBm, adjustable for answerback tones

Receive Sensitivity: 0 to −36 dBm total power

Input and Output Impedances: 600 or 900 ohms

Attenuation and Delay Distortion Equalizer: Not required

Maximum Attenuation Distortion: 4 dB 1000-1600 Hz
3 dB 700-1000 Hz

Maximum Envelope Delay Distortion: 700-1600 Hz 2500 μsec

Recommended Conditioning: Basic channel

BSP References: Data Set 407A
594-800-100 — Description

L. 1A Data Station

Data Input and Output: Serial, nonsynchronous

Channel Baud Rate: 0 to 75 bauds (single bandwidth channels)
0 to 150 bauds (double bandwidth channels)

Method of Operation: Frequency shift keying (FSK) in narrow bands for data channel operation. Alternate data/voice operation is not included.

Channel Capacity: 4-wire operation provides maximum channel capacity. See channels available with recommended conditioning.

Operating Frequencies (Hz):

SINGLE BANDWIDTH CHANNELS

CHAN NUMBER	SPACE	CENTER	MARK
1	390	425	460
2	560	595	630
3	730	765	800
4	900	935	970
5	1070	1105	1140
6	1240	1275	1310
7	1410	1445	1480
8	1580	1615	1650
9	1750	1785	1820
10	1920	1955	1990
11	2090	2125	2160
12	2260	2295	2330
13	2430	2465	2500
14	2600	2635	2670
15	2770	2805	2840
16	2940	2975	3010
17	3110	3145	3180

DOUBLE BANDWIDTH CHANNELS

CHAN NUMBER	SPACE	CENTER	MARK
21(57)	610	680	750
22(58)	950	1020	1090
23(51)	1290	1360	1430
24(52)	1630	1700	1770
25(53)	1970	2040	2110
26(54)	2310	2380	2450
27(55)	2650	2720	2790
28(56)	2990	3060	3130

Note 1: Center frequency transmitted only with ternary (binary plus supervision) operation.

Note 2: Dual numbering for double bandwidth channels is for those companies using the higher channel numbering assignments for existing 43A1 and 43B1 systems.

Transmit Level (dBm): Strap to deliver a maximum total composite system power of 0 dBm at a +13 TLP for the maximum number of channels anticipated. Refer to Section 591-813-101 for single channel power levels.

Receive Level (dBm): Maximum total composite system power of −16 dBm. Minimum per-channel level of −38 dBm required for 12-dB margin before carrier-fail operation.

Impedance: Transmit: 600 ohms
Receive: 600 ohms

Maximum Attenuation Distortion: Same as recommended grade of conditioning.

Maximum Envelope Delay Distortion: Same as recommended grade of conditioning.

Recommended Conditioning (2-Way Channels):

CONDITIONING	4-W CHANNEL CAPACITY		2-W CHANNEL CAPACITY	
	SW	DW	SW	DW
Basic	12	6	6	3
C1	14	6 (plus 2 SW)	7	3 (plus 1 SW)
C2	16	7 (plus 2 SW)	8	3 (plus 2 SW)
C4	17	8 (plus 1 SW)	8	4

Note: Single width (SW) and double width (DW) channels may be mixed. Two single width channels may electrically replace one equivalent bandwidth double width channel.

Channels Not Recommended With a Given Type of Conditioning:

TYPE OF CONDITIONING	CHANNEL NUMBER	
	SW	DW
Basic	1, 14, 15, 16, 17	27(55), 28(56)
C1	15, 16, 17	27(55), 28(56)
C2	17	28(56)
C4	—	—

BSP References: 1A Data Station
591-813-100 — Description

NOTES

VOICE BANDWIDTH PRIVATE LINE DATA CIRCUITS

END-TO-END TRANSMISSION PERFORMANCE

CONTENTS PAGE

1. GENERAL

1.01 This section provides examples of the estimation of end-to-end transmission performance based on sectional measurements of a 2-point service, or measurements of end links and midlinks. These measurements are discussed in Section 314-410-300. All the methods of combining discussed in this section apply to one direction of transmission. In general, the results of using these methods are approximations. Therefore, if the results are out of limits, actual end-to-end measurements must be made.

1.02 The information provided in this section was previously contained in Appendix B of Section 314-410-500.

2. ESTIMATION OF TRANSMISSION PERFORMANCE

2.01 This part provides examples of methods used in the estimation of overall circuit performance.

A. Attenuation Distortion

2.02 The sectional loss with respect to 1000 Hz measurements should be added algebraically for each frequency.

Note: Although test frequencies are shown here as precise multiples of 100 Hz, the actual test frequencies should be offset by 4 Hz (1004 Hz instead of 1000 Hz), due to level variations of as much as ±0.25 dB caused by the 8000-Hz sampling rate used on T carrier.

2.03 *Example:*

LOSS WITH RESPECT TO 1000 HZ (dB)

FREQUENCY* (HZ)	LINK A	LINK B	OVERALL
300	1.0	−0.3	0.7
500	0.8	−0.2	0.6
600	0.4	−0.2	0.2
800	0.2	−0.1	0.1
1000	0	0	0
1200	−0.1	−0.1	−0.2
1400	−0.1	0.1	0
1600	−0.2	0.2	0
1800	−0.1	0.2	0.1
2000	0	0.2	0.2
2200	0.1	0.1	0.2
2400	0.2	0	0.2
2500	0.3	0.1	0.4
2600	0.3	0.2	0.5
2700	0.5	0.4	0.9
2800	0.9	0.7	1.6
3000	1.3	1.4	2.7

* Refer to Table B of Section 314-410-500 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 1000 Hz between 500 to 2800 Hz = −0.2 dB
The maximum loss with respect to 1000 Hz between 500 to 2800 Hz = 1.6 dB
The minimum loss with respect to 1000 Hz between 300 to 3000 Hz = −0.2 dB
The maximum loss with respect to 1000 Hz between 300 to 3000 Hz = 2.7 dB

The overall attenuation distortion then is:

500-2800 Hz: −0.2 to +1.6 dB
300-3000 Hz: −0.2 to +2.7 dB

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

B. Envelope Delay Distortion

2.04 The sectional envelope delay measurements should be added algebraically for each frequency.

2.05 *Example:*

ENVELOPE DELAY (MICROSECONDS)

FREQUENCY (HZ)	LINK A	LINK B	OVERALL
500	410	380	790
600	320	270	590
800	180	170	350
1000	130	100	230
1200	80	50	130
1400	40	20	60
1600	20	0	20
1800	0	−30	−30
2000	15	−10	+5
2200	30	5	35
2400	70	30	100
2500	110	70	180
2600	160	120	280
2700	220	180	400
2800	290	260	550

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

The minimum envelope delay between 1000 and 2600 Hz = −30 μsec
The maximum envelope delay between 1000 and 2600 Hz = 280 μsec
The minimum envelope delay between 600 and 2600 Hz = −30 μsec
The maximum envelope delay between 600 and 2600 Hz = 590 μsec
The minimum envelope delay between 500 and 2800 Hz = −30 μsec
The maximum envelope delay between 500 and 2800 Hz = 790 μsec

The overall envelope delay distortion between 1000 and 2600 Hz = 280− (−30) = 310 μsec
The overall envelope delay distortion between 600 and 2600 Hz = 590− (−30) = 620 μsec
The overall envelope delay distortion between 500 and 2800 Hz = 790− (−30) = 820 μsec

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

C. C-Message Noise, C-Notched Noise, and Single Tone Interference

2.06 Combine the sectional measurements on a power basis using Table A.

2.07 *Example:* C-Message Noise

Link A 31 dBrnc0
Link B 36 dBrnc0

Difference between quantities = 36 − 31 = 5 dB
From Table A combining term = 1.2 dB
Add combining term to the higher number: 36 + 1.2 = 37.2

The overall noise should be 37 dBrnc0 (rounded off).

TABLE A

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

2.08 *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 3rd order harmonic distortion (commonly found on some short haul carrier systems), then the tone measurements will add on a voltage basis and Table B should be used. A harmonic or intermodulation distortion measurement is therefore recommended and should be made in conjunction with C-notched noise measurements.

D. Nonlinear Distortion (Harmonic Distortion)

2.09 Combine the sectional second order distortion measurements on a power basis using Table A. Combine the sectional third order distortion measurements on a voltage basis using Table B.

2.10 ***Example:***

	RATIO OF FUNDAMENTAL TO SECOND ORDER DISTORTION
Link A	35 dB
Link B	38 dB

Difference between quantities = 38 — 35 = 3 dB
From Table A combining term = 1.8 dB (power addition)
Subtract combining term from the lower number (representing the highest distortion) = 35 — 1.8 = 33.2 dB
The overall ratio of the fundamental to the second order distortion is 33 dB (rounded off).

	RATIO OF FUNDAMENTAL TO THIRD ORDER DISTORTION
Link A	37 dB
Link B	41 dB

Difference between quantities = 41 — 37 = 4 dB
From Table B combining term = 4.2 dB (voltage addition)
Subtract combining term from the lower number (representing the highest distortion) = 37 — 4.2 = 32.8 dB
The overall ratio of the fundamental to the third order distortion is 33 dB.

TABLE B

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

E. Phase Jitter

2.11 Table C may be used to add phase jitter measurements expressed in degrees.

2.12 *Example:*

Link A = 3°
Link B = 5°

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

TABLE C

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

F. Impulse Noise

2.13 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.

2.14 *Example:*

Link A = 5 counts
Link B = 2 counts
Overall = 7 counts

G. Frequency Shift

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

2.16 *Example:*

Link A = +1 Hz
Link B = –2 Hz
Overall = –1 Hz

3. MAXIMUM POWER PER TONE IN MULTICHANNEL MODEMS

3.01 In the case of multichannel modems, it may become necessary to determine the level to which each tone should be adjusted, to ensure the total output power of the modem will not exceed —13 dBm0. If equal-level tones are used, the output of any single tone with reference to 0 TLP (relative power) should not exceed —13 — 10 log (number of channels). Logarithms to the base 10 are given in Table D for from two to thirty channels.

3.02 *Example of Test:* A modem that will use a maximum of four equal-level tones is to be connected to a Telco channel. The relative power permitted per tone is as follows:
Relative power per tone = —13 — 10 log (4)
Log 4 from Table D = .602
Relative power per tone = —13 — 10 (.602) = —13 — 6.02 = — 19.02 dBm

Note: The power of each tone at the standard transmit modem interface (+13 TLP) may be determined by adding the relative power per tone to the TLP value where measured as follows:

—19.02 + 13 = —6.02 dBm

TABLE D

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		

NOTES

VOICE BANDWIDTH PRIVATE LINE DATA CIRCUITS

OVERSEAS CIRCUITS

1. GENERAL

1.01 This section provides information on overseas circuits.

1.02 The information provided in this section was previously contained in Appendix C of Section 314-410-500.

1.03 Overseas circuits may be provided wholly by the Bell System or in conjunction with an international carrier.

1.04 If any overseas point-to-point data channel is provided in its entirety under FCC Tariff No. 260, the same conditioning limits must be met for this 2-point service as are specified for the type of service ordered. C4 conditioning limits can be met only if satellite facilities or cable carrier channels of normal 4-kHz bandwidth are used in the overseas portion of the circuit.

1.05 For overseas data services provided in conjunction with an international record carrier (IRC), the IRC is responsible for the end-to-end transmission characteristics. This means if mop-up equalization is required, the IRC will provide it. The Bell System is responsible only for the sections it provides, and should test to the limits specified in this section.

1.06 A typical example of an overseas circuit section is shown in Fig. 1. Circuit sections between the IRC gateway and the ground station or cable head are provided to the IRC, and are ordered and provided in only one of two ways:

(a) Basic overseas channels should be maintained to the same specifications as other 2-point basic channels.

(b) All types of conditioned channels should be maintained to the specifications listed in Table A.

1.07 The following applies to circuit sections between the continental U.S. (CONUS) terminal and the IRC gateway:

(a) C1 conditioned channels arranged for switching and C2 channels should be maintained so as to meet the limits given in Table A.

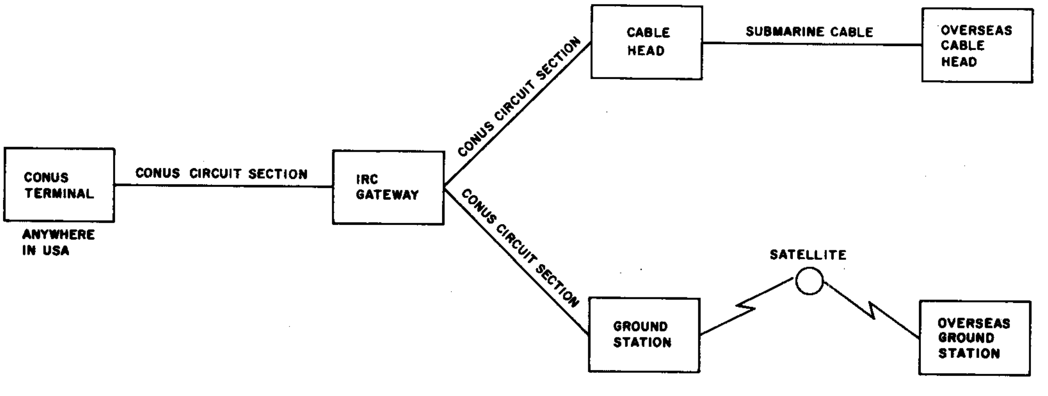


Fig. 1—Overseas Circuit Sections

TABLE A

CONDITIONING REQUIREMENTS FOR OVERSEAS CIRCUITS

CONUS TO INTERNATIONAL CARRIER'S GATEWAY	
C1 Conditioned Channel Arranged for Switching	
Loss-Frequency Response*	
1000 — 2400 Hz	−0.6 to +1.7 dB
300 — 2700 Hz	−1.2 to +3.5 dB
300 — 3000 Hz	−1.7 to +7.0 dB
Envelope Delay Distortion	
1000 — 2400 Hz	370 microseconds
800 — 2600 Hz	640 microseconds
C2 Conditioned Channel	
Loss-Frequency Response*	
500 — 2800 Hz	−0.6 to +1.7 dB
300 — 3000 Hz	−1.2 to +3.5 dB
Envelope Delay Distortion	
1000 — 2600 Hz	185 microseconds
600 — 2600 Hz	550 microseconds
500 — 2800 Hz	1100 microseconds
INTERNATIONAL CARRIER'S GATEWAY TO GROUND STATION OR CABLE HEAD	
For Either of Above Types of Circuit	
Loss-Frequency Response*	
500 — 2800 Hz	−0.5 to +1.5 dB
300 — 3000 Hz	−0.8 to +3.0 dB
Envelope Delay Distortion	
1000 — 2600 Hz	110 microseconds
600 — 2600 Hz	300 microseconds
500 — 2800 Hz	650 microseconds

* Referred to 1000 Hz
(+) is more loss; (−) is less loss

(b) Other channels, including those ordered without conditioning, and those ordered as C1 not arranged for switching, should be maintained to the grade of service ordered as though they were 2-point services terminating at the IRC gateway.

1.08 If the overseas circuit is part of a multipoint or central office relay switched configuration, the customer should be made aware that the station-to-station conditioning response may not be met from many of the CONUS locations to the overseas station. This is because the transmission objectives for multipoint or central office relay switched arrangements are subdivided portions of the overall requirements, and to further subdivide these requirements between CONUS and overseas is not technically feasible.

VOICE BANDWIDTH PRIVATE LINE DATA CIRCUITS
CIRCUIT CONDITIONING REQUIREMENTS
USING THE COLLINS CLA-101A SYSTEM

1. GENERAL

1.01 This section provides attenuation distortion and envelope delay distortion requirements for voice bandwidth private line data channels when tests are performed using the Collins CLA-101A system.

1.02 The CLA-101A 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-101A system test equipment. This difference is due to the different test frequencies that are used. Limits have been developed for attenuation distortion and envelope delay distortion at the CLA-101A frequencies that will give reasonable assurance that the channel conditioning requirements are met within the specified frequency bands.

1.03 The limits for attenuation distortion and envelope delay distortion are given in Tables A and B of this section. These tables should be substituted for the attenuation distortion and envelope delay distortion requirements given in Section 314-410-500 when the Collins CLA-101A system is used to perform these tests. Table C provides the limits for overseas circuits.

1.04 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.

1.05 The Collins CLA-101A 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.

1.06 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-101A 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.

TABLE A

PRIVATE LINE VOICE BANDWIDTH CIRCUIT ATTENUATION DISTORTION REQUIREMENTS (dB) USING COLLINS CLA-101A SYSTEM

FREQUENCY RANGE IN HZ	2-POINT	0	1		2		3		4	
		MID LINK	MID LINK		MID LINKS		MID LINKS		MID LINKS	
		END LINK	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)
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
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 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 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	(C5)									
500-2750	−0.5 to +1.3									
250-3000	−1 to +3									

( ) Figures in parentheses are classification codes which may be found on some CLRCs 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.

TABLE B

PRIVATE LINE VOICE BANDWIDTH CIRCUIT ENVELOPE DELAY REQUIREMENTS (MICROSECONDS)
USING COLLINS CLA-101A SYSTEM

FREQUENCY RANGE IN HZ	2 POINT	0	1		2		3		4	
		MID LINK	MID LINK		MID LINKS		MID LINKS		MID LINKS	
		END LINK	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	(C5)									
1000-2500	90									
750-2750	240									
500-2750	530									

( ) Figures in parentheses are classification codes which may be found on some CLRCs 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.

TABLE C

CONDITIONING REQUIREMENTS FOR OVERSEAS CIRCUITS
USING COLLINS CLA-101A SYSTEM

CONUS TO INTERNATIONAL CARRIER'S GATEWAY	
C1 Conditioned Channel Arranged for Switching	
Loss-Frequency Response*	
1000-2500 Hz	−0.6 to +1.7 dB
250-2750 Hz	−1.2 to +3.5 dB
250-3000 Hz	−1.7 to +7.0 dB
Envelope Delay Distortion	
1000-2500 Hz	370 microseconds
750-2750 Hz	710 microseconds
C2 Conditioned Channel	
Loss-Frequency Response*	
500-2750 Hz	−0.5 to +1.6 dB
250-3000 Hz	−1.2 to +3.5 dB
Envelope Delay Distortion	
1000-2750 Hz	185 microseconds
750-2750 Hz	475 microseconds
500-2750 Hz	1000 microseconds
INTERNATIONAL CARRIER'S GATEWAY TO GROUND STATION OR CABLE HEAD	
For Either of Above Types of Circuit	
Loss-Frequency Response*	
500-2750 Hz	−0.5 to +1.4 dB
250-3000 Hz	−0.8 to +3.0 dB
Envelope Delay Distortion	
1000-2500 Hz	100 microseconds
750-2750 Hz	250 microseconds
500-2750 Hz	600 microseconds

* Referred to 1000 Hz

(+) is more loss; (−) is less loss.

CHANGE NOTICE

314-410-105

AT&T letter EL2978/PL2774 indicates that the title previously assigned as "HIGH PERFORMANCE DATA OPTION (HPDO)" has been changed to "HIGH PERFORMANCE DATA CONDITIONING (HPDC)".

To accommodate this change and to meet publication schedules, the title of the section shown in this handbook has been changed to "HIGH PERFORMANCE DATA CONDITIONING". References to **HPDO** in the text have been modified to read **HPDC.**

VOICE BANDWIDTH PRIVATE LINE DATA CIRCUITS TYPE D1 - HIGH PERFORMANCE DATA CONDITIONING (HPDC) DESCRIPTION AND TEST REQUIREMENTS

CONTENTS PAGE

1. GENERAL

1.01 This section provides information on maintenance considerations and testing policy to be used when providing service on voice bandwidth private line data circuits ordered with the ***H***igh ***P***erformance ***D***ata **Conditioning**. These circuits may be identified by the Universal Service Order Code (USOC) QHA.

1.02 A HPDC channel may be necessary when more stringent control over nonlinear distortion and C-notched noise is required in order to support high speed data transmission.

1.03 The HPDC design is furnished only on 2-point (not multipoint) 3002-type channels. It may be provided on 3002 alternate voice data arrangements; however, voice performance may be degraded due to the possible removal of the N or ON carrier compandored channel units. It should not be provided on transfer arrangements such as alternate night use of a PBX tie trunk, because the degraded performance due to noise is not acceptable for this type operation.

1.04 The HPDC design may be furnished on basic 3002-type or C1, C2, C4, or C5 conditioned channels. The available combinations are shown in Table A.

1.05 The policies, methods, and requirements specified in Sections 314-410-100, -101, -102, -103, -104, -300, and -500 apply to all HPDC private line data circuits unless stated otherwise in this section.

TABLE A

CIRCUIT DESIGN AND CONDITIONING COMBINATIONS

CIRCUIT DESIGN	CONDITIONING				
	BASIC	C1	C2	C4	C5
2-Point Standard	A	A	A	A	A
2-Point HPDC	A	A	A	A	A
Multipoint Standard	A	A	A	R	NA
Multipoint HPDC	NA	NA	NA	NA	NA

A—Available

R—Restricted to 3- or 4-point operation. Refer to Section 314-410-100.

NA—Not Available

2. MEASUREMENT TESTS

2.01 The required transmission tests given in Table C of Section 314-410-300 specify the circuit order, routine, and trouble tests that are required on private line data circuits. When using that table, all HPDC circuits should be considered as terminating in type 3 data sets. The C-notched noise and nonlinear distortion requirements for HPDC circuits are tariff requirements and must be met.

2.02 End-to-end measurements of HPDC circuits are preferred in all cases and should be performed if service conditions permit. If all carrier channels assigned to the circuit are located between the serving test centers (STCs) at each end of the circuit, measurement tests of C-notched noise, nonlinear distortion, and phase jitter may be made between the STCs instead of at the customer station. The end-to-end requirements for these parameters should be met at the STC.

2.03 C-notched noise measurements may be made with a C-message noise test set when compandored facilities are not used. (N or ON carrier channels equipped with special service channel units or VF amplifiers are considered as noncompandored channels.) In this case make a C-message noise measurement with and without a 1004-Hz holding tone applied at data level. The test tone to C-notched noise ratio is determined as follows:

C-notched noise = C-message noise measured with holding tone minus the C-message noise measured without the holding tone.

Example: C-message noise with holding tone = 75 dBrnc

C-message noise without the holding tone = 29 dB

Note: This method will give misleading results when used on T carrier channels or N or ON carrier channels equipped with compandored channel units.

2.04 The measurement tests of attenuation distortion, envelope delay distortion, C-message noise, and impulse noise must be made at the customer station. Sectional measurements of these parameters are permitted on basic (nonconditioned) HPDC channels only. Sectional measurements of these parameters made entirely with the Collins CLA-101A system are permitted on C-conditioned HPDC channels also. End-to-end measurements are required in all cases where the customer is not satisfied and the need for technical escalation is indicated.

2.05 For the purpose of estimating end-to-end performance from sectional measurements, a 2-point circuit should be divided into only two sections. One section should normally be from the control STC to its station and the other section should be from the same 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 314-410-102.

Note: If sectional measurements are permitted and are made partly with the Collins CLA-101A and partly with other test equipment, the static measurements should be made using the CLA-101A frequencies where possible.

3. TEST REQUIREMENTS

3.01 All of the transmission requirements specified in Section 314-410-500 apply to the HPDC designed channel, with the exception of the C-message noise, C-notched noise or nonlinear distortion (harmonic distortion) requirements. The requirements for these parameters are as follows:

C-Notched Noise

Ratio of the received 1004-Hz test tone power to the C-notched noise power: 28 dB

Nonlinear Distortion (Four Tone Method)

Ratio of fundamental to second order products: 35 dB

Ratio of fundamental to third order product: 40 dB

Note: If this test capability for measuring nonlinear distortion is not available, the following limits for harmonic distortion may be substituted.

Harmonic Distortion

Ratio of fundamental to second harmonic: 35 dB

Ratio of fundamental to third harmonic: 42 dB

C-Message Noise

Circuits using N or ON carrier with special service channel units or VF amplifiers; all mileage bands: 49 dBrnc0

Circuits ***not*** using N or ON carrier with special service channel units or VF amplifiers; all mileage bands: Use C-message noise limits given in Section 314-410-500.

3.02 A channel that fails to meet the preceding requirements cannot be designated as a HPDC channel. Refer this problem to the responsible circuit design engineer.

4. FACILITY CONSIDERATIONS

4.01 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.

4.02 Careful selection of facilities is necessary in order to meet the strict C-notched noise and nonlinear distortion requirements for HPDC circuits. LMX channels and metallic facilities are preferred. When a choice is available, select T carrier equipped with D1D, D2, or D3 channel banks.

4.03 If N2, N3, or ON carrier must be used, VF amplifiers will generally be required. Enhanced levels should be used on N2 channel as specified in Section 362-800-510. N1 carrier and T carrier equipped with D1A or D1B channel banks normally will not be used.

4.04 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 pair of channel banks.

4.05 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 nonlinear 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 nonlinear distortion requirements can be easily met, it may be worthwhile to try compandored channel units as a means of improving the noise performance. The nonlinear distortion test must be repeated after making this equipment substitution to ensure that it is still within limits.

4.06 The facility C-notched noise and nonlinear 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. REFERENCES

5.01 The following sections provide additional information on facilities and equipment that may be associated with HPDC channels.

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 Circuits
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
362-800-510	Type N2 Carrier Telephone System—Voice Amplifier J99272B (STD), J99272AA (MD), and J99272BA (MD)—Through Channel Connector J99272CA—Transmitting and Receiving

NOTES

VOICE BANDWIDTH PRIVATE LINE DATA CIRCUITS

MAINTENANCE

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LIST OF TABLES AND FIGURES

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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 10,800 bits per second).

1.02 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 every 6 months and are a part of every trouble report involving a CPM.

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 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. C5 conditioning can be ordered only on 2-point circuits. Some C5 circuits have more than one station per exchange, but only one can be connected at a time. A given station may communicate only with a particular designated station in the distant exchange. No trouble report will be accepted nor testing done for combinations of stations other than those specified by the service order.

2.03 The minimum conditions under which end-to-end measurements are required are given in Table A. End-to-end measurements are preferred in all cases and should be performed if service conditions permit. Sectional measurements made with the Collins CLA-101A system are considered equivalent to end-to-end measurements in conjunction with the minimum conditions given in Table A. End-to-end measurements are required in all cases where the customer is not satisfied and/or the need for technical escalation is indicated.

TABLE A

CONDITIONS UNDER WHICH END-TO-END CIRCUIT ORDER ATTENUATION DISTORTION AND ENVELOPE DELAY DISTORTION MEASUREMENTS ARE REQUIRED ON 2-POINT CIRCUITS

CONDITIONING	DATA SET TYPE		
	1	2	3
Basic	No	No	No
C1	No	No	Yes
C2	No	Yes	Yes
C4	Yes	Yes	Yes
C5	Yes	Yes	Yes

2.04 For the purpose of estimating end-to-end performance from sectional measurements, a 2-point circuit should be divided into only two sections. One section should normally be from the control STC to its station and the other section should be from the same 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 314-410-102.

Note: If sectional measurements are permitted as given in Table A and are made partly with the Collins CLA-101A and partly with other test equipment, the static measurements should be made using the CLA-101A frequencies where possible.

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 circuit layout record card (CLRC).

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 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 and the data set is customer-provided, 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; however, no overall conditioning can be guaranteed.

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.

2.13 The end-to-end facility parameter must be met on each individual channel. However, it is often not possible nor is it 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 TLP. Figure 1 illustrates a typical 4-wire data set circuit design at a customer location using DAS 828A or equivalent. In this case the test access points would be at the point where the data set is connected to the circuit. This point has been chosen because it is a fixed 600-ohm point and terminated measurements can be made (with the data set disconnected from the circuit) which include all the pads and amplifiers at the station.

2.15 If DAS 828A is used at the station, an alternate test point may be considered. This would be the AMP IN jack looking toward the central office and the AMP OUT jack looking from the central office. Measurements at these points are made on a terminated basis at a 600-ohm impedance.

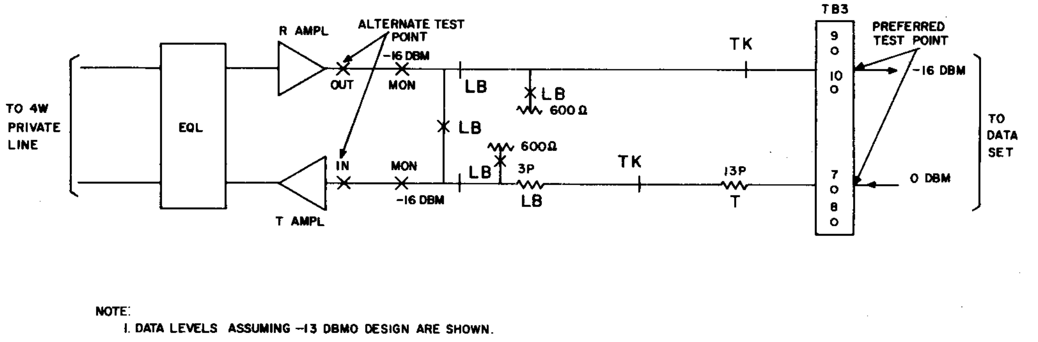


Fig. 1—Standard Circuit Design for Data Only, 4-Wire Data Set

> ***Note:*** The station loss between this point and the connection to the data set must be tested before this test access point is used. This 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.

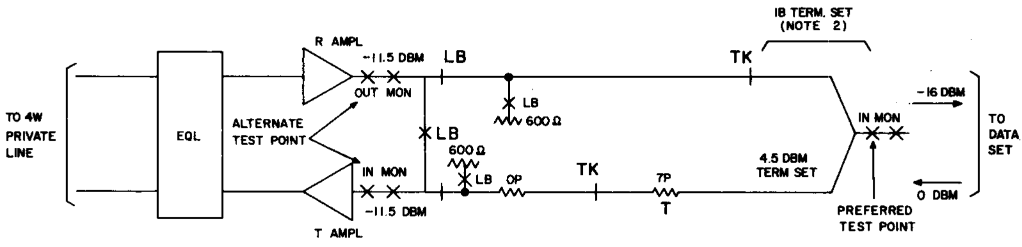
2.16 When making transmission measurements at the station, DAS 828A is considered to be part of the channel facilities and tests are to be made through it.

2.17 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. If the data set is connected directly to the cable pair, the test equipment should be connected at the same point with the data set temporarily disconnected. The test equipment should be set to make measurements in a 600-ohm terminated mode unless the circuit layout record card (CLRC) 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 insertion loss characteristics of the circuit with which the data set (which should also be 600 ohms) is designed to work.

2.18 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. In the case of DAS 828A, this would correspond to the 2-WIRE IN jack. Measurements are made on a 600-ohms terminated basis unless the CLRC specifies some other impedance.

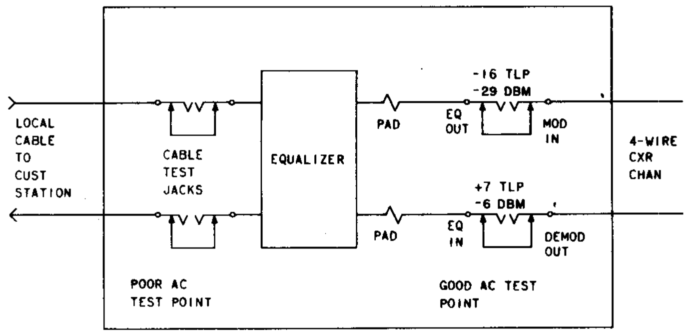
2.19 Figure 3 illustrates a 4-wire circuit at a typical serving test center. Measurements should be made at a point where the impedance is known to be 600 ohms rather than looking directly at the cable pair. An excellent measuring point is the VF jacks or equivalent private line testboard jacks associated with a 4-wire carrier channel.

2.20 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.



NOTES:
1. DATA LEVELS ASSUMING -13 DBM O DESIGN ARE SHOWN.
2. S1 SCREW AND COMP NET SCREW MUST BE DOWN IN ALL CASES.

Fig. 2—Standard Circuit Design for Data Only, 2-Wire Data Set



NOTE: POWER SHOWN IN DBM IS AT DATA LEVEL.

Fig. 3—Test Access Points on 4-Wire Circuit at Typical STC Office

3. TESTING POLICY

A. Required Channel Transmission Tests

3.01 Table B shows the three basic types of data sets used for voiceband data service. The general classifications are used to determine the degree of initial testing required. Table C is used to determine the specific parameter that should be measured for the circuit order, routine, or initial trouble tests.

3.02 Table C is arranged to reduce the number of tests required to verify that the channel meets critical requirements for the ordered service. This minimizes the testing of some parameters to which the data set is not particularly sensitive, or which are likely to be within limits as specified in this section.

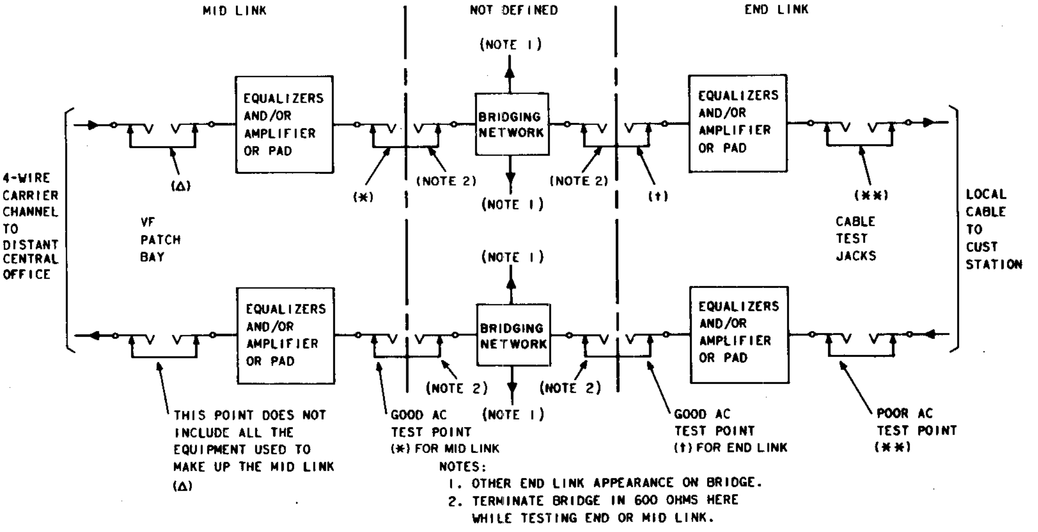


Fig. 4—Test Access Points on 4-Wire Multipoint Circuit at Bridge Location

TABLE B

TYPE LISTING OF DATA SETS BY BIT RATE SPEED

TYPE 1	TYPE 2	TYPE 3
Generally low speed (below 300 bps) Bell System analog or digital serial and parallel sets: 100 Series 401-type 403 407 601 603	Generally medium speed analog or digital serial and parallel sets: 201-type 202-type 205 207 402 602 All CP modems operating at 2400 bps or below	203-, 208-, 209- type All CP modems operating above 2400 bps

TABLE C

REQUIRED TRANSMISSION TESTS FOR MAINTENANCE PROCEDURES

TRANSMISSION TEST	CIRCUIT ORDER TEST			ROUTINE TEST			INITIAL TROUBLE REPORT TEST		
	DATA SET TYPE			DATA SET TYPE			DATA SET TYPE		
	1	2	3	1	2	3	1	2	3
NET LOSS	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes
MESSAGE CIRCUIT NOISE	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes
C-NOTCHED NOISE	No	No	Yes	No	No	No	(5)	(5)	Yes
IMPULSE NOISE	No	Yes	Yes	No	No	No	Yes	Yes	Yes
TOTAL POWER OUTPUT (8)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FREQUENCY RESPONSE	(1)	(1)	Yes	No	No	No	(5)	Yes	Yes
ENVELOPE DELAY	(1)	(1)	Yes	No	No	No	(5)	Yes	Yes
SINGING MARGIN/RETURN LOSS	(7)	(7)	(7)	No	No	No	(5)	(5)	(5)
FREQUENCY SHIFT	No	No	No	No	No	No	(5)	(5)	(5)
PHASE JITTER (2)	No	No	Yes	No	No	No	(5)	(5)	Yes
NONLINEAR DISTORTION (3)	No	No	Yes	No	No	No	Yes	Yes	Yes
DC LOOP RESISTANCE	Yes	Yes	Yes	No	No	No	(4)	(4)	(4)
SINGLE TONE INTERFERENCE (6)	Yes	Yes	Yes	No	No	No	(5)	(5)	(5)

( ) Numbers in parentheses refer to the following notes.

(1) If conditioning (C1, C2, C4, or C5) or a multipoint circuit has been ordered, a frequency response and envelope delay distortion measurement must be made. If a basic (not C-conditioned) 2-point (not multipoint) channel is ordered, the following policy applies:

Type 1 Data Sets — Frequency response and envelope delay distortion measurements are not required.

Type 2 Data Sets — Measure the loss deviation of the channel at 3000 Hz as compared to 1000 Hz. The measurement should be within the limits of Table C in Section 314-410-500. If not, equalize and make frequency response and envelope delay measurements over the entire frequency band using the measurement frequencies given in Table C of Section 314-410-500. The limits are specified in Tables D and E of Section 314-410-500.

Type 3 Data Sets — A frequency response and envelope delay distortion measurement must be made using the measurement frequencies given in Table C of Section 314-410-500. The limits are specified in Tables D and E of Section 314-410-500.

(2) This measurement required if LMX carrier facilities make up part of the circuit.

(3) This measurement required only if D1A or B channel banks (used on T1 carrier, for example) or N or ON carrier make up part of the circuit.

(4) The dc loop resistance measurement is required if loss measurements are out of limits between the customer station and the STC.

(5) This test required after repeated trouble reports have been received and the source of the problem cannot be determined.

(6) A listening test for single tone interference will normally be sufficient.

(7) Required to 2-wire data station if the circuit is 4-wire at any point.

(8) Refer to Part 3G for total power output test policy and intervals.

B. Testing Circuits Terminating in Telco-Provided Modems

3.03 When the modem (data set) is provided by Telco and the conditions specified in Table D are met, the following testing policy applies:

(1) Measure and meet the requirements for 1000-Hz loss, attenuation distortion, and envelope delay distortion.

(2) Make error performance test specified in the 59X Division for each modem with the modem output power reduced 3 dB below normal (−16 dBm0 or 3 dB below data level).

(3a) If normal error performance requirements are met, no further installation tests are necessary.

(3b) If normal error performace requirements are not met, perform additional circuit order installation tests as specified in Table C and meet all reqirements.

(4) After all transmission requirements in (3b) are met, repeat the error performance tests with the modem output power at data level (−13 dBm0). If the error performance requirements specified in the 59X Division for each modem are met, no further tests are required.

> ***Note:*** The modem power output may be reduced by 3 dB by double terminating. To do this, connect a 600-ohm termination or the input of a 600-ohm test set to the EQ OUT jack (looking from the data set) of DAS 828A. Error performance tests at a reduced output power help to determine the margin of the modem against noise and impulse noise.

3.04 When the modem is provided by Telco but the conditons specified in Table D are not met, the following testing policy applies:

(1) Measure and meet the requirements for each of the transmission tests specified in Table C.

(2) The modems should be tested and maintained to their requirements given in the appropriate section (590—596 Divisions).

3.05 Although the modem error performance may be satisfactory, it is possible that other interface requirements may not be met by the modem. For example, the modem receive clock may be momentarily out of synchronization in starting up a polling-type system. If error tests are satisfactory but the customer is still experiencing trouble, the problem should be referred immediately via established procedure to a DATEC representative. Procedures for obtaining data technical support are covered in 3.24.

3.06 If the customer has ordered a 2-point conditioned channel, it is a tariff requirement to meet the conditioning requirements (attenuation distortion and envelope delay distortion), regardless of the satisfactory error performance of the Bell System modem. In addition, if alternate voice service is ordered, the message circuit noise limits must also be met before the channel is placed in service, regardless of the error performance of the modem. All other transmission parameter requirements are provided to serve as a guide for troubleshooting in the event that error performance tests are not made. On multipoint circuits it may be difficult to make error performance tests between all modems; therefore, transmission parameter requirements should be met on all end links and midlinks.

C. Testing Circuits Terminating in Customer-Provided Modems

3.07 If a customer-provided modem (CPM) terminates the channel, normal Bell System testing is restricted to channel-only tests. ***Do not test any customer-provided equipment (CPE)*.*** This includes cases where Bell System equipment is on both sides of CP equipment; the Bell System equipment must be tested separately rather than through the CPE. The channel limits specified in this section must be met.

*Joint tests of CPE are permitted only if Bell System data technical support personnel request such tests.

3.08 After circuit order tests given in Table C have been made, any trouble condition is corrected, and the CPM has begun operation on the channel, the customer may complain of a high error rate which he believes is due to the channel. The initial trouble measurements specified in Table C should then be made on an end-to-end basis even though the Bell System does not guarantee any error rate when a CPM is used. All transmission tests must be performed if recurring trouble reports

TABLE D

CIRCUIT TYPES WHERE TELCO MODEMS ARE USED AND ERROR RATES ARE MAINTAINED

TYPE OF CIRCUIT	ERROR RATE MAINTAINED
Private Line	
Recommended channel*	Yes
Lower grade than recommended	No
Access to Switched Telecommunications Network from PBX or Centrex	
From on-premises station	Yes
From off-premises station	No†
Connection to Switched Telecommunications Network from Private Line	
Network (via PBX, Centrex, etc)	No†

*Where more than two circuits are to be switched together, the combined circuits must meet the recommended grade of channel. Interconnecting a series of point-to-point channels, each having the recommended grade of conditioning, will not necessarily result in an overall circuit meeting the recommended grade of channel conditioning. Where switching arrangements are desired, the channel conditioning must be ordered and billed as switched under F.C.C. Tariff No. 260 or similar intrastate tariff. Refer to Section 314-410-101 for data set channel conditioning requirements.

†Low speed (below 300 bps) and limited distance high speed may be successful, but no performance is specified.

are received. However, repeated reports of high error rates with a CPM after the chanel has been verified to be within limits should not result in the channel being measured repeatedly. Such cases may require data technical (DATEC) assistance referred to in 3.24.

3.09 If a channel-only service with a CPM has operated satisfactorily for an extended period of time (several weeks) and the customer complains of high error rates which he attributes to the telco channel, the initial trouble measurements should be made as given in 3.12 through 3.21.

3.10 Channel measurements are made in the cases mentioned in 3.08 and 3.09, since the customer will usually know only that he has a high error rate and in these instances this may well be due to a channel problem. The customer should have tested his own equipment first. The customer should not be required to specify which transmission parameter is out of limits for such initial trouble reports. However, on a complex trouble investigation where Bell System channels have been measured and are meeting limits and the customer calls in the technical support people representing the manufacturer or maintenance organization responsible for the data set, more definitive trouble reports may be expected.

3.11 If the channel is within all specified limits when measured following a customer complaint and repair personnel have been dispatched to the customer location, the supervisor should be notified, since a service charge may be applied.

D. Loop-Back Tests

3.12 The loop-back tests given in Table E should be performed for purposes of trouble sectionalization on 4-wire facilities from the STC with the circuit looped back at the customer station. Before operating the loop-back arrangement at the customer station, the transmit leg from the customer station should 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.

3.13 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, it may be necessary to apply sealing current to the circuit.

E. Interexchange and Midlink Tests

3.14 The initial trouble report tests given in Table C 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.

F. End-to-End Trouble Tests

3.15 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.

3.16 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.

3.17 It is not necessary to make all end-to-end transmission tests at the customer station 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 station.

3.18 When the modems (data sets) are provided by Telco and the conditions specified in Table D are met, error performance tests should be made between the appropriate modems. If error runs are unsatisfactory, the initial trouble report transmission tests should be performed in order to sectionalize the trouble. Trouble tests should be continued only until satisfactory error runs are obtained.

3.19 As soon as satisfactory error runs are obtained, the customer should be asked to determine whether his equipment is performing satisfactorily. If not, the customer should be asked to perform extensive trouble tests on the CPE. If no problems can be found in the CPE, follow the procedures in 3.05 of this section.

3.20 When the modems are provided by Telco but the conditions in Table D are not met, it may still be useful to make error performance tests between the appropriate modems. If the error runs are satisfactory, transmission tests will not be required. Instead, the procedures given in 3.19 may be followed.

3.21 If the error performance tests are unsatisfactory, the modems should be tested and maintained to their requirements given in the appropriate section (590-596 Divisions). In addition, the initial trouble report tests specified in Table C should be made at this time. There is no requirement to obtain satisfactory error performance when the conditions in Table D are not met and the Telco-provided modems and channel meet specifications.

TABLE E

SUGGESTED LOOP-BACK TROUBLE TESTS (STC-TO-STA)

MAINTENANCE TEST	DATA SET TYPE		
	1	2	3
NET LOSS	Yes	Yes	Yes
MESSAGE CIRCUIT NOISE	Yes	Yes	Yes
IMPULSE NOISE	No	No	Yes
NONLINEAR DISTORTION	No	No	Yes (1)
C-NOTCHED NOISE	No	No	Yes (1) (2)
TOTAL POWER OUTPUT	Yes (2)	Yes (2)	Yes (2)

( ) Numbers in parentheses refer to the following notes.

(1) This measurement required only if N, ON, or T carrier. Compandored channels make up part of the local channel.

(2) Remove the loop-back condition and connect the data set transmitter to the line.

3.22 When the modem is provided by the customer, the intial trouble report tests specified in Table C should be made and any troubles found cleared.

3.23 If the initial trouble report tests specified in Table C are made and the limits met but the customer's problem is not cleared, or if recurring trouble reports are received, it will be necessary to verify that all transmission parameters are met. The customer should be advised that considerable circuit turndown time may be required to make a complete set of measurements.

3.24 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 conditon should be referred immediately upon receipt of the third trouble report within a 2-month period.

(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.

3.25 Refer to Section 010-521-100 for guidelines regarding data technical support.

G. Routine Tests

3.26 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 inital 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. No further total power output routine tests are necessary if the power is not excessive on the first routine test or on subsequent trouble tests. If the total output power is excessive, action should be taken to bring it within limits, and further total output power routine tests should be made at 6-month intervals until the limits are met for two consecutive tests. Repeated failures to keep the total output power from exceeding Telco specifications may require one of the following:

(a) The addition of limiting amplifiers to the channel in order to prevent possible deterioration of service to other customers.

(b) The suspension of the customer's service on a specified date (10 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, disconnect the device, or allow installation of a signal limiting device.

H. Parallel Tests

3.27 Parallel testing is the simultaneous testing of several channels of the same carrier system or group during a customer data run or error performance test. This type of testing assists in locating objectionable facility time-varying parameters such as phase jitter, impulse noise, dropouts, frequency shift, phase hits, and gain hits. The test sets on the adjacent (parallel) channels are observed for fluctuations (or other indications such as counts) that occur at the same time that data errors are noted. A high level of coincidence indicates that the facility being tested is the probable offender.

4. USE OF FORM E-5596

4.01 The tests to be performed are given in Table C. These measurements should be made and the results recorded on Form E-5596. A separate Form E-5596 will be required for recording benchmark loop-back measurements at the STC. Enter the term LOOP-BACK under entry 2 as described in 4.02. Note that the circuit mileage is doubled when loop-back tests are made for purposes of determining message circuit noise and impulse noise requirements.

4.02 The following is an explanation of entries for Form E-5596 (Fig. 5).

1. Enter circuit number.
2. Enter appropriate link or section of circuit if straightaway measurements are recorded. Also, use this space to indicate loop-back test results.
3. Enter date of test.
4. Enter circuit order number.
5. Enter results for gain-frequency and envelope delay distortion measurements made for circuit order or trouble tests.
6. Enter frequency shift measurements as required.
7. Enter phase jitter measurements as required.
8. Enter single tone interference measurements as required. Also enter the approximate frequency of the tone.
9. Enter harmonic distortion measurements as required.
10. Enter C-notched noise test results as required.
11. Enter return loss measurements as required.
12. Enter dc loop resistance test measurements as required.

13. Enter the total power.

14. Enter the 1000-Hz loss measurement.

15. Enter the noise measurement.

16. Enter the impulse noise measurement.

17. Enter the P/AR measurement.

18. Enter routine measurements of total power and any others as required by local practices. The total power measurement is a high-impedance level measurement.

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.	(5) TR (INITIAL)		(5) REC (INITIAL)		(5) TR		(5) REC		(5) TR		(5) REC	
(4)	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

TESTS AND REQUIREMENTS

CONTENTS PAGE

LIST OF TABLES AND FIGURES

CONTENTS PAGE

1. GENERAL

1.01 This section describes the routine, circuit order, and maintenance test requirements for voice bandwidth channels used for private line data service. This service includes telemetry, alternate voice/data, 2-point, multipoint, and certain switching arrangements.

1.02 This section is reissued to provide additional information on the various transmission tests. The descriptive and maintenance information previously contained in this section have been moved to Sections 314-410-100 and 314-410-300, respectively. In addition, information previously contained in Appendixes A, B, and C has been moved to Sections 314-410-101, 314-410-102, and 314-410-103, respectively. Since this reissue is a general revision of the section, arrows ordinarily used to denote changes have been omitted.

1.03 This issue affects Equipment Test Lists.

1.04 Form E-5596, Data Transmission History Card, is available for recording the results of initial, routine, and "as required" measurements. The form is a 5- by 8-inch card printed on buff cardstock. It should always be attached to the circuit layout record card (CLRC) for reference in testing and maintenance. A sample copy of this form is described in Section 314-410-300.

1.05 The circuit control office should record the circuit order, trouble, and routine test results on Form E-5596. On multipoint circuits, the office responsible for an end link and/or a middle link should record the circuit test results on this form. This form should also be used to record loop-back test results from the serving test center (STC) to a customer station. In addition, noncontrol offices may keep similar records. However, the STC should keep records for the portion of the circuit it maintains. More than one Form E-5596 may be kept with the CLRC if an office is responsible for more than one portion of the circuit.

1.06 The tests to be performed are listed in Section 314-410-300.

2. TESTING APPARATUS

2.01 Accurate measurements require good test equipment. All equipment should be checked prior to use to ensure that it is working and is calibrated properly. Ample warmup 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.

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 4B-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
P/AR	• Hewlett-Packard 4940A Transmission Impairment Measuring 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
Harmonic Distortion*, ¶ & Single Frequency Int.**	• General Radio 1568-A Wave Analyzer • Hewlett-Packard 302A Wave Analyzer • WECo 4A Frequency Analyzer
Frequency Shift*	• Halcyon 515A Data Line Test Set • Hewlett-Packard 4940A Transmission Impairment Measuring Set • KS-20805 Transmission and Noise Measuring Set • Wandel-Goltermann FVM-1 Frequency Shift Meter • WECo 72A Frequency Meter

TABLE A (Cont)

FUNCTION	TEST SETS
Phase Jitter*	• Bradley Associates Corp. Tone Lock Phase Jitter Test Set Model 75LM • Hekimian Laboratories, Inc. Model 48 or 56 Phase Jitter Set • Hewlett-Packard 4940A Transmission Impairment Measuring Set • Telecommunications Technology, Inc. 1200 Phase Jitter Test Set (Use only with SELECT switch in P-P FLT IN position)
Nonlinear Distortion	• Hekimian Laboratories, Inc. Model 65 Linearity Analyzer • Hewlett-Packard 4940A Transmission Impairment Measuring Set
Singing Margin/ Return Loss	• KS-20501 Return Loss Measuring Set • WECo 2D or 2E Singing Point Test Set • Wiltron Model 9031 Return Loss Measuring Set
Total Power * Output	• Hewlett-Packard 3555B Transmission and Noise Measuring Set • Hewlett-Packard 4940A Transmission Impairment 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
DC Loop Resistance	• KS-14510 Volt-Ohm-Milliammeter

* 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.

¶ Harmonic distortion measurements will be discontinued after nonlinear distortion test sets become more commonly available.

§ 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.

2.03 The application of dc voltage to the input circuit of some test equipment, such as the 21A transmission measuring set (TMS), may cause permanent damage or affect the accuracy of the instrument. To prevent accidental exposure of dc voltage to the TMS, a voltage measurement, using a suitable dc voltmeter should first be made across the line pair. If the reading is 1 volt dc or greater, an isolation (holding) coil arrangement must be used.

2.04 In addition to the dc restriction, the input resistance network and coil of the 21A TMS are not designed to provide a holding bridge. When a dialed connection must be held to transfer to the TMS, a typical holding circuit such as SD-96540-01, or a 2AB auxiliary transmission test set should be used.

2.05 All transmission measurements, unless otherwise stated, are to be made between balanced (not one side grounded) 600-ohm resistive terminations. If unbalanced 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. As an example, most oscilloscopes have an unbalanced input. If an isolation transformer is not available, a 3A noise measuring set can be used to isolate a line from unbalanced and/or non-600-ohm equipment. The 3A NMS can be connected to the line either on a terminated or bridged basis as appropriate.

3. TRANSMISSION REQUIREMENTS AND TEST METHODS

A. General

3.01 The transmission requirements given in this part may be divided into two categories, circuit limits and facility limits. Circuit limits are generally specified for overall, end links, and midlinks. The end link and midlink limits given here and elsewhere in this section apply only to multipoint circuits. Facility limits are specified on a per-channel basis. The overall circuit limits must be met in all cases. The facility limits are intended as a trouble isolation guide and may be disregarded as long as the overall circuit limits are met.

3.02 All test tone frequencies should be offset slightly from multiples of 100 Hz (such as 1200 Hz) in order to avoid possible measurement errors over D-type channels (used in T carrier). For this reason this section will generally indicate an offset of 4 Hz in the test tone frequency to be applied (for example 2804 Hz) to the circuit under test.

Test Level

3.03 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 transmission level point (TLP) at which it is applied will have a major influence on the test results obtained.

3.04 The circuit layout record cards (CLRC) issued by the companies may indicate the expected 1000-Hz loss of the 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 data level (data modem power).

It will be necessary to know which method is used before making measurements. Generally the CLRC will indicate whether TLP or data level is being specified. If not, note the level specified at either the data set transmitter or the MOD IN jack of a 4-wire carrier channel. If the level at the data set transmitter is given as +12 dB or +13 dB, the CLRC is probably written in terms of TLP. If the level at the data set transmitter is given as 0 dBm, it is likely that the CLRC is written in terms of data level. In this case, or if other than the above values are given, note the level at the MOD IN jack of a 4-wire carrier channel as follows:

- If the level is given as −16 dB, the CLRC is written in terms of TLP.
- If the level is given as −28 dB or −29 dB, the CLRC is written in terms of data level.

3.05 If it is still not possible to determine whether the CLRC is written in terms of TLP or data level, the engineer responsible for the CLRC should be notified.

All transmission measurements are to be made at data level. The data level for all new data circuits is a power 13 dB below the TLP at the point where tests are being made. For example, at a −16 TLP the data level would be −29 dBm. A test power of −29 dBm would be applied here. This level of −13 dBm0 is a change from −12 dBm0, which is why two numbers are given in 3.04. An earlier standard was −8 dBm0. All references to data level or test levels in this section will specify −13 dBm0 (13 dB below 0 TLP). However, if a design of −8 dBm0 has been used in the circuit under test and not been changed to either −12 dBm0 or −13 dBm0, the appropriate design organization should be notified. A test level of −8 dBm0 will be required until design changes can be made. Circuits using a −12 dBm0 design should be tested with a −12 dBm0 test level.

B. Categories of Transmission Parameters

3.06 Following the requirements for each of the transmission parameters beginning in 3.07, an example is given using the test points for a 4-wire data set circuit at the customer station and a serving test center. The results given in the example are recorded on a sample Form E-5596 as shown in Fig. 1.

1000-Hz Loss Deviation

3.07 The overall 1000-Hz loss requirements of a circuit depend upon the application of the channel being used. There should normally be 16 dB of loss between any data sets or between 4-wire telephone sets. There should normally be only 10 dB of loss between 2-wire telephone sets. The 2-wire telephone set hybrids add in the additional 6 dB of loss. The CLRC should be consulted before making level adjustments, since special circumstances may require nonstandard loss design.

3.08 The 1000-Hz loss of PBX tie trunks should be specified on the CLRC in terms of expected measured loss (EML). In the event that the EML is not specified, a loss requirement of no more than 8.5 dB should be met. Section 311-100-501 should be referred to when making transmission measurements on PBX tie trunks.

3.09 It will be necessary to test circuits with D1 channels at some frequency near 1000 Hz (perhaps 1004 or 1020 Hz) rather than at 1000 Hz, because level variations caused by the 8000-Hz sampling rate will be as large as ±0.25 dB.

3.10 Table B includes the maximum loss deviation requirements for all private line circuits. 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 data level (−13 dBm0).***

TABLE B

1000-HZ LOSS DEVIATION
MAXIMUM DEVIATION FROM EML STATED ON CIRCUIT LAYOUT RECORD CARD

	CIRCUIT ORDER	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
LOOP-BACK (STC-STA-STC)	±0.8 dB	±2.0 dB

STA A TO STA B

314-410-500
CIRCUIT NUMBER FDA 65072 DATA TRANSMISSION HISTORY CARD TR=A-B LINK (2) REC=B-A
E-5596
PRINTED IN U.S.A.

TEST DATE	10-1-71				12-1-71							
CKT. ORDER NO.	TR (INITIAL)		REC (INITIAL)		TR		REC		TR		REC	
(4) AB 12345-01	DELAY	GAIN FREQ	DELAY	GAIN FREQ	DELAY	GAIN FREQ	DELAY	GAIN FREQ	DELAY	GAIN FREQ	DELAY	GAIN FREQ
300		+1.1										
500	525	+.2										
600	275	-.1										
800	180	-.1										
1000	150	0										
1200	65	-.4										
1400	25	-.2										
1600	10	-.1										
1800	0	0										
2000	-15	0										
2200	-35	+.1										
2400	-10	+.2										
2500												
2600	15	+.4										
2700												
2800	85	+1.1										
3000		+2.1										
3200												
FREQ. SHIFT HZ — HZ	0											
PHASE JITTER — DEGREES	6° LMX											
SINGLE-FREQ-INT. — DBRNCO	36.5											
HARMONIC DIST. (2ND/3RD) DB	27/31											
C-NOTCHED NOISE — DBRNCO	22 TABLE J											
RETURN LOSS - SP — DB	26											
DC LOOP RESISTANCE — OHMS	675		700									

A-Form E-5596 (Front)

ROUTINE MEASUREMENTS

CIRCUIT NUMBER FDA 65072 LINK

TEST DATE	TOTAL POWER DBMO		1000 HZ LOSS DEVIATION		NOISE DBRNCO		IMPULSE NOISE COUNTS/15 MIN		P/AR	REC
	TR	REC	TR	REC	TR	REC	TR	REC	TR	REC
INITIAL MSMNTS	10		-0.2		34		7		89	

B-Form E-5596 (Back) TPA 570151

Fig. 1—Sample of Data Transmission History Card—Form E-5596

3.11 Circuits to which CPMs are connected may be equipped with power limiters either at a customer station or in a central office. It is important to verify that these devices are not limiting the test signal level since this may seriously affect the test results. The following test procedure should be performed to verify that the test signals will not be improperly limited:

STEP	PROCEDURE
1	At the customer station, connect an oscillator to the input of the circuit under test. The oscillator should be adjusted to transmit 1004 Hz at data level and at an impedance of 600 ohms.
2	At a point on the circuit, (after the limiter under test), measure and record the received tone level.
3	At the customer station, increase the tone level by 1 dB. Measure and record this received tone level.
4	Note the difference between the two received tone levels. Continue to raise the oscillator output in 1-dB steps and note at which point an increase of 1 dB in the transmitted tone power results in an increase of 0.5 dB or less of received power. This is the limiting point. Once this point is reached, note the number of dB the tone level was increased above data level before limiting action took place. It will not be necessary to raise the test tone level more than 4 dB above data level. ***Observe the received level for at least 10 seconds to allow the effect of the limiter action to take place.*** ***Note:*** If limiting action took place when the oscillator was adjusted 1 dB above data level, decrease the oscillator output by 1 dB and note whether limiting action no longer occurs (a 1 dB change in receive level is observed when the transmit level is changed by 1 dB).

3.12 The points at which limiting action may occur depend upon the location of the limiter. If the limiter is at the customer station, limiting action should not occur until the oscillator output is 0.5 dB above data level. Limiters at customer stations are adjusted to limit any signal greater than ***−12.5 dBm0.***

3.13 If the limiter is at the central office, limiting action should not occur until the oscillator output is at least 3 dB or more above data level. Limiters at the central office are adjusted to limit at ***−10 dBm0*** in order to take into account the possibility of loss variations between the customer station and the central office. Readjust the limiter according to the appropriate section (332-104-503 or 598-080-500) if the limiter acts on a power lower than that indicated above.

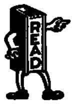
3.14 ***Example of Test:*** An oscillator is connected at a customer station in place of a data set transmitter (+13 TLP). A transmission level meter is placed at the distant customer station in place of the data set receiver (−3 TLP). The limiter is at the central office. The following readings were recorded:

OSC OUTPUT (+13 TLP) (dBm)	RECEIVED LEVEL (−3 TLP) (dBm)
0.0	−15.8
+1.0	−14.8
+2.0	−13.8
+3.0	−12.8
+4.0	−12.4 (limiting point)

As shown, the limiting point was 4 dB above data level. This is more than 3 dB above data level so that transmission tests can safely be made at data level on this circuit without limiting action. The loss deviation at data level in the above example is −0.2 dB. The correct data level at a −3 TLP would be −16.0 dBm. Enter the −0.2 dB loss deviation value on Form E-5596 as shown in Fig. 1.

Attenuation Distortion (Frequency Response)

3.15 The attenuation (gain-frequency) distortion and envelope delay distortion requirements given for C-conditioned channels are tariff requirements and must be met even though meeting those requirements may not be essential to the service provided.



Circuit order measurements of attenuation distortion and envelope delay distortion are made at the customer station location using the measurement frequencies given in Table C. The practice of making loop-back measurements and dividing the results by two is not valid, since significant differences may exist in each direction of transmission.

In the case of circuit rearrangements, straight-away tests to the customer may not be necessary if attenuation distortion and delay distortion measurements are taken in a loop-back condition to the customer station before and after the rearrangements are made and little change is noted in the measurement results. If the loop-back is without an amplifier which can properly terminate the receive loop and provide for the correct transmitter impedance, then large errors in impedance termination can occur. The loop-back provided by DAS 828A ***will not*** create termination errors.

3.16 If a protective arrangement is required, all transmission measurements from the station must be made through the protective arrangement and overall requirements should be met in the appropriate direction of transmission. The equalizers specified by the circuit design engineer are intended to compensate for the attenuation distortion and envelope delay distortion introduced by the protective arrangement as well as the line facilities.

3.17 Attenuation distortion requirements are given in Table D. Figure 2 illustrates the attenuation distortion requirements of a 2-point C2 conditioned channel. Measurements falling within the outlined area are considered as meeting requirements. 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. The attenuation distortion should be brought within limits before envelope delay distortion is measured, since adjustment of the attenuation distortion equalizers may have considerable effect on the envelope delay distortion.

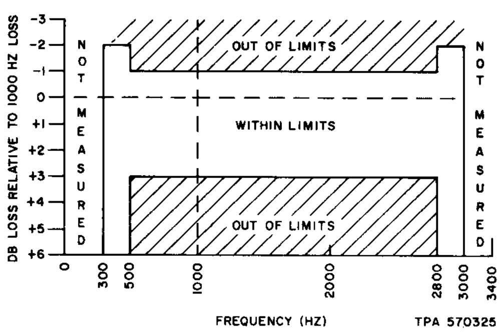


Fig. 2—Graphical Representation of 2-Point C2 Attenuation Distortion Requirements

3.18 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 excessive loss at the high end of the band. The 950A amplitude equalizer can be used to equalize the amplitude characteristics of the interexchange facility as well as mopping up any residual amplitude distortion of the loop.

TABLE C

MEASUREMENT FREQUENCIES

FREQUENCY (Hz)	BASIC CHANNELS		CONDITIONING					
			C-1		C-2 & C-5		C-4	
	FREQ. RESP.	ENV. DELAY	FREQ. RESP.	ENV. DELAY	FREQ. RESP.	ENV. DELAY	FREQ. RESP.	ENV. DELAY
304	X		X		X		X	
504	X		X		X	X	X	X
604	X		X		X	X	X	X
804	X	X	X	X	X	X	X	X
1004	X	X	X	X	X	X	X	X
1204	X	X	X	X	X	X	X	X
1404	X	X	X	X	X	X	X	X
1604	X	X	X	X	X	X	X	X
1804	X	X	X	X	X	X	X	X
2004	X	X	X	X	X	X	X	X
2204	X	X	X	X	X	X	X	X
2404	X	X	X	X	X	X	X	X
2504	X	X	X	X	X	X	X	X
2604*	X	X	X	X	X	X	X	X
2704†	X		X		X	X	X	X
2804	X		X		X	X	X	X
3004	X		X		X		X	X
3204							X	

Make frequency response and/or envelope delay-distortion runs at the frequencies indicated for each type of data channel. The limits are found under each configuration.

* Do not measure at this frequency if 2600-Hz signaling units are used in the layout. Instead interpolate from the values measured at 2504 and 2704 Hz.

† Tone-operated loop-back devices (such as the 44A1 data unit) must be disabled.

TABLE D

PRIVATE LINE VOICE BANDWIDTH CIRCUIT ATTENUATION DISTORTION REQUIREMENTS (dB)

FREQUENCY RANGE IN HZ	2-POINT	0	1		2		3		4	
		MID LINK	MID LINK		MID LINKS		MID LINKS		MID LINKS	
		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 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)									
500-3000	−2 to +3									
300-3200	−2 to +6									
C5	(C5)									
500-2800	−0.5 to +1.5									
300-3000	−1 to +3									

Classification Codes – Examples

( ) Figures in parentheses are classification codes which may be found on some CLRCs 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.

3.19 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. Descriptive information on the 950A amplitude equalizer is given in Section 314-820-107.

3.20 The attenuation distortion equalizers on multipoint circuits should be adjusted to give the best frequency response 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, adjustment of the equalizers to obtain the best frequency response initially may eliminate the need to reequalize multipoint circuits later.

3.21 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 pair or the use of older N2 carrier channel 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 unit with ***crystal*** filters may be needed. N2 modems with LC filters are coded J99272F; with crystal filters, J99272BF. Additional information on these channels is available in Sections 362-806-100 and 362-801-501.

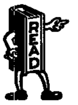
3.22 If a D1 channel bank (used on T1 carrier) is used, verify that 4019 BD transmitting gates and filters are used. The older filters have a poorer high frequency response and should not be used if the attenuation distortion requirements cannot be met. The older filter can be used as long as requirements are met.

3.23 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.

Delay Distortion

3.24 Delay distortion requirements are given in Table E. The delay distortion of a circuit should be measured only after the attenuation distortion of the circuit has been brought within limits. The delay equalizers should be specified on the CLRC and are usually of the nonadjustable variety with three major exceptions, the 385A-, 385B- and 950B-types. 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 specified 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.



Circuit order measurements of attenuation distortion and envelope delay distortion are made at the customer station location using the measurement frequencies given in Table C. The practice of making loop-back measurements and dividing the results by two is not valid, since significant differences may exist in each direction of transmission.

In the case of circuit rearrangements, straight-away tests to the customer may not be necessary if attenuation distortion and delay distortion measurements are taken in a loop-back condition to the customer station before and after the rearrangements are made and little change is noted in the measurement results. If the loop-back is without an amplifier which can properly terminate the receive loop and provide for the correct transmitter impedance, then large errors in impedance termination can occur. The loop-back provided by DAS 828A ***will not*** create termination errors.

3.25 Information on the 384- and 385-type delay equalizers may be found in Section 314-820-104. Information on the 200-type delay equalizers may be found in Section 314-820-100. Information on the 950-type equalizer may be found in Section 314-820-107.

3.26 In the event that delay distortion requirements cannot be met using the equalizers specified, refer the problem to circuit engineering. Engineering personnel should be able to specify the required equalizers which will bring the circuit within limits.

TABLE E

PRIVATE LINE VOICE BANDWIDTH CIRCUIT ENVELOPE DELAY REQUIREMENTS (MICROSECONDS)

FREQUENCY RANGE IN HZ	2-POINT	0	1		2		3		4	
		MID LINK	MID LINK		MID LINKS		MID LINKS		MID LINKS	
		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	110	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)									
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 CLRCs 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.

The 25A and 25B voiceband gain and delay measuring sets may produce erroneous delay measurements when used to measure short local circuits consisting of only nonloaded cable or measuring equipment within an office. Certain harmonic products generated in the transmitting modulator stage may enter the receiver producing erroneous measurement results in the form of ripple. For more information, refer to Sections 103-115-100 and 103-115-101.

3.27 ***Example of Test:*** A 25B voiceband gain and delay set is connected in place of the transmitting data set at station A and set for an output level of 0 dBm at a +13 TLP. Another 25B set is connected in place of the receiving data set at the distant customer station B (−3 TLP). Both received level and envelope delay in this direction are measured and recorded as shown in Table F. Figures 3 and 4 illustrate the determination of the attenuation distortion and delay distortion for this circuit. The measurements are recorded on Form E-5596 as shown in Fig. 1.

TABLE F

SAMPLE MEASUREMENT RESULTS

MEASURED FREQUENCY	ENVELOPE DELAY	RECEIVED LEVEL	LOSS WITH RESPECT 1004 HZ
304		−16.9	+1.1
504	525	−16.0	+0.2
604	275	−15.7	−0.1
804	180	−15.7	−0.1
1004	150	−15.8	0
1204	85	−15.4	−0.4
1404	25	−15.6	−0.2
1604	10	−15.7	−0.1
1804	0	−15.8	0
2004	−15	−15.8	0
2204	−35	−15.9	+0.1
2404	−10	−16.0	+0.2
2604	15	−16.2	+0.4
2804	85	−16.9	+1.1
3004		−17.9	+2.1

Note 1: To calculate the envelope delay distortion between 504 Hz and 2804 Hz, determine the maximum envelope delay (525 μsec) and the minimum envelope delay (−35 μsec) between those frequencies. The envelope delay distortion is the difference between those values 525 − (−35) = 560 μsec. The envelope delay distortion between 604 Hz and 2804 Hz is 275 − (−35) = 310 μsec. Refer to Fig. 4.

Note 2: To calculate the attenuation distortion, reference all loss measurements with respect to 1004 Hz. The attenuation distortion between 504 Hz and 2804 Hz would be the minimum loss (−) and maximum loss (+) between those frequencies (−0.4 to +1.1 dB). The attenuation distortion between 304 Hz and 3004 Hz is −0.4 to +2.1 dB. Refer to Fig. 3.

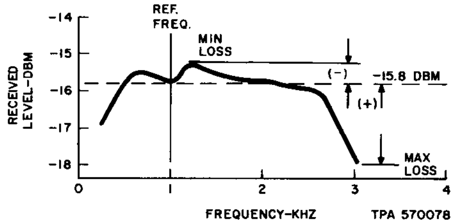


Fig. 3—Attenuation Distortion Determination for 300- to 3000-Hz Band

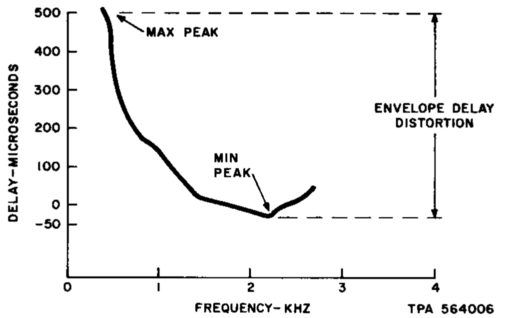


Fig. 4—Envelope Delay Distortion Determination for 500- to 2800-Hz Band

Peak-to-Average Ratio (P/AR)

3.28 P/AR measurements may be made at those locations where P/AR test equipment is currently available. The purchase of the WECo J94027B and J94027E P/AR test equipment is not recommended. New P/AR test sets are available that will provide greater accuracy than the above sets. Benchmark P/AR measurements may be made between STCs and between the STC and the customer station on 4-wire loops equipped with a loopback arrangement, and recorded on Form E-5596 as shown in Fig. 1. The benchmark measurements should be made only after determining that the overall attenuation distortion and envelope delay distortion measurements are within limits.

Note: The WECo J94027E transmitter is designed for use at a 0 ±3 dB TLP. If used at some other TLP, an external attenuator or amplifier will be required to adjust to this level.

3.29 The benchmark measurements should be referred to during trouble isolation testing. If the P/AR measurement is not within ±6 of the benchmark value, the following parameters should be checked in the order listed:

(1) 1000-Hz loss

(2) Message circuit noise

(3) Envelope delay distortion

(4) Attenuation distortion.

3.30 Information on the significance and relationship of P/AR measurements to other transmission parameters may be found in Section AB27.425.01. Tentative overall P/AR requirements for the various types of conditioned circuits are listed in Table G. If these requirements are met, it is a strong indication that the circuit envelope delay distortion is within limits. If the P/AR requirements are not met, the envelope delay distortion requirements may be within limits but other transmission parameters such as C-notched noise may be causing P/AR to be degraded.

TABLE G

OVERALL P/AR REQUIREMENTS

CIRCUIT CONDITIONING	MINIMUM P/AR
Basic Channel	45
C1	48
C2	78
C4	87
C5	95

3.31 ***Example of Test:*** A P/AR transmitter is connected at the AMP IN jack at DAS 828A looking towards the central office at customer station A. Since the P/AR transmitter is connected at a −3 TLP, the output power is adjusted to −16 dBm. A P/AR receiver is connected in place of the data set receiver at customer location B. A reading of 89 is obtained on a C2-conditioned circuit. Since the result is within requirements, the measurement is recorded on Form E-5596 as shown in Fig. 1 in the event that the circuit conditioning must be confirmed later as a result of a customer trouble report. Later measurements that fall within ±6 points of the original reading will help quickly confirm that the circuit conditioning has not changed substantially.

Message Circuit Noise (C-Message Noise)

3.32 The limits for message circuit noise are as follows:

End Link Middle Link Loop-Back (STC-STA-STC) Overall	Use mileage limits from Table H. *Note:* Double one-way mileage for loop-back limits.

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. Although the C-message filter was originally developed for voice applications, it has been found to be quite useful for data applications as well. It offers relatively little attenuation in the 1000- to 3000-Hz band but attenuates power line frequencies (60 Hz and its low harmonics). The 3-kHz weighting network may be used to measure noise at these frequencies.

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 or crossmodulation 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 3.76).

3.35 Table H lists the requirements of C-message noise. This table may be used for station-to-station measurements or on a per-link basis. If type 3 data sets are to be used, a C-notched noise measurement will also be required, since a C-message noise measurement does not indicate the true noise contribution of compandored facilities in the presence of a data signal.

TABLE H

MESSAGE CIRCUIT NOISE OBJECTIVES

CIRCUIT LENGTH (MILES)	NOISE MEASUREMENT (dBrnc0)
0-50	31
51-100	34
101-400	37
401-1000	41
1001-1500	43
1501-2500	45
2501-4000	47
4001-8000	50
8001-16,000	53
Satellite Channel	44*

* Add this figure to land line objective on a random power basis (as described in Section 314-410-102) to obtain overall circuit objective.

3.36 Loop-back measurements of noise are allowed for purposes of initial trouble sectionalization tests. If the distance between the STC making the measurement and the customer location where the circuit is looped back is, for example, 70 miles, the mileage figure is doubled and the noise requirement would correspond to a figure for 140 miles.

3.37 Under certain conditions, noise (for example, from 60-Hz power induction) may cancel out in a looped back measurement. An end-to-end measurement may be necessary to confirm that noise limits are met at the customer station.

3.38 If special service channel units are used on a data only service on N1 carrier, an "enhanced level lineup" should be made on the channel unit. This has the effect of improving the signal-to-noise ratio by 7 dB. Information on "enhanced level lineup" may be found in Section 362-315-501 for the transmit channel unit and in Section 362-315-502 for the receive channel unit.

Note: The use of special service channel units (with or without the enhanced level lineup) generally provides a poorer signal-to-noise ratio than that obtainable with the compandored channel units.

3.39 The measured noise must be corrected to the 0 TLP reference point in order to determine whether requirements are being met, ie, for comparison to the requirements stated in dBrnc0. For example, when measuring at a +7 TLP, subtract 7 dB from the reading and when measuring at −3 TLP, add 3 dB to the reading.

3.40 If the CLRC specifies data level, convert the data level to TLP by adding 13 dB to the data level. At the −29 dBm data level point, add 13 dB to convert to a −16 dB TLP, then proceed as in 3.39.

Note: If a −12 dBm0 design is used, convert the data level to TLP by adding 12 dB to the data level.

3.41 Additional information on message circuit noise may be found in Section 331-100-100. Engineering information may be found in Section 870-200-100.

3.42 ***Example of Test:*** At customer station A, a 600-ohm termination or a 3A noise measuring set is connected across the input to the circuit in place of the data set transmitter. At customer station B, a 3A noise measuring set is connected to the circuit in place of the data set receiver (a −3 TLP or −16 dBm data level point). A reading of 31 dBrnc is taken. To adjust this to dBrnc0, 3 dB is added to the reading to obtain 34 dBrnc0. The circuit has a length of 1400 miles of both N carrier and LMX carrier facilities. The requirement from Table H of 43 dBrnc0 is met. The corrected measured noise value is entered on Form E-5596 as shown in Fig. 1.

C-Notched Noise

3.43 The limits for C-notched noise are expressed as a ratio of the received 1000-Hz test tone power to the C-notched noise power, as follows:

End Link	See
Middle Link	Note
Loop-Back	Below
Overall	24 dB

Note: To determine the end link, midlink, and loop-back C-notched noise limits, use the facility limits specified in Table I. Combine the uncorrected C-notched limits for each facility as given in Section 314-410-102. Note that when loop-back measurements are performed, the number of channels (if any) measured will double and the C-notched noise (ratio) requirement will be reduced by 3 dB.

Example: A loop-back measurement of C-notched noise is to be made. There is a T carrier system using D1A channels between the STC and the customer. From Table I the C-notched noise requirement for D1A channels is 26 dB. The loop-back requirement is 26 − 3 = 23 dB.

C-notched noise should be investigated when excessive errors are encountered with type 3 data sets, since it is a measure of the amount of noise on a channel when a signal is present. The C-message noise described in 3.33 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 is signal dependent, it is impossible to approximate the signal-to-noise (S/N) ratio, which is important to data transmission, from received level and C-message noise measurements alone.

3.44 A C-notched noise measurement differs from a C-message noise measurement in that 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 thus simulates a data signal. At the receiving end, the tone is removed by a very narrow band-elimination filter (notch filter) and the noise is then measured through a C-message filter. The requirements for C-notched noise in this section are expressed as the ratio of received 1004-Hz test tone power (applied at data level) to the C-notched noise, and are an approximation of the S/N ratio.

3.45 It is planned to use a holding tone at a frequency from 1004 to 1020 Hz for measurement of C-notched noise. Some test sets are presently available with this capability (refer to test set list in Table A). A suitable notch filter is under development for use with the WECo 3 type noise measuring sets and has an expected availability of late 1974.

TABLE I

COMPANDORED FACILITY NOISE REQUIREMENTS

FACILITY LENGTH (MILES)	C-MESSAGE NOISE (1) (dBrnc0)			C-NOTCHED NOISE (2) (dB)				
	N1 ON	N2	N3	N1 ON	N2	N3	D1A D1B	D1D D2 D3
0-50	26	23	18	28	31	33	26	33
51-100	26	23	20	28	31	32	26	33
101-200	26	26	23	28	29	31	26	33

(1) Noise requirements using a quiet termination at the MOD IN jack.

(2) Noise requirements using a holding tone at data level at the MOD IN jack. These requirements include the effects of any test tone harmonics.

(3) To determine the C-notched noise requirements in dB for uncompandored facilities, subtract the C-message noise requirements in dBrnc0 for the facility in question from 77 dBrnc0.

Example: The C-notched noise requirement for 150 miles of LMX is 77—37 (from Table H) = 40 dB.

3.46 The WECo 6F noise measuring set may be used if a more suitable noise measuring set is not available. The 497E and G networks supplied with this set offer a maximum of 30 dB rejection to test tone frequencies of 2750 or 2800 Hz. This rejection may not be adequate for other than end-to-end measurements. In addition, the noise measurements obtained by the use of this test set may be 1 or 2 dB lower than actually present.

3.47 The practice of using a holding tone at 1004 to 1020 Hz will provide a more predictable measurement of the signal-to-noise ratio than the use of a holding tone at 2750 Hz or 2800 Hz, which was formerly used for this measurement. This occurs because the overall circuit and the individual links are adjusted at 1004 Hz, permitting accurate prediction of the 1004-Hz tone level at various points in the connection. When a holding tone is applied at the customer station and near this frequency at data level (−13 dBm0), it may be assumed that the power entering the MOD IN jack at a compandored channel will also be approximately −13 dBm0. The noise generated by the use of the holding tone on the compandored channel will then be comparable to that generated by a data signal at data level.

3.48 If a holding tone of 2750 Hz or 2800 Hz is applied at the customer station at data level, it is likely that the power entering the MOD IN jack of a compandored channel may be several dB different than −13 dBm0 because of the allowances permitted for the frequency response of the local loop or intermediate channels. If the 2800-Hz power is 2 dB lower than expected, the C-notched noise measured on the channel may appear to be as much as 1 dB lower than is actually the case.

3.49 The use of a holding tone at 2750 Hz or 2800 Hz does eliminate the possibility of harmonic (nonlinear) distortion affecting the C-notched noise measurement when N or ON channels (but not T carrier) are involved. This is not true when a holding tone near 1004-Hz is used, as the harmonics will be present in the C-notched noise measurement.

3.50 The noise measuring set may indicate the C-notched noise level in either of two ways. Some noise measuring sets automatically indicate the ratio of the 1004-Hz holding tone to the C-notched noise in dB. This reading can be compared directly with the C-notched noise requirements in this section, and no calculations are required.

3.51 Other noise measuring sets indicate the C-notched noise power in dBrnc rather than the ratio of the test tone to the C-notched noise. In this case, perform the following steps:

(1) Apply the test tone (at data level) of 1004, 1020, 2750, or 2804 Hz at the transmitting location.

(2) At the receiving location, measure the noise power using a C-notched filter. Adjust the test tone frequency at the transmit location for the minimum noise reading on the meter. Record this value in dBrnc as "A". Do not correct for 0 TLP.

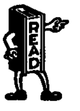
(3) At the receiving location, replace the C-notched filter with a C-message filter and record the measured tone power in dBrnc as "B". Do not correct for 0 TLP. The test tone at the transmitting location is left on for this measurement.

(4) The test tone to C-notched noise ratio is B − A.

3.52 ***Example of Test:*** A 1004-Hz test tone is applied at customer station A at a power of 0 dBm at a +13 TLP. At customer station B, a reading (B) of 74 dBrnc is obtained using a C-message filter, and a reading (A) of 52 dBrnc is obtained using a C-notched filter. The S/N ratio is B − A = 74 − 52 = 22 dB. Although the C-notched noise in this example appears to be out of limits, it will be necessary to make further measurements before reaching this conclusion. This is explained in 3.53 and 3.54, followed by Example 1 in 3.55.

3.53 The circuit limits given in 3.43 allow only for the presence of noise and not for nonlinear distortion (refer to 3.104 and 3.107 for information on nonlinear distortion). A C-notched noise measurement which includes the effect of nonlinear distortion is referred to as UNCORRECTED C-NOTCHED NOISE. If calculations are made to determine the C-notched noise without the effect of the nonlinear distortion, it will be referred to as CORRECTED C-NOTCHED NOISE.

3.54 As long as uncorrected C-notched noise measurement meets the C-notched noise limits, there will be no need to account for the effect of nonlinear distortion. If the overall uncorrected C-notched noise is out of limits by 1 or 2 dB, measure the harmonic or nonlinear distortion as discussed in 3.104, and consult Table J. If the conditions in that table are met, the corrected C-notched noise is within limits and further action is not required. In some cases, the uncorrected C-notched noise may be out of limits because the harmonic or nonlinear distortion is out of limits. In this case, correct the distortion problem first, then remeasure the C-notched noise.



Under conditions where the nonlinear distortion is out of limits, repeat the C-notched noise measurement after the distortion problem has been cleared.

3.55 The following examples are intended to further explain the use of Table J.

Example 1: In the example of 3.52, the uncorrected C-notched noise appeared to be out of limits. This example will use that C-notched noise measurement and the harmonic distortion measurements from the example of 3.106 to determine if the corrected C-notched noise is within limits. Uncorrected signal to C-notched noise ratio = 22 dB

2nd order harmonic distortion = 27 dB

3rd order harmonic distortion = 31 dB

Locate the row in Table J in which the S/N ratio is 22 dB and the 2nd order harmonic distortion is 27 dB. As shown in the table, the 3rd order harmonic distortion must fall within the range of 30 to 35 dB in order to be within limits. Since the measured distortion of 31 dB falls within that range, the corrected C-notched noise is within limits. Record the results on Form E-5596 as shown in Fig. 1. Since C-notched noise was previously expressed in dBrnc0, it will be necessary to cross out the rnc0 on the form. (The form will be changed in the near future.) Also, note the reference to Table J to indicate that the corrected C-notched noise is within limits.

3.56 ***Example 2:***

Uncorrected signal to C-notched noise ratio = 22 dB

2nd order nonlinear distortion = 28 dB

3rd order nonlinear distortion = 31 dB

TABLE J

CONDITIONS UNDER WHICH OVERALL CORRECTED C-NOTCHED NOISE REQUIREMENTS ARE MET

UNCORRECTED TEST TONE TO C-NOTCHED NOISE RATIO	2ND ORDER DISTORTION HARMONIC OR NONLINEAR	3RD ORDER DISTORTION	
		HARMONIC	NONLINEAR
24-∞	NR	NR	NR
23	25-30	NR	NR
	31	30-39	28-37
	32	30-35	28-33
	33	30-33	28-31
	34-35	30-32	28-30
	36-39	30-31	28-29
	40	30	28
22	25-26	NR	NR
	27	30-35	28-33
	28	30-31	28-29
21	The distortion must be out of limits in order for the corrected C-notched noise to be within limits.		

NR = Not required (the 2nd order distortion alone is within the range to put the corrected C-notched noise within limits)

See 3.53 to 3.56 for an explanation of the use of this table.

From values given in Table J, the 3rd order nonlinear distortion must be in the range of 28 to 29 dB in order for the corrected C-notched noise to be within limits. Since the measured distortion is lower than this, the corrected C-notched noise is out of limits. This example shows that if the 3rd order nonlinear distortion had been higher, for example 26 dB, the corrected C-notched noise would have been in limits but the 3rd order nonlinear distortion would have been out of limits.

3.57 To sectionalize C-notched noise, it will be necessary to look at the performance of LMX carrier, N and ON carrier, and T carrier individually.

3.58 The most probable source of C-notched noise is the D1A or D1B channel banks used on T1 carrier. Request a distortion measurement be made of all D1A and D1B channels as outlined in Section 365-104-500. Request the measurement results. The limits for this test are given in Table L of that section and are reproduced in Table K of this section under the heading of maximum readings. Measurements which are normal for a well maintained system are given under the heading of the typical readings column in Table K. The limits of Table K include the effects of both distortion and noise, and correspond to an uncorrected C-notched noise measurement as described in 3.53.

3.59 Table I provides C-message noise and C-notched noise requirements for compandored carrier facilities for use in sectionalizing C-notched noise troubles. C-notched noise measurements should be used to sectionalize C-notched noise troubles. However, C-message noise measurements may be used in those cases where C-notched noise measuring sets are not available and C-message noise limits are specified in Table I. The C-notched noise limits in Table I include the effect of any possible test tone harmonics.

3.60 The C-message noise requirements in Table I are to be used in isolating C-notched noise troubles to N or ON carrier channels (but not T carrier) when C-notched noise measuring sets are not available. These requirements correspond to the limits given in Section 362-305-510 for N1 and ON carrier, Section 362-800-506 for N2 carrier,

TABLE K

MEASUREMENT LIMITS FOR C-NOTCHED NOISE (DISTORTION) ON D1A/B CHANNELS

TRANSMITTING END MATCHING NETWORK KEYS HORIZONTAL	TRANSMITTING TEST LEVEL (dBm0)	MAXIMUM RECEIVING END 3A NMS READINGS DBRN	TYPICAL RECEIVING END 3A NMS READINGS DBRN
0	0	56 (30)	52 (34)
10	−10	50 (26)	46 (30)
20	−20	41 (25)	37 (29)
30	−30	30 (26)	26 (30)
30 and 10	−40	24 (22)	21 (25)

Note: Figures in ( ) are the corresponding signal-to-distortion ratios in dB. For example, when all keys in the matching network are vertical, the test tone is 0 dBm relative to 0 TLP. Since the RCV jack is a +2 TLP, the test tone will then be nominally +2 dBm or 92 dBrn at this point. If the 3A NMA reads 56 dBrn at the output of the 1-kHz reject filter, the distortion products are 62 dBrn at the RCV jack (since the 1-kHz reject filter has 6 dB of loss). The signal-to-distortion is therefore 92 − 62 = 30 dB.

and Section 362-900-506 for N3 carrier. The C-message noise limits in Table I are not normally to be used for isolating C-message noise facility troubles, as they are tighter than needed to meet the overall private line C-message noise requirements. (The requirements in Table H are to be used to sectionalize C-message noise facility troubles.)

3.61 The use of noncompandored channel units (special service channel units or VF amplifiers) on N or ON carrier will increase the C-notched noise power significantly (poorer signal-to-noise ratio) and should be discouraged for type 3 data transmission.

3.62 In some cases C-notched noise may be caused by phase jitter on LMX carrier, if the jitter source occurs at 180 Hz or higher. Most phase jitter occurs at frequencies of less than 180 Hz and the phase jitter sidebands are rejected by the C-notched filter. The C-message noise limits given in Table H may be converted into C-notched noise limits for the isolation of C-notched noise on LMX carrier, since these channels are not compandored. To do this, subtract the C-message noise limits in dBrnc0 in Table H from 77 dBrnc0 in order to obtain the C-notched noise limits in dB.

Impulse Noise

3.63 The threshold settings for impulse noise are as follows:

End Link	67 dBrnc0
Middle Link	Use mileage limits from Table L
Loop-Back	Use round trip mileage limits from Table L
Overall	71 dBrnc0

3.64 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.

3.65 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 L) + 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.

3.66 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 L 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 3.63 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.

3.67 ***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 data set 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 3.14. 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 Form E-5596 as shown in Fig. 1.

TABLE L

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
1000-1999	—	—	61
over 2000	—	—	64

(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.

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.

3.68 An impulse noise counter is also sensitive to other parameters such as phase hits and harmonic hits when used in conjunction with a holding tone.

3.69 If phase hits are suspected on LMX carrier, remove the holding tone and repeat the measurement using the same threshold level. If the counter continues to register impulses at the previous rate, the trouble is probably impulse noise. If the counting rate decreases, the trouble is probably phase hits. Verify that the phase hits do not exceed the requirements specified in 3.99.

3.70 If harmonic hits are suspected on D1 carrier when a holding tone and a threshold of 67 dBrnc0 is used, remove the holding tone and repeat the measurement using threshold levels of 63 dBrnc0 and 57 dBrnc0. A multiple level meter such as the 6F NMS may be used to count the impulses above each threshold simultaneously, or a single level meter such as the 6H NMS may be used singly at each threshold. A good channel will have less than 1 count in 5 minutes at 63 dBrnc0 and less than 5 counts in 5 minutes at 57 dBrnc0. If these limits are not met, the trouble is probably impulse noise and the procedures given in 365-105-500 under impulse noise should be followed. If the limits were met without the holding tone but were not met with the holding tone, harmonic hits may be the problem. Consult 3.113 and 3.114 for information on harmonic "hits"

> ***Note:*** The impulse noise threshold levels given in Section 365-105-500 (65 dBrnc and 59 dBrnc) are used at the D1 carrier RCV jack, which is a +2 TLP and equivalent to the 63 dBrnc0 and 57 dBrnc0 thresholds given above.

3.71 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.

3.72 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 3.63 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.

3.73 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

Multiple level impulse noise tests should be made when repeated trouble reports are received that the data error rate is higher than normal or when the data set receiver loses synchronization for no apparent reason.

Single Frequency Interference

3.74 The overall circuit requirements for single frequency interference are given in Table M. The limits in this table may also be used to sectionalize troubles to a particular facility.

TABLE M

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

3.75 Spurious single frequency tones may interfere with certain data signals, particularly narrowband signals which are multiplexed onto a voiceband channel. Since the output of the multiplexer 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.

3.76 A listening test is required to check for single frequency interference while the C-message noise measurement is being made as given in 3.34. 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, perform a C-message noise measurement. If the noise measurement meets the limits listed in Table M, the single frequency tone is within limits.

3.77 If the limits in Table M are not met, a level measurement of the interference must be made using a frequency selective voltmeter. Tune the voltmeter to the interfering tones between the frequency range of 300 to 3200 Hz and measure the level in dBm. This figure may be converted to dBrnc0, using the following procedure:

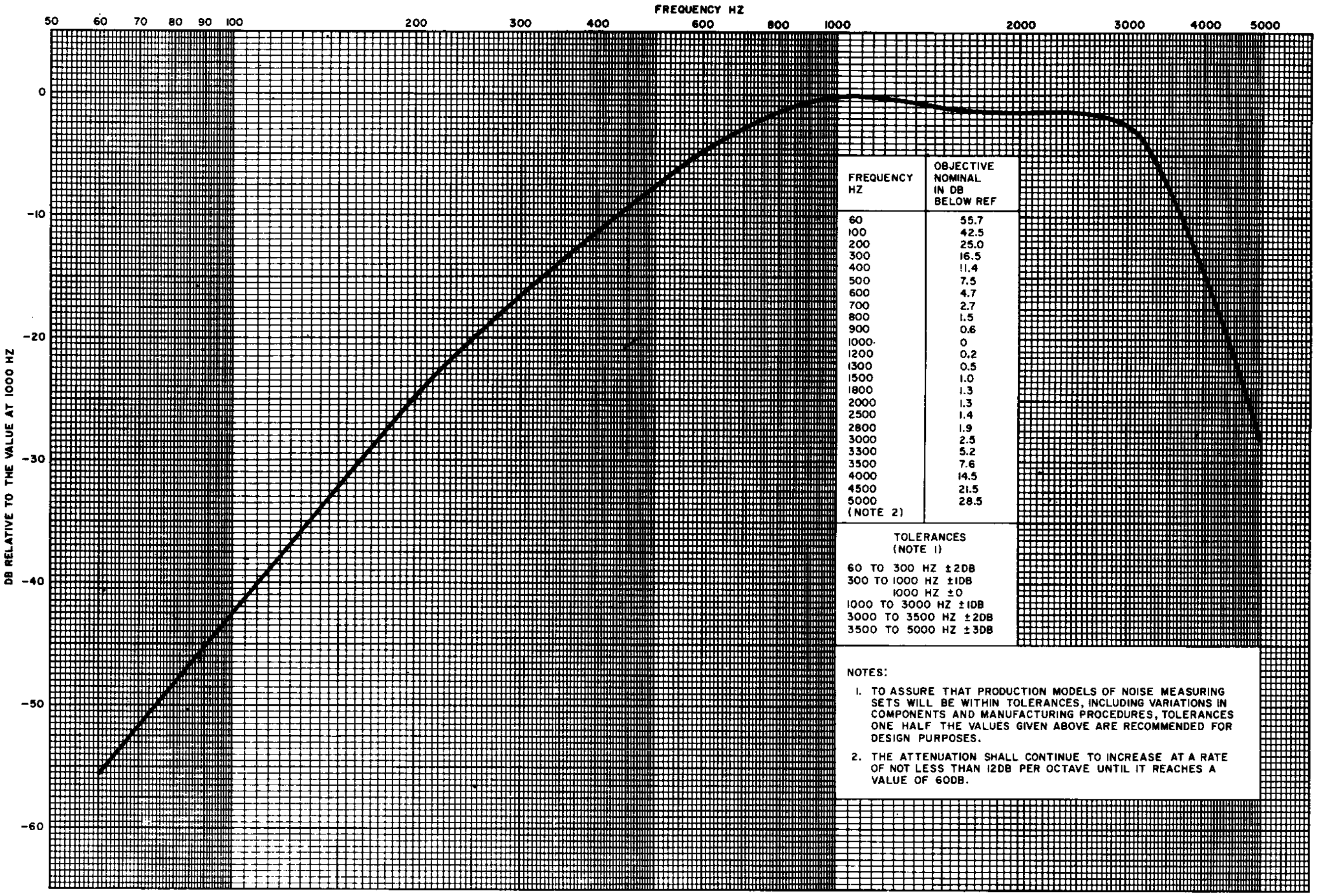
STEP	PROCEDURE
1	Convert the level measurement to dBm0 by algebraically subtracting the TLP at the point of measurement from the reading obtained on the meter. If the CLRC specifies data level instead of TLP, add 13 to the data level shown on the CLRC to obtain the TLP.
2	Convert from dBm0 to dBrn0 by adding 90 to the dBm0 figure.
3	Convert to C-message weighting using the curve in Fig. 5 as follows: 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. 5. Subtract this loss from the figure in dBrn (Step 2) to obtain the level in dBrnc0, and compare this figure against the requirement table.

3.78 ***Example of Test:*** Single frequency interference is heard when making a listening test at customer station B at a −16 dBm data level point (−3 TLP). A frequency selective voltmeter is connected at this point and a reading of −52 dBm at a frequency of 600 Hz is obtained. A termination was applied to the distant end of the circuit which is approximately 1200 miles long. To convert the test point from data level to TLP, 13 is added to −16 to obtain a −3 TLP. To convert the level measurement from dBm to dBm0, the TLP is subtracted from the level measurement: −52 dBm − (−3) = −49 dBm0. Convert the dBm0 figure to dBrn0 by adding 90: −49 dBm0 + 90 = 41 dBrn0. Referring to Fig. 5, the loss at 600 Hz as compared with 1000 Hz is 4.7 dBm. Convert the dBrn0 figure to dBrnc0 by subtracting the loss at 600 Hz: 41 dBrn0 − 4.7 dB = 36.3 dBrnc0. Although the interference can be heard, it falls within the requirement of 40 dBrnc0 for a 1200-mile circuit and need not be corrected. Enter this figure on Form E-5596 as shown in Fig. 1. If the listening test had revealed no single frequency interference, the notation OK may be made on Form E-5596, as a level measurement would not have been required.

Frequency Shift

3.79 The overall circuit requirements for frequency shift are as follows:

End Link Middle Link	Refer to Table N
Overall	±5 Hz
Loop-Back	Not a valid test



FREQUENCY HZ	OBJECTIVE NOMINAL IN DB BELOW REF
60	55.7
100	42.5
200	25.0
300	16.5
400	11.4
500	7.5
600	4.7
700	2.7
800	1.5
900	0.6
1000-	0
1200	0.2
1300	0.5
1500	1.0
1800	1.3
2000	1.3
2500	1.4
2800	1.9
3000	2.5
3300	5.2
3500	7.6
4000	14.5
4500	21.5
5000 (NOTE 2)	28.5

TOLERANCES
(NOTE 1)

60 TO 300 HZ ±2DB
300 TO 1000 HZ ±1DB
1000 HZ ±0
1000 TO 3000 HZ ±1DB
3000 TO 3500 HZ ±2DB
3500 TO 5000 HZ ±3DB

NOTES:

1. TO ASSURE THAT PRODUCTION MODELS OF NOISE MEASURING SETS WILL BE WITHIN TOLERANCES, INCLUDING VARIATIONS IN COMPONENTS AND MANUFACTURING PROCEDURES, TOLERANCES ONE HALF THE VALUES GIVEN ABOVE ARE RECOMMENDED FOR DESIGN PURPOSES.
2. THE ATTENUATION SHALL CONTINUE TO INCREASE AT A RATE OF NOT LESS THAN 12DB PER OCTAVE UNTIL IT REACHES A VALUE OF 60DB.

Fig. 5—C-Message Weighting Curve

NOTES

Facility limits are shown in Table N. A VF carrier channel includes all modulation stages between two channel banks. Frequency shift measurements are only required on the carrier channel portions of the circuit and do not normally include the metallic facilities to the customer stations. Frequency shift measurements are only required in the event of repeated customer trouble reports.

TABLE N

FREQUENCY SHIFT REQUIREMENTS

NO. OF VF CARRIER CHANNELS IN TANDEM	MAXIMUM FREQUENCY SHIFT
1	1 Hz
2-4	2 Hz
5-9	3 Hz
10-16	4 Hz

3.80 Frequency shift of carrier facilities will seldom be a serious problem for most data applications. It cannot appear on physical plant 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 system which is connected to an L-type system with an N3-L connector and where the frequency control grid has not been extended to the N3 terminal. In this case either the frequency control grid should be extended or a different channel on the N3 system should be chosen. Frequency shift will not be found on D1, D2 or D3 channels of T carrier systems. The LMX channels of L-type carrier should normally hold frequency shift well within the limits given in Table N. An exception to this may be the result of improperly performed maintenance activity on the primary frequency supplies when deviations in excess of 10 Hz for a number of hours have been observed. If such trouble is suspected, an inquiry regarding maintenance activity associated with primary frequency supplies on the route should be made and supervisory assistance requested to ensure that the work is carefully done so as not to interfere with data transmission. C or H carrier channels may exhibit large amounts of frequency shift and should be avoided.

3.81 To measure the frequency shift parameter, a frequency counter is used at both ends of a 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.

3.82 Momentary frequency shifts ranging as great as 100 Hz or more for a period of a few milliseconds to 5 seconds and return to zero may be experienced. A 72A frequency meter and a phase jitter test set may be helpful in detecting this problem. An electronic frequency counter cannot detect this type of problem.

3.83 ***Example of Test:*** When frequency shift is suspected on a circuit, an oscillator is connected at data level (−13 dBm0) at the STC serving customer station A. A frequency counter is then bridged across the output. Another frequency counter is bridged across the circuit at the STC serving customer station B. Metallic facilities are used exclusively between both STCs and their respective customer stations. If a carrier channel other than N1, N2, or T were used between the STC and the customer station, it would be necessary to make this measurement at the customer station. A frequency of 1004 Hz is read at both STCs at the same time. The frequency shift on this circuit is therefore 0 Hz. Record this value on Form E-5596 as shown in Fig. 1.

Phase Jitter

3.84 The circuit requirements for phase jitter are as follows:

End Link Middle Link	Refer to Table O
Overall	10° peak-to-peak
Loop-Back	Not a valid test

3.85 Various sources cause the instantaneous phase, or zero crossings, of a signal to "jitter" at rates normally less than 300 Hz. Phase jitter is typically caused by ripple in the dc power supply appearing in the master oscillator of LMX carrier supplies and is introduced in the process of modulation of the voiceband signal to group and supergroup frequencies. It may also occur on N3 carrier in cases where the frequency correction unit is subject to crosstalk coupling at frequencies near the frequency correction carriers from other pairs in the same cable sheath.

3.86 Distortion, quantizing noise, random noise, and single tone interference can also cause an apparent increase in phase jitter. The overall phase jitter limits apply only when the C-notched noise requirement of 24 dB is met.

3.87 The primary source of phase jitter on LMX carrier is ripple on the 24-volt supply circuit which amplitude modulates this supply at the ripple frequencies. Harmonics of the 4-kHz frequency supply circuit are used to derive group and supergroup carrier frequencies. The process of harmonic generation causes the amplitude modulated signal to be transformed into a frequency modulated signal. The original ripple modulation, which was quite small, is magnified by the process of harmonic generation and may become quite significant at the higher carrier frequencies. The phase jitter from a given carrier supply will be greatest at the highest supergroup carrier frequency.

3.88 The relative phase jitter of different supergroup carrier frequencies originating from the same 4-kHz supply is generally directly proportional to the carrier frequency. For example, if 1 degree of phase jitter is found on the supergroup 5 carrier frequency (1612 kHz) then 1.9 degrees should be measured on the supergroup 10 carrier frequency (3100 kHz).

$$1.9^\circ = \frac{3100}{1612} \times 1^\circ$$

3.89 Each supergroup modulation stage will introduce phase jitter to a voiceband channel. Channels which will have the lowest phase jitter will generally pass through as few supergroup or group connectors as possible and will be assigned to the lower frequency supergroup.

3.90 The LMX phase jitter limits given in Table O have been based on the fact that as the channel mileage increases the number of modulation exposures will generally increase.

3.91 The maximum phase jitter permissible for a LMX terminal at either the supergroup D28 (3396 kHz) or supergroup 10 (3100 kHz) carrier supply frequencies is 3.6 degrees. Under certain conditions, such as the assignment of a channel to all "worst case" supergroups, a limit of 3.6 degrees will not be sufficient to permit the requirements of Table O to be met. The limits in Table O may be disregarded if an overall LMX (all LMX channels in tandem) objective of 8 degrees can be met. Otherwise, every attempt should be made to reduce the supergroup D28 or 10 carrier supply phase jitter as much as possible below 3.6 degrees. This may generally be accomplished by comparing the phase jitter generated using the regular equipment (such as the drive amplifiers) as compared to that generated with the standby equipment switched in. The equipment giving the higher readings should be investigated and/or replaced and the equipment giving the lower readings should be retained. LMX carrier supply phase jitter tests and troubleclearing procedures are covered in Section 356-270-506. If the supergroup D28 or 10 phase jitter cannot be reduced below 3.6 degrees and the overall LMX objective of 8 degrees cannot be met, DATEC assistance should be requested, through proper lines of supervision. As a last resort, facility reassignments may be necessary.

TABLE O

MAXIMUM PEAK-TO-PEAK PHASE JITTER REQUIREMENTS FOR CHANNELS TO BE USED FOR DATA TRANSMISSION

N, ON, D1 (T1 CARRIER) CHANNELS	
NUMBER OF CHANNELS	DEGREES PHASE JITTER
1	3.5
2	4.7
3	5.4
4	6.0
LMX CARRIER	
MILEAGE BAND	DEGREES PHASE JITTER
0-250	4.0
251-500	5.0
501-1000	6.0
1001-2000	7.0
2001-4000	8.0

Note: Under certain "worst case" conditions, the above limits may not be met for some channels. If overall phase jitter requirements cannot be met, facility reassignment may be necessary in these cases.

3.92 The mechanism for unsatisfactory phase jitter performance of N3 channels is related to the exposure of the frequency correction unit to the crosstalk interference from other pairs in the same cable sheath. Existing J99300AS frequency correction units (Lists 1, 2, 3, 4, 3A, and 4A) tend to increase phase jitter if the crosstalk interference is in a 16-Hz band centered about the frequency correction carrier. List B (option W, SD 97178-02) may be added to existing units to reduce the susceptibility of the frequency correction unit to crosstalk.

3.93 In most cases where the N3 carrier noise requirements are met, these channels will also meet the phase jitter requirements for private line data circuits given in Table O. If these limits cannot be met with the addition of List B to the frequency correction carrier unit, and the N3 facility requirements given in Section 362-900-507 (when available) can be met, it may be necessary to request another facility assignment. This action will only be necessary when the overall phase jitter requirement of 10 degrees cannot be met.

3.94 The measurement of apparent phase jitter on D1 channels (used on T1 carrier) will vary considerably with slight changes in test frequencies. This occurs because, although the total distortion power of a single tone is constant, the distortion components may vary in number and intensity across the voiceband, depending upon the test frequency. A phase jitter meter will only detect these components in the 700- to 1300-Hz band. For example, measurements of a typical D1 channel with a test tone varied between 1025 Hz and 1075 Hz produced readings varying from a low of 1.2 degrees to a high of 3.0 degrees. Therefore, D1 channels that meet phase jitter limits given in Table O may not meet nonlinear distortion or C-notched noise requirements. A C-notched noise test or nonlinear distortion test will generally be of more value than a phase jitter test in locating a faulty D1 carrier channel. If phase jitter measurements of D1 channels must be made, readings should be obtained with test tones of 1004 Hz or 1020 Hz. These frequencies are within the specified 980-1030 Hz phase jitter measurement band, and do not suffer from the erratic readings possible with a 1000-Hz tone.

3.95 Phase jitter measurements are normally required only on the overall LMX carrier portions of the circuit as shown in Fig. 6, unless N3 carrier makes up a portion of the circuit. The total end-to-end phase jitter contribution of all LMX carrier channels in tandem should not exceed 8 degrees. Measurements may be made in only one direction on LMX carrier since the same carrier supplies are used in both directions and the measurement results in either direction will be almost identical. Loop-back measurements are not meaningful on LMX carrier.

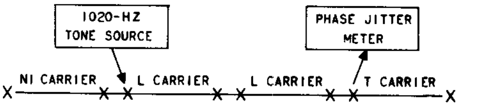


Fig. 6—Test Arrangement for Measuring Phase Jitter

3.96 If N3 carrier makes up a portion of the circuit, it may be necessary to make phase jitter measurements in both directions on the N3 channel in addition to the LMX measurements. As an alternative, overall measurements may be made which include all carrier channels in tandem. The overall limit of 10 degrees should be met. Note that metallic facilities to the customer location need not be included in this measurement.

3.97 It may be necessary to make overall phase jitter measurements at the customer stations if repeated trouble reports are received and there is some question as to whether Telco facilities are meeting objectives. An overall requirement of 10 degrees must be met between all customer stations. If this limit is not met, verify that C-notched noise and nonlinear distortion requirements are met before attempting to locate the source of a phase jitter problem.

3.98 ***Example of Test:*** A 2-point circuit is to be tested for phase jitter. An oscillator known to have a low jitter source is connected to the MOD IN jack at the first LMX carrier channel and adjusted to a frequency of 1020 Hz at a level of −29 dBm (−16 TLP). At the DEMOD OUT jack of the LMX channel closest to the distant end (a distance of 700 miles from the test oscillator), a phase jitter test set is connected and a reading of 6 degrees peak-to-peak is obtained. This value is recorded on Form E-5596 as shown in Fig. 1. A notation "L Cxr" is made after the value to indicate that only the LMX carrier has been measured.

Phase Hits

3.99 Limits for phase hits are currently under consideration. A current study indicates an average of 2.9 phase hits occurred per hour where the phase hits were at least 22.5 degrees in magnitude and 2 milliseconds in duration. Under no circumstances should more than 10 hits greater than 20 degrees occur in 15 minutes. Some areas have adopted the following tentative limits over a 15-minute measurement interval which should only be applied where local instructions indicate:

THRESHOLD	HITS
30°	1
20°	4
10°	15

3.100 Phase hits are large abrupt changes in signal phase occuring on data channels as a result of switching two carrier supplies not in phase, or switching to alternate transmission facilities having different propagation times. They will generally affect error performance in the same manner as impulse noise.

3.101 Phase hits may show up on impulse noise counters when a holding tone is used and vice versa. To partly remove the effect of impulse noise, a 4-ms gate must be used in the phase hit counter. This means that the phase hit must last for at least 4-ms in order to be counted.

3.102 If excessive impulse noise is recorded on LMX facilities in the presence of a holding tone, the measurement should be repeated without the holding tone, using the same threshold setting. The absence of impulse noise counts without a holding tone indicates the possibility of phase hits. A phase hit counter should be used to determine whether the above phase hit requirements can be met.

> *Note:* If a phase hit counter is used first and detects excessive hits, an impulse noise test should be made of the same facility without a holding tone to be certain that the problem is not impulse noise.

Nonlinear Distortion (Harmonic Distortion)

3.103 The limits for nonlinear distortion and harmonic distortion are as follows:

HARMONIC DISTORTION

	RATIO OF 704 HZ TO HARMONIC	
	1408 Hz 2nd Harmonic	2112 Hz 3rd Harmonic
End Link	28 dB	36 dB
Middle Link*	40 dB	40 dB
Loop-Back (STC-STA-STC)	25 dB	30 dB
Overall	25 dB	30 dB

NONLINEAR DISTORTION

	RATIO OF FUNDAMENTAL TO SECOND AND THIRD ORDER PRODUCTS	
	2nd Order	3rd Order
End Link	28 dB	34 dB
Middle Link*	40 dB	38 dB
Loop-Back (STC-STA-STC)	25 dB	28 dB
Overall	25 dB	28 dB

*These requirements assume the use of no short haul carrier channels (N, O, ON, D) for midlinks. If such is not the case, use the requirements in Table P for trouble isolation. The overall requirement shown above applies under all circumstances.

3.104 Nonlinear distortion can be broadly defined as the generation of signal components from the transmitted signal that add to the transmitted signal, usually in an undesired manner. To date, nonlinear distortion has been measured by applying a single frequency tone of 704 Hz at one end of a channel and measuring the second harmonic and third harmonic products at the other end of the channel with a selective voltmeter or spectrum analyzer. These distortion powers are not meaningful unless the power of the wanted signal (the fundamental) is known. Therefore, measurements are usually referred to the power of the fundamental and termed second or third harmonic distortion.

> *Note:* Measurement frequencies are offset by 4 Hz because of cases where D1 channel banks (used on T1 carrier) are used. The

D1 channel bank tends to exaggerate the test results when test frequencies that are subharmonics of 8000 Hz are used.

3.105 To measure harmonic distortion, a test tone of 704 Hz is applied at a data level of 13 dB below the TLP shown on the CLRC. At the MOD IN jack of a typical carrier channel (−16 TLP) this would correspond to a level of −29 dBm. If a test oscillator such as the 21A TMS is used, ensure that the harmonic output of the oscillator is at least 40 dB below the fundamental of the test frequency. Older 21A TMSs or those due for routine maintenance frequently do not meet the 40-dB spread. At the distant end, adjust a frequency selective voltmeter to measure the level of the 704-Hz tone in dBm (A). Second, measure the level at 1408 Hz in dBm (B).

> ***Note:*** It may be necessary to increase the sensitivity of the measuring set from 30 to 60 dB to make this measurement.

Third, measure the level at 2112 Hz in dBm (C). The second harmonic distortion is A − B. The third harmonic distortion is A − C. An example of these calculations follows in 3.106.

3.106 ***Example of Test:*** An oscillator is connected in place of the data set transmitter at customer station A and adjusted to a level of 0 dBm (+13 TLP) at a frequency of 704 Hz. A frequency selective voltmeter is connected at station B in place of the data set receiver (−3 TLP).

The level and frequency readings are as follows:

704 Hz −16 dBm

1408 Hz −43 dBm

2112 Hz −47 dBm

The second harmonic distortion is

$-16 - (-43) = 27$ dB

The third harmonic distortion is

$-16 - (-47) = 31$ dB

These values meet the circuit limits. Record the results on Form E-5596, as shown in Fig. 1. The letters HD should follow the harmonic distortion measurement results on Form E-5596 to distinguish these results from nonlinear distortion measurement results.

3.107 It is planned to use intermodulation distortion measurements and to discontinue the use of harmonic distortion measurements for purposes of characterizing the nonlinear distortion of telecommunications channels. This will provide for less variable measurements for PCM systems than currently realized using harmonic distortion measurements techniques.

3.108 The term nonlinear distortion, as used in this section, shall denote the measurement of intermodulation distortion unless otherwise stated. Harmonic distortion measurements will continue to be acceptable in most cases until nonlinear distortion test sets are found to be in more common usage. Nonlinear distortion measurements will be required in lieu of harmonic distortion measurements in those cases where the customer indicates that the channel does not meet Bell System specifications and DATEC support is required.

3.109 To measure nonlinear (intermodulation) distortion, four equal-level tones (as shown in Fig. 7) are transmitted over the facility to be measured. 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). Each pair of narrowly spaced tones is used to simulate a narrow band of noise at each center frequency. The second order distortion is determined by measuring the energy through narrowband filters centered at B − A (520 Hz) and B + A (2240 Hz). Third order distortion is measured through a narrowband filter centered at 2B − A (1900 Hz). The 2nd order nonlinear distortion is generally equal to the 2nd order harmonic distortion. It appears that the 3rd order nonlinear distortion is generally 2 dB lower than the 3rd order harmonic distortion. Most present and planned nonlinear distortion test sets will read out the distortion (and noise factor) as a ratio in dB with respect to the measured power of the fundamental signal.

3.110 If the C-notched noise on the circuit being measured is high, or the nonlinear distortion on the facility is low, the distortion measurement may be influenced by the channel noise. Therefore, the distortion measurement reading obtained from the nonlinear distortion test set is actually the uncorrected distortion. The nonlinear distortion test set is equipped with a signal-to-noise mode (as shown in Fig. 8), which removes the tone pair at "B" and increases the power of the tone pair at "A" by 3 dB to transmit the same total power over the channel as is transmitted during the nonlinear distortion test mode. The noise energy in the second order and third order slots, discussed in 3.109, is measured at the other end of the facility

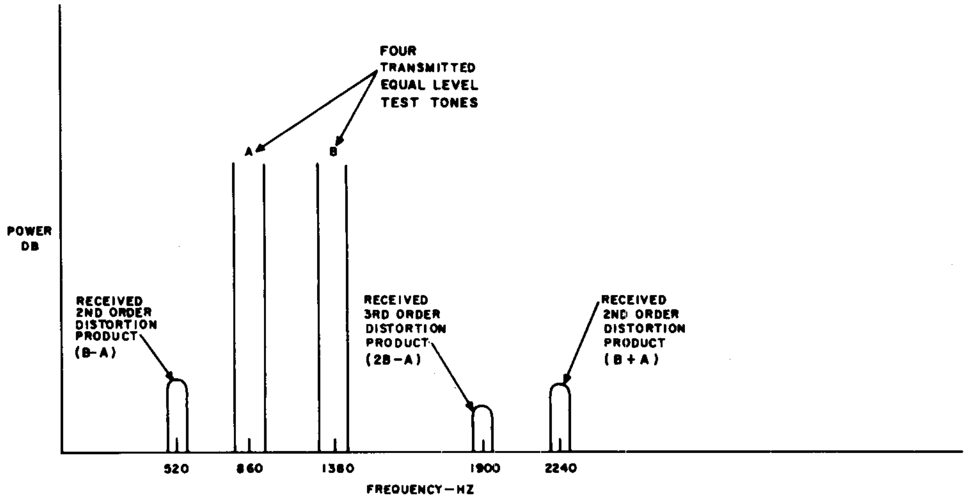


Fig. 7—Distortion Test Signals

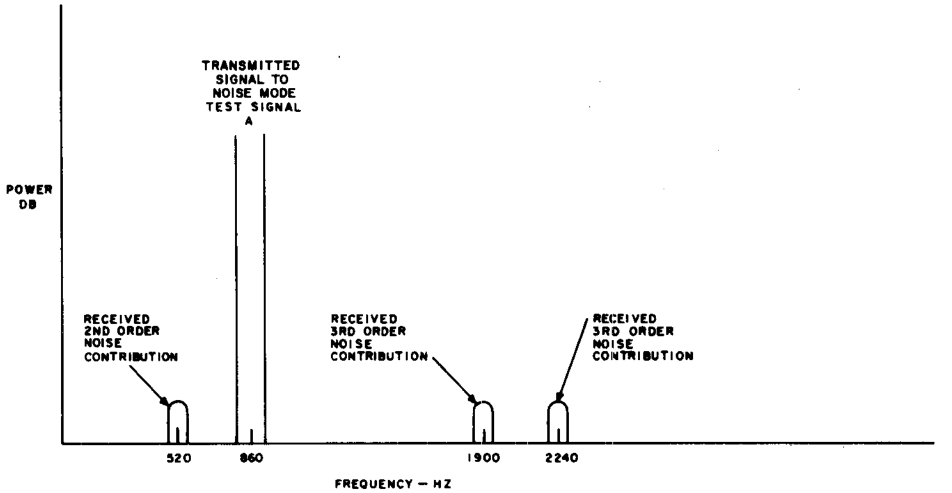


Fig. 8—Signal to Noise Mode Test Signals

in both the second order and third order measurement modes. The actual distortion (corrected distortion) present is determined by calculations involving the use of a correction factor (shown in Fig. 9) which removes the influence of noise from the distortion measurement. If the uncorrected distortion meets the requirements in this section, there will be no need to calculate the corrected distortion. If the limits are not met, the corrected distortion should be determined, since the circuit may meet requirements. The use of the correction factors is illustrated in the following example.

3.111 ***Example of Test:*** A nonlinear distortion test set is connected in place of the data set transmitter at customer station A and adjusted to a level of 0 dBm (+13 TLP) in the distortion or normal mode. Another nonlinear distortion test set is connected at station B in place of the data set receiver (−3 TLP). The following measurements are made at station "B" with the test set at station "A" in the distortion mode:

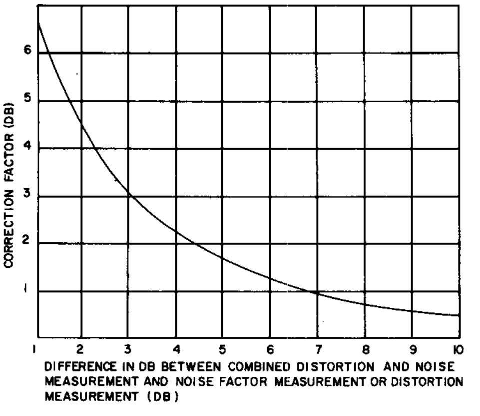


Fig. 9—Correction Factor for Noise or Distortion

Total received power = −16 dBm (This measurement confirms the test signal has been applied at data level at station "A".)

Received distortion (signal-to-distortion ratio, which includes distortion and noise)

2nd Order Mode = 27 dB
3rd Order Mode = 32 dB

The test set at station "A" is placed in the noise factor or S/N mode. The following measurements are taken at station "B", and the following ratios read:

Received noise (signal-to-noise ratio)

2nd Order Mode = 34 dB
3rd Order Mode = 35 dB

Determine the difference between the received distortion and the received noise as recorded above.

	RECEIVED NOISE		RECEIVED DISTORTION		DIFFER-ENCE
2nd Order	34 dB	−	27 dB	=	7 dB
3rd Order	35 dB	−	32 dB	=	3 dB

Use the difference from above to determine the correction from Fig. 9.

	DIFFERENCE	CORRECTION FACTOR
2nd Order	7 dB	1 dB
3rd Order	3 dB	3 dB

Determine the actual distortion by adding the correction factor to the received distortion.

	RECEIVED DISTORTION		CORRECTION FACTOR		CORRECTED DISTORTION
2nd Order	27 dB	+	1 dB	=	28 dB
3rd Order	32 dB	+	3 dB	=	35 dB

Enter the distortion on Form E-5596, followed by the letters ND to distinguish the measurement from the measurement of harmonic distortion. Following ND, use a U (NDU) for uncorrected distortion and a C (NDC) for corrected distortion.

Table P lists the facility nonlinear distortion and harmonic distortion requirements for channels to be used for data transmission.

3.112 The D1A and D1B channel banks used on T1 carrier are the most common source of harmonic distortion. The following steps should be followed when D1/T1 carrier is used for data transmission.

(1) Ensure that the new 4020B, series 6 expandor, containing the new electronic oven, is used in all D1 terminals.

(2) Ensure that the "hardened compressor" 4020AA is used on D1/T1 groups carrying high-speed data services (2 compressors required to handle 12 channels, 4 compressors to treat a complete D1/T1 system, assuming both ends are equipped).

(3) Verify that the transmission levels of the data channel and all other special service channels in the system are correct.

(4) Check to be sure that the T1 line error rate meets the BSP requirements.

(5) Check to be certain that the channel (D1A channel only) being used is arranged for 7-digit transmission (off-hook) by providing −48 volts on the M lead during data transmission periods. This can be accomplished as follows:

(a) For a 4-wire E and M channel unit, list 2, used without signaling, the Y option on the channel unit should be screwed down.

(b) For a 4-wire E and M channel unit, list 2, used with signaling, or for a 4-wire E and M channel unit, list 1, used with or without signaling, the application of −48V to the M lead during transmission of the data signal should be ensured.

(6) The T carrier personnel should be requested to measure distortion on the D1 channel as given in Section 365-105-500. The distortion measurements must not exceed the maximum readings given in Table K of this section. A set of typical readings is also given, and if met, will provide additional margin in meeting overall nonlinear distortion and C-notched noise objectives. The limits in Table K are actually uncorrected C-notched noise requirements which the T carrier personnel use instead of performing a nonlinear distortion measurement. However, if the limits of Table K are met, the T carrier nonlinear distortion requirements given in Table P should also be met, since an uncorrected C-notched noise measurement includes both quantizing noise and nonlinear distortion.

3.113 The D1A and D1B channel banks are subject to momentary increases in harmonic distortion that follow office activity or traffic. These momentary increases in channel distortion (commonly referred to as "harmonic hit") are caused by

TABLE P

FACILITY NONLINEAR DISTORTION REQUIREMENTS
FOR DATA TRANSMISSION

TYPE OF CHANNEL	HARMONIC DISTORTION		NONLINEAR DISTORTION	
	2ND HARMONIC	3RD HARMONIC	2ND ORDER	3RD ORDER
N1, ON, O	30 dB	36 dB	30 dB	34 dB
D1A, D1B (T Cxr.)	30 dB	36 dB	30 dB	34 dB
D1D, D2, D3 (T Cxr.)	50 dB	52 dB	50 dB	50 dB
N2, N3	35 dB	40 dB	35 dB	38 dB
LMX	50 dB	50 dB	50 dB	48 dB

transient changes in the bias of the D1A/B compressor networks. Accordingly, the "hits" affect a group of channels (ie, 12) on the D1/T1 system. The basic traffic dependent phenomena that produce the momentary misbiasing of D1 compressors are as follows:

(1) Certain transients in No. 5 crossbar office 48-volt battery supplies used by the D1 power converter

(2) Certain transient high level signals (ie, dial pulse transients) on D1 channels that overload an ac coupled pre-amplifier that establishes compressor bias

(3) The storage of cross-talk energies at the 10-Hz dialing rate in ac coupled amplifiers which affect the bias of the compressor diode network.

3.114 The 4020 AA compressor has been developed to provide additional immunity against office transients. When testing the D1/T1 system [as given in (6) of 3.112], the distortion test must be performed during the busy hour when the D1 terminal is exposed to office battery and front-end transients (dialing, etc). The NORM—DAMP switch on the 3A NMS should be placed in the NORM position. If the 3A NMS exhibits momentary kicks or fluctuations in the reading (±1 dB), the 4020AA compressor serving the channel under test is defective and should be replaced. If the 3A NMS readings are stable but exceed any of the maximum limits given in Table K, the system ***must*** be turned down and the trouble cleared. (Refer to Section 365-104-500.)

Singing Margin/Return Loss

3.115 The requirements for singing margin tests are as follows:

NUMBER OF 2-WIRE STATIONS	MINIMUM SINGING MARGIN (EACH STATION)
1-2	10 dB
3-4	16 dB
5-8	22 dB
Over 8	28 dB

3.116 A singing margin test measures the stability of a circuit against singing or howling. In principle, the channel is terminated in its normal impedances. A variable gain amplifier is then inserted on one side of the 4-wire facility and the gain of the amplifier increased until singing (oscillation) occurs. The amount of gain in dB required to cause singing is called the singing margin.

3.117 Singing margin tests are required when 2-wire data sets terminate circuits that are provided in part over 4-wire facilities. These tests are necessary to assure that a given data set receiver will not receive any transmitted signal above an interfering level more than once (echo effect or listener echo). To operate satisfactorily, the level of the echo must be 12 dB or more below the level of the original received signal. Since a 1000-Hz loss deviation of ±4 dB is permitted in each direction of transmission, a singing margin of 20 dB must be obtained to keep the echo within limits under worst case conditions.

3.118 On 2-point circuits it may be simplest to perform a singing margin test on the overall circuit. In this case, connect the test set as shown in sketch A of Fig. 10. The reading obtained in dB on the test set corresponds to the singing margin, and no additional calculations are required. A minimum singing margin of 20 dB should be met.

3.119 The same 2-point circuit may be tested in two parts. In this case a test is made looking towards each station as in sketch B of Fig. 10. In the case illustrated, the test set is placed across equal TLPs in both directions of transmission and the reading in dB obtained on the test set corresponds to the singing margin. If the test set is placed across unequal TLPs, a correction factor must be added to the test set reading to determine the singing margin. If the TLP towards the customer station is A, the TLP from the customer station is B, and the test set reading is C, then the singing margin in dB is C + B − A. The singing margin requirement for a single station on a 2-point circuit is half of that for the entire circuit of 10 dB.

3.120 The latter method is also used to measure the singing margin on multipoint circuits. The singing margin to each station may be tested at any point on the 4-wire portion of the end link. The singing margin requirements given in 3.115 will allow the circuit to meet an overall requirement of 20 dB.

3.121 Before making a singing margin measurement, verify that the station is in the data (not voice) mode and an idle circuit termination is not used to terminate the circuit. An idle circuit termination may be provided on stations arranged for supervisory signaling and may be removed by placing the station in an off-hook condition.

3.122 If the KS-20501 return loss measuring set (RLMS) is used to measure the singing margin of the circuit, set the THL switches to 0. Make the measurement with the test switch in the SRL and SRL-HI positions. Record the sum of the lowest on scale meter reading and the ADD-DB switch. To obtain the singing margin, correct the reading for the TLPs at the point of measurement as explained in 3.119. Instructions on the use of this set are given in Section 103-106-115.

3.123 If the 2D singing point test set is used to measure the singing margin of the circuit, adjust the GAIN DB switches until the circuit sings. The singing margin is the gain of the set corrected by the TLPs at the point of measurement as explained in 3.119. Instructions on the use of the 2D test set are given in Section 103-106-105.

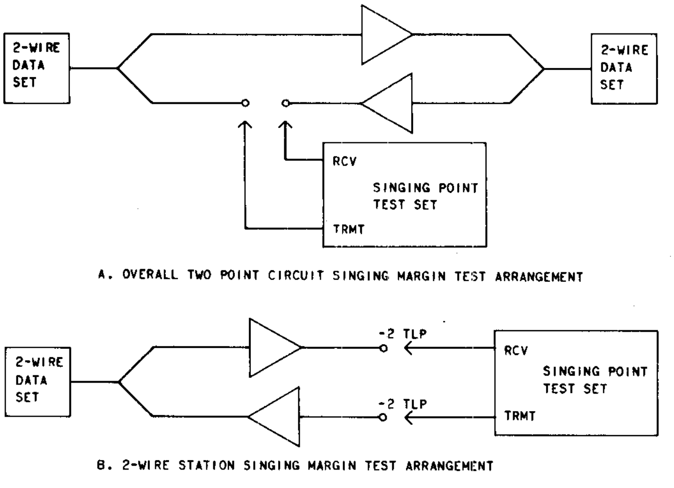


Fig. 10—Singing Margin Test Arrangements

3.124 ***Example of Test:*** A 2D singing point test set is connected to a circuit at a +7 TLP (A) towards the 2-wire data set and at a −16 TLP (B) receiving from the 2-wire data set as shown in Fig. 11. A 2D set reading of 49 dB (C) is measured which means 49 dB gain is added in the singing point test set to make the circuit sing. The singing margin is 49 − 16 − 7 = 26 dB. Enter this result on Form E-5596, as shown in Fig. 1.

3.125 If 4-wire cable facilities are used out to the customer station and the customer 2-wire data set is connected to the circuit at the levels shown in Fig. 11, it will not be necessary to measure the singing margin of multipoint circuits with up to four stations, since the singing margin requirements will automatically be met by means of the circuit design.

> ***Note:*** The COMP NET screw on the 1-type terminating set must always be down in order to achieve any return loss, unless an external network is used.

3.126 If singing margin requirements cannot be met, it will be necessary to improve the balance at the term set or change the circuit design. The impedance of the network associated with the term set should match the 2-wire facilities or equipment as closely as possible. If the local loop is 2-wire, a precision network may be required to obtain adequate return loss. Missing load coils, long bridge taps, and frequent changes in gauge may make it impossible to obtain adequate return loss at the CO. A change in 2-wire loop facilities or a 4-wire loop design may be necessary.

3.127 The data set internal impedance should be as close to 600 ohms as possible. Verify that the correct options are used in the data set (and in some cases the DAS) to obtain this impedance. It should be possible to obtain a minimum singing point of at least 12 dB at the term set if the data set is within 40 percent of a resistive 600-ohm impedance across the voiceband. (This assumes that the term set is located at the customer station). The general theory covering singing point tests is given in Section 332-015-100.

3.128 Singing point measurements are made in a manner similar to singing margin measurements. To determine the singing point at the term set perform the following steps:

(1) Connect the singing point test set to the circuit as shown in Fig. 11. Terminate the data station in the same manner as if a singing margin test were being made.

(2) Short the tip and ring leads on the 2-wire line side of the term set.

(3A) If the 2D singing point test set or equivalent set is being used, determine the amount of gain required to make the circuit sing. Record this reading (A) as the reference loss.

(3B) If the KS-20501 RLMS is used, adjust the THL switches to obtain a 0-dB reading on the meter with the ADD DB switch set to 0.

(4) Remove the short from across the term set.

(5A) If the 2D singing point test set is used, readjust the gain of this set until the circuit sings. Record this value (B). The singing point is B − A.

(5B) If the KS-20501 RLMS is used, adjust the ADD DB switch until an on-scale meter reading is obtained. This should be done using both the SRL and SRL-HI switch positions.

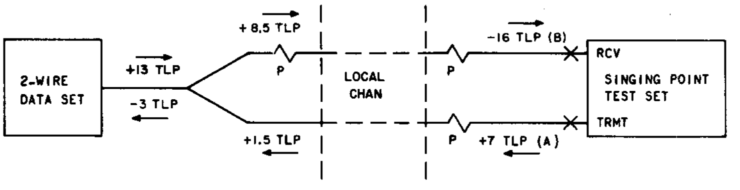


Fig. 11—2-Point and Multipoint Circuit Singing Test Arrangement

Record the value of the sum of the ADD-DB switches and the meter reading which is lowest. This is equivalent to the singing point and no further calculations are required.

3.129 ***Example:*** The 2D test set was left connected to the circuit shown in Fig. 11 to make a singing point test. Recall that 49 dB of gain was required to make the circuit sing. The 2-wire line side of the term set is shorted to reduce the return loss at the term set to 0 dB. A 2D set reading of 39 dB is required to make the circuit sing. The singing point at the term set is 49-39 = 10 dB. The data set impedance varies from a desired 600-ohm impedance by more than 40 percent. In this example, this would be a problem if the circuit were a multipoint with more than eight 2-wire stations. There would be no problem if the circuit had eight or less 2-wire stations, as the singing margin requirement would have been met through the use of 4-wire loop facilities.

3.130 No action is required when the singing margin requirements are met, regardless of the impedance of the data set. However if singing margin requirements cannot be met and singing point measurements indicate a possible data set impedance problem, the DATEC team should be consulted.

Total Power Output

3.131 The measurement limits for the total signal power are as follows:

Maximum Signal Power from Customer Station Served by STC	−11 dBm0
Maximum Signal Power Toward Customer Station Served by STC	−9 dBm0

3.132 Each STC is responsible for measuring the signal power to and from each customer station which it serves. A high impedance bridged measurement should be taken on an in-service basis where possible.

3.133 A trouble investigation should be started if the limits given in 3.131 are exceeded. These limits are based on the maximum data signal level of −13 dBm0 modified by the permissible long term loss variation. In the case of excessive signal power from the local (served) customer station, the customer should be asked to check this modem output power. If this does not clear the problem, it may be necessary to dispatch maintenance personnel to confirm that the customer equipment is not exceeding interconnection limits. The effects of extreme temperature variations on aerial cable resistance (and attenuation) and cable cutovers may be responsible for the problem. In either case, some action will be required to limit the total signal power to the above requirements in order to reduce possible loading on Bell System carrier facilities.

3.134 Connect a high impedance noise meter such as the 3A NMS at the MON jack. Select the 3-kHz weighting network and read the level in dBrn. In some cases the NMS may be overloaded by the data signal power, and a pad will be needed to reduce the level. In this case, a 600-ohm terminated measurement must be made. The value of this pad must be added to the results of the measurement. To convert the NMS reading to dBm0, subtract the TLP from the reading taken in dBrn at the point of measurement, then subtract 90.

3.135 ***Example of Test:*** A reading of 84 dBrn is measured at a TLP of +7 looking towards Station B at the STC serving Station B. This corresponds to 77 dBrn0. To convert this to dBm0, 90 is then subtracted from the dBrn reading of 77 to give a reading of −13 dBm0. This value meets the total power requirement of −9 dBm0, since this is the power going towards the station B end.

3.136 If the signal power is out of limits towards the local (served) customer station, in-service signal power measurements should be made at other STCs in order to determine the source of the excessive signal. On multipoint circuits, particularly with frequency division multiplex equipment, the 3-second average signal power from any individual station may be less than −13 dBm0, but the combined power of all stations at some common point on the circuit could exceed the above limits. Engineering should be advised and given the number of narrowband transmitting locations along with the level in dBm0 measured from each station in order to determine a possible solution.

DC Loop Resistance

3.137 The dc loop resistance of cable pairs or pairs between STC and the customer station should be measured and recorded on Form E-5596 for use as a benchmark figure in the event of a later trouble condition. The overall requirements are as follows:

MAXIMUM PERCENT CHANGE IN LOOP RESISTANCE

STC-STA	Predominantly Aerial Cable	20%
	Predominantly Underground Cable	5%

3.138 If a trouble condition is suspected on the loop, another dc resistance check should be made (A). This second measurement should be compared as a percentage change from the benchmark measurement (B). The percentage change is:

$$\frac{B-A}{B} \times 100$$

For example, a dc resistance check indicates a present loop resistance of 470 ohms (A). The benchmark measurement indicated a resistance of 490 ohms (B). The percent change is:

$$\frac{490-470}{490} \times 100 = 4.1\%$$

3.139 If the change is greater than the requirement given in 3.137, a trouble investigation of the loop should be made. Verify that cable pair or equipment changes have not taken place since the benchmark measurement was taken. On 4-wire loops a loopback P/AR reading compared against a previous benchmark reading will be useful in verifying that cable pair or equipment substitutions have not been made. If substitutions have been made, it may be necessary to compensate for these changes. Also, it may be necessary to notify Engineering of the condition via lines of organization.

> ***Note:*** If resistance varies on a short term basis, indicating poor unsoldered pair connections, consider dc sealing current. Refer this problem to Engineering Staff.

3.140 ***Example of Test:*** The dc loop resistance of the local cable pair is measured using a KS-14510 volt-ohm-milliammeter or equivalent. It is not required to short the pairs at the customer station since a repeat coil in DAS 828A offers a relatively low resistance between the tip and ring of the cable pair. A dc resistance of 675 ohms is measured on the pair transmitting from the customer station and this value is entered on Form E-5596. Later, following a trouble report, the loop resistance is again measured and reads 700 ohms. The cable pair involved is predominantly underground. The percentage change is:

$$\frac{700-675}{675} \times 100 = \frac{25}{675} = 3.7\%$$

The result shows the change in resistance is within limits and the loop appears to be satisfactory.

4. REFERENCES

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

SECTION	TITLE
AT&T PUB 41003	Analog Parameters Affecting Voiceband Data Transmission—Description of Parameters—October 1971
AT&T PUB 41004	Data Communications Using Voiceband Private Line Channels—October 1973
AT&T PUB 41009	Transmission Parameters Affecting Voiceband Data Transmission—Measuring Techniques—January 1972
EL 1172	Application of Protection to Voicegrade Private Line Data Channels Which Connect to Customer-Provided Equipment
EL 1540	Application of Protection to Voicegrade Private Line Data Channels Which Connect to Customer-Provided Equipment
EL 2333	Application of Protection to Voicegrade Private Line Data Channels Which Connect to Customer-Provided Equipment

SECTION	TITLE
EL 2415	Application of Protection to Voicegrade Private Line Data Channels Which Connect to Customer-Provided Equipment
AB27.350	Voice Bandwidth Circuits for Private Line Data Use—2000 Series and 3002 Channels—General Information
AB27.425.01	Data-Phone Service—Analysis of Transmission Factors
010-521-100	Data Technical (DATEC) Support
103-106-105	J94002D (2D) and J94002E (2E) Singing Point Test Sets—Description
103-106-115	Western Electric Company Model KS-20501—Return Loss Measuring Set—Description and Operation
103-115-100	25A Voiceband Gain and Delay Sets—(J94025A)—Description and Operation
103-115-101	25B and 25BR Voiceband Gain and Delay Sets—(J94025B and J94025BR)—Description, Operation and Maintenance
309-200-300	Switched Services Networks Using Central Office Switching Machines—Service Maintenance
Division 310	Non-Switched Special Services System
Division 311	Switched Special Services Systems
311-100-501	Switched Special Services—1000 Hz and Noise Measurements—PBX Central Office Trunks, Off-Premises Station Lines, and Tie Trunks Having Access to the Direct Distance Dialing Network
314-016-125	TWX Service—Attenuation Equalization Arrangements and Adjustments—Using 44V4 Repeaters
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 Circuits
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
314-820-100	Data Systems—Common Circuits, Equipment and Procedures Envelope Delay Characteristics of 200-Type Delay Equalizers
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314-820-107	950-Type Equalizer—Description
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331-100-100	Message Circuit Noise—General Information
332-015-100	Simplified Theory of Singing Point Tests
332-104-500	V4 Telephone Repeaters—Initial Line-Up
332-104-503	V4 Telephone Repeater—F58122 AGC Amplifier—Tests and Adjustments
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SECTION	TITLE
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362-305-510	Type N, O, and ON Carrier Systems—Overall Channel Lineup—Channel Noise Measurement
362-315-501	Type N1, O, and ON Carrier Telephone Systems—Overall Channel Line-Up—Special Service Channel Unit—Transmitting Section
362-315-502	Type N1, O, and ON Carrier Telephone Systems—Overall Channel Line-Up—Special Service Channel Unit—Receiving Section
362-800-506	Type N2 Carrier Telephone System—Overall System—Channel Noise Measurement
362-801-501	N2 Carrier Terminal Telephone System—Terminal Equipment—Test Summary Charts
362-806-100	Type N2 Carrier Telephone System—Message and Schedule C and D Program—Channel Modem Units—Description
362-900-506	Type N3 Carrier Telephone System—Terminal Equipment—Channel Noise Measurement
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365-104-500	Digital Transmission Systems—D1 Bank—Lineup and Adjustments
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463-331-103	Voice Connecting Arrangement CD4—31B Voice Coupler
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590-103-103	1000A Data Coupler—Description, Installation, Maintenance, and Tests
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598-080-100	Data Auxiliary Set 828A—Description and Operation
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NOTES

PART III

VOICE BANDWIDTH DATA TEST SETS

MODEL TTS 4BNH TRANSMISSION TEST SET

(NORTHEAST ELECTRONICS CORP.)

INSTRUCTION MANUAL

1. GENERAL

1.01 This section provides information in connection with the operation and maintenance of the Northeast Electronics Corporation Model TTS 4BNH Series of Transmission Test Sets.

1.02 The section consists of an instruction manual prepared by Northeast Electronics Corporation, Concord, New Hampshire. The instruction manual has been abridged to delete references to internal wiring diagrams and repair procedures. Accuracy checks and repair service for the TTS 4BNH Transmission Test Set is available at Western Electric Service Centers under the "Red Ball" program.

Attached:

Abridged Instruction Manual for the TTS 4BNH series of Transmission Test Sets.

FOREWORD

The information provided in Northeast Electronic Corporation's Instruction Manual has been included only to describe the operation of the TTS 4BNH Transmission Test Set. The information provided should not be construed as a substitute for the transmission procedures described in Bell System Practices.

General transmission requirements for Bell System equipment and facilities may be found in the 300 division series of Bell System Practices. Specific transmission parameters for a particular item of equipment will usually be found in the installation and maintenance practices associated with the equipment.

TTS 4BNH

INSTRUCTION MANUAL (ABRIDGED)

GENERAL DESCRIPTION

1.0 GENERAL INFORMATION

Overall Features

1.01 The TTS 4BNH portable Transmission Test Set and the rack mounted version, the TTS 4BNHR, were designed to operate in the audio-frequency range and to permit transmission measurements over a wide range of telephone circuits. The appearance and the operation of these sets is almost identical to that of the earlier TTS 4ANH series of test sets. The TTS 4BNH and TTS 4BNHR contain all the features provided in these earlier sets and provide a number of additional features, such as individually calibrated meter scales, a 20 dB increase in receive sensitivity, the ability to provide bridging measurements at full sensitivity and additional send frequencies.

1.02 The set may be used on local exchange or PBX circuits as well as on two-wire or four-wire toll circuits and program circuits. In addition to the transistorized transmission measuring circuits and their associated switching provisions, the set contains a built-in talk circuit as well as precision terminations of 600Ω +2 μF and 900Ω +2 μF. A 4 ½" mirror-scale level meter, which is individually calibrated, is centrally located on the panel.

For operation on local circuits which carry DC, the set contains switchable low resistance holding coils. A self-contained talk circuit, equipped with jacks for a 52A or equivalent external headset, is provided. This circuit can be switched to the ON HOOK condition; in this case, a neon bulb indicates incoming ringing. The receiver of the headset can be switched to monitor the signals in the receive amplifier; this provision is also used in the "four-wire TALK" position. When equipped with an external 52A headset and an external dial, which can be inserted in the unused line jack, the set duplicates the functions of a subscriber dial set.

A connector is provided for connecting external frequency determining networks; these are located in accessory "slip-on" covers and provide networks for both switchable and continuously variable frequencies.

1.03 All connections to the test set are made through standard telephone type jacks or through universal binding posts; these are arranged along the lower edge of the front panel. The sleeve circuits of the SEND jacks are connected to a pin jack to provide for external sleeve connections and the sleeve circuits of the LINE, REC, DIRECT and NMS jacks are connected to another pin jack. The TTS 4BNH series of equipment provides a SEND 309-310, LINE 309-310, REC 310, REC DIR 310 and an NMS 310 jack. The REC DIR jack gives direct access to the amplifier-meter circuits, thereby eliminating the frequency response of the receive transformer. The NMS jack makes it possible to connect external devices, which do not provide a path for DC current, such as certain types of noise measuring equipment, to the line, while holding the external circuits through the DC path provided by the hold coil in the TTS 4BNH set. The LINE 310 jack and the REC 310 jack are located adjacent to each other and they are spaced to permit insertion of a twin plug. This arrangement facilitates testing of 4-wire systems; for these systems the LINE 310 jack provides the send functions and the REC jack provides the receive functions.

1.04 To facilitate measurements on 4-wire circuits, and to provide test terminations, special precision termination circuits have been added. Their purpose is as follows: assume that a 4-wire circuit is terminated at the distant end by a 4-wire termination set and that a test signal is applied to the 2-wire side of this termination set. Assume also that it is desired to measure the transmission loss from the 2-wire far end circuit to the receive leg of the near end 4-wire circuit. In this case it is necessary to make sure that no signals are applied to the near end send leg of the 4-wire circuit. If signals should, by mistake, be applied to the near end send leg, part of their energy will normally be transmitted through the far end hybrid and be added to the far end test signal; the only occasion when this does not occur is when a "perfect" hybrid balance exists at the far end. This extra signal will result in erroneous transmission loss measurements. To insure that no signals can be applied by the TTS 4BNH set to the near end send leg, the line circuit of the TTS 4BNH is terminated in either 600Ω +2 μF or 900Ω +2 μF whenever the LINE switch is in the REC position while, simultaneously, the receive leg of the TTS 4BNH circuit is patched into the REC jack of the set. The position of the REC IMP switch determines whether a 600 Ω or 900Ω termination is used. As precision, non-inductive resistors are used, this circuit can also provide a test termination on the LINE jack for other measurements. Note, however, that a plug, perferably a dummy plug, must be inserted into the REC jack to complete the circuits which connect this test ternination to the LINE jacks.

1.05 The TTS 4BNH and TTS 4BNHR provide maximum send levels of +11 dBm in a 600Ω or a 900Ω circuit. A special 600Ω output circuit can be selected for program circuits. These modes of operation are selected by the SEND IMP switch. The SEND LEVEL attenuator permits immediate selection of levels from +10 to -40 dBm. Intermediate send levels can be established by means of the CAL SEND control.

The receive section of these sets provides 0 dBm readings on the meter for levels from +10 to -60 dBm under the control of the REC LEVEL attenuator. As the meter scale is calibrated from +3.0 dBm to -15 dBm, levels from +13 dBm to -75 dBm can be measured. In addition to the dBm scales, voltmeter scales are provided permitting measurement of voltages from 1.0mV to 3.0V full scale. For voltage measurements the REC IMP switch must be in the 600Ω position.

When accessed through the LINE or REC jacks, the receive section can be used in the 900Ω terminated, the 600Ω terminated or the 600Ω bridging mode of operation under the control of the REC IMP switch. In the bridging mode of operation, the sensitivity is the same as in the terminated mode. When accessed through the REC DIR jack, the receive section is always operated in a bridging, DC blocked, mode; when used in this manner, the circuit can be switched for operation on 600 or 900Ω circuits by means of the REC IMP switch.

1.06 The TTS 4BNH series of sets are equipped with an internal regulated power supply circuit. This circuit can be supplied either from a number of self-contained D cells or from external central office batteries having any voltage between 20 and 70 volts. The condition of the self-contained batteries can be checked by depressing the button marked "BATT TEST". The source of power is selected by the POWER switch. In the center position of this switch, all power is turned off. When closing the cover, a bracket in the cover returns the POWER switch to the OFF position if it had been inadvertently left in the INT BATT position.

Batteries may be replaced by removing the set from the case.

CAUTION: The patch cord for the central office battery operation must be inserted in the "external power" jack on the test set BEFORE the other end is connected to any jack which is used to provide connections to the station battery. To disconnect power, remove connection from central office battery first.

1.07 The TTS 4BNH is contained in a gray finished aluminum case which is approximately 8 ½" wide x 12" long x 10" high. These demensions include the standard detachable hinged cover. The weight of the set is approximately 21 pounds. The eighteen "D-cells" required for the self-powered operation are contained within the case

1.08 This manual describes the TTS 4BNH in detail. Unless specific mention is made of differences, it also applies to the TTS 4BNHR.

Oscillator Section

1.09 The oscillator portion provides for sending individual tone frequencies of 300, 400, 500, 800, 1000, 1400, 1600, 2000, 2300,2500, 2700, 2800, 3000, 3100, 3200, and 3400 Hz, selected by operation of the SEND FREQ switch. An additional position, marked EXT on the SEND FREQ switch, can be used to transfer the frequency determining circuits in the oscillator to a front panel connector socket marked EXT FREQ. Adapter units contained in special removable covers may be connected to this socket to provide additional fixed or variable frequencies for testing program circuits, FAA voice control circuits, etc. One switch position is vacant and is available to install an additional frequency.

Output levels of +10, +7, 0, -5, -10, -16, -20, -25, -30, -35 and -40 dBm can be selected by the SEND LEVEL attenuator, provided the CAL SEND control has been adjusted to provide the correct 0 dBm level. Output levels of +5 and -15 dBm can be substituted for the +7 and -16 attenuator positions on special order. By adjusting the CAL SEND control, intermediate levels may be obtained; in addition, the use of this control permits sending a maximum level of +11 dBm.

1.10 The maximum level variation when switching the self-contained send frequencies is less than 0.1 dB. In general, this permits a change of frequency without requiring a readjustment in the oscillator level for each new frequency. The output of the oscillator is available at jacks designated LINE and SEND and on binding posts.

1.11 The CAL SEND potentiometer, which is used to adjust the send level to the desired value, can be locked in any position by means of a concentric ring on this control.

Precision Terminations

1.12 The set contains a precision 600Ω +2 μF and 900Ω +2 μF termination. These are available on the LINE terminals when the LINE switch is in the REC position and a plug or dummy plug is inserted in the REC jack. Selection of a 600Ω +2 μF or 900Ω +2 μF is done by the REC IMP switch.

Amplifier and Level Meter

1.13 The receive section of the test set provides a level meter which can be operated either on a bridging or a terminated basis. The receive sensitivity is controlled by an attenuator which provides a 0 dB reading on the meter scale for signal levels of +10 +7, 0, -5, -10, -16, -20, -25, -30, -35, -40, -45, -50, -55 and -60 dB. Attenuator steps providing 0 level reading at +5 and -15 can be substituted on special order. As the meter scale is calibrated from +3 to -15 dB. levels from +13 to -75 dBm may be measured. Scale divisions of 0.10 dB between +1.0 and -1.0 dBm and divisions of 0.20 dB for the range +3.0 to +1.0 and -1.0 to -3.0 dB permit accurate measurements over the range of +13 to -63 dB. Between -3.0 and -10.0 dB, sub-divisions of 0.50 dB are provided; below this point the divisions are 1.0 dB. Additional voltmeter scales have been provided on the meter and corresponding markings have been provided on the attenuator to permit use of the receive section to measure voltages from 0.10 mV to 3.0 V To use the voltmeter scales the REC IMP switch should be in the 600Ω terminated or 600Ω bridging position. Individually calibrated meters are used to increase the accuracy of the level measuring section. The meter is driven by a detector circuit which responds to the AVG. value of the applied signal.

Access to the receive portion is obtained either through the LINE jacks or LINE terminals when the LINE switch is in the REC position or through the REC jack or the REC terminals which are connected in parallel with the REC jack. When so accessed, the REC IMP switch permits selection of a 900Ω terminated, a 600Ω terminated or a 600Ω bridging mode of operation. In this mode of operation, a balanced, DC blocked, input transformer is inserted in the receive channel. The "hold" circuit is available only when access is obtained through the LINE jacks or terminals. When accessed through the REC DIR jack, the input transformer is bypassed thereby extending the frequency response of the receive section. In this mode of operation, the receive section is always operated on a bridging basis; DC blocking is provided in this input circuit and the REC switch is used to select operation on 600 or 900Ω circuits. It should be noted that when external equipment is inserted in the NMS jack, the connection between the receive section and the LINE jacks and terminals is interrupted; in this case, it is still possible to access the receive section through the REC or REC DIR jacks, however, hold functions are not available in this mode of operation.

1.14 Highly stable circuits are used in the receive section of this test set. As a result, no front panel control is provided for the calibration of the receive sensitivity. Internal controls are provided for recalibration as described in the section on maintenance.

Talk, Monitor, Calibration and Power Circuits

1.15 The test set contains an induction coil and an internal "talk battery" supply. TEL SET jacks are provided for insertion of a 52A or equivalent headset, thus permitting test personnel to send, receive or talk on any line connected to the LINE jack by moving the LINE key to the desired position. A key designated LINE/MON, when in the OPEN (ON HK) position, opens the hold coil circuit, thus creating an on hook condition for the talk and the receive circuits. To create an on hook condition for the send circuits the SEND IMP key switch must be in the 600P position. In the on hook condition, the talk circuit remains operative and a neon bulb, in series with a capacitor, is connected across the line to indicate incoming ringing signals. In the center position of this switch, a hold coil is placed across the line to provide an off hook condition. The LINE/MON key has a third position marked MON AND 4W TALK which provides a transfer of the headset receiver to the amplifier output circuit. This provides monitoring of the signals which are being measured. Operation of this key will not affect the meter indication. Two series connected LINE jacks, marked 309 and 310, are provided. The line under test is connected to one of these. A dial may be plugged into the second, unused jack. As an alternative, the line under test may also be connected to the LINE terminals.

On 4-wire circuits, the headset transmitter is connected to the LINE circuit and thus to the send leg of the 4-wire system, provided the LINE switch is in the TALK position. When the LINE/MON switch is in the MON AND 4W TALK position, the headset receiver remains connected to the receive amplifier, which in turn is connected to the receive leg of the 4-wire system through the REC jack. This completes the 4-wire talk circuit. Acceptable receive levels in the headset are obtained by moving the REC LEVEL switch until the desired level is obtained.

1.16 A three-position FUNCTION switch is provided. In the CAL SEND position, this switch establishes a direct connection between the send and the receive section of the test set for the purpose of setting up the desired send level. This connection is independent of any connection which may have been made to the set through the jsck strip or the binding posts. The CAL SEND level control is adjusted to obtain the desired send level; normally, this send level is adjusted to provide a 0 dBm reading at 1000 Hz. To set up this adjustment both SEND and REC IMP switches should be set to the desired send impedance and the SEND LEVEL and REC LEVEL controls should be set to the 0 dBm positions. After adjustment, the CAL SEND control may be mechanically locked by means of the concentric ring which is provided for this purpose.

In the center position of the switch the SEND, REC and TALK functions can be selected under the control of the LINE switch. In the REC +TALK position the SEND circuits are disabled and the REC and TALK functions can be selected by the

LINE switch; this eliminates any interference from the SEND circuit when extremely low send signals are to be measured and reduces battery drain.

1.17 A three-position POWER switch is provided. In the center position, the set is turned off. When this switch is moved to the INT BATT position, the set is operated from self-contained D-cells. A bracket in the cover operates the switch to the OFF position when the cover is closed if the switch had been inadvertently left in the INT BATT position. The CO BATT position connects the power from the CO battery to the set. Power from any central office battery having a voltage between 20 and 70 volts may be supplied to the test set through this jack.

CAUTION:
The patch cord for the central office battery operation must be inserted in the CO BATT jack on the test set BEFORE the other end is connected to any jack which is used to provide connections to the station battery. To disconnect power, remove connection from station battery first.

Jack Connections and Terminals

1.18 A number of jacks and two pairs of universal binding posts are located at the bottom of the front panel. A jack marked CO BATT is located near the POWER switch and a connector for external frequency determining networks near the CAL SEND control. The following describes these in more detail.

SL (left) This pin jack located to to the left of the jack strip provides a connection to the sleeves of both SEND jacks.

TEL SET A twin jack to accept a 52A or equivalent headset connects to the talk circuits in the set.

SEND Two cut-off type jacks in tandem, one accepting a 309 and the other a 310 plug, provide direct access to the LINE side of the balanced, DC blocked, output transformer. A low resistance hold coil is connected across the SEND jacks for the 600 and 900Ω positions of the SEND IMP key switch. In the 600P position on this key switch, the hold coil is removed to provide extended low frequency response for measurements on program lines.

LINE Two jacks connected in series; one accepting a 309 and and the other a 310 plug and connected in parallel to the LINE binding posts provide access to the LINE switch in the test set. The LINE switch connects the LINE jacks to either the SEND, TALK or REC circuits of the test set. In the SEND and REC positions of the LINE switch, impedances of 600 or 900Ω are selected by the operation of the SEND IMP or REC IMP keys; in the REC position of the LINE switch, an additional bridging input is available at full sensitivity. In the TALK and REC positions of the LINE switches, a hold coil may be connected across or removed from the line circuit under the control of the LINE/MON key. In the SEND position of the LINE switch a hold coil is connected across the LINE circuit at all times. A telephone dial may be connected to the unused LINE jack to permit dialing test calls through the set.

CALL A recessed neon bulb serves as an incoming ringing indicator when the LINE/MON key is in the LINE OPEN position.

PRECISION TERMINATION The set contains a precision 600Ω +2 μF and 900Ω +2 μF termination. These are available on the LINE jacks when the LINE switch is in the REC position and a plug or dummy plug is inserted in the REC jacks. The impedance of this termination is determined by the position of the REC IMP switch.

REC A jack to accept a 310 plug provides direct access to the LINE side of the balanced DC blocked, input transformer. A pair of universal binding posts is connected across this circuit. No hold circuit is available in this mode of operation.

REC DIR A jack to accept a 310 plug provides direct, DC blocked, access to the high impedance amplifier input attenuator. Using this jack, the input transformer is by-passed to take advantage of the full frequency response of the REC circuits. To avoid the need for recalibration, a pad equivalent to the transformer insertion loss is automatically inserted in the REC circuits when this jack is used. In this mode of operation, theREC IMP switch is used to select operation from 600 or 900Ω circuits. DC voltages in excess of 100 V must not be applied to this section.

NMS A jack to accept a 310 plug provides a direct connection to the LINE jack when the LINE switch is in the REC position. A low resistance hold coil can be bridged across this jack under the control of the LINE/MON key. The amplifier input transformer and the amplifier circuits are disconnected from the LINE circuit when a plug has been inserted in this jack.

SL (right) A pin jack to the right of the jack strip provides a connection to the sleeves of the LINE, REC, REC DIR and NMS jacks.

CO BATT This jack, located near the POWER switch, accepts a 310 plug and provides an input connection to the internal regulated power supply for any central office station battery having a voltage between 20 and 70 volts. See the CAUTION note for the use of this jack under Section 1.06.

EXT FREQ This is a multi-connector which serves to connect external frequency determining circuits to the send section of the test set.

TRANSMISSION PERFORMANCE

2.0 TRANSMISSION PERFORMANCE

Design objective Specifications

SEND SECTION

2.01 General

After a warm-up period of two minutes the output level of the oscillator will hold ±0.1 dB for an ambient temperature of 10° to 40°C when changing to any of the self-contained SEND frequencies. If the test set is used in an area which the temperature varies from the above range, the SEND LEVEL may need to be recalibrated when changing frequencies by means of the CAL SEND control. In temperatures approaching freezing, the efficiency of the batteries drops rapidly and frequent check of the battery condition is recommended.

2.02 Oscillator Performance

Data are for room temperature unless otherwise stated and for battery test readings within the green arc.

Frequency: Controlled by multi-position switch-- 300, 400, 500, 800, 1000, 1400, 1600, 2000, 2300, 2500, 2700, 2800, 3000, 3100, 3200, and 3400Hz. Different frequencies or one extra frequency can be supplied on special order.

External Frequency Plug: An extra position, marked EXT is provided on the SEND FREQ switch and a connector is provided on the panel for connecting external frequency determining net-works.

Frequency Stability: Better than 1% from 10°to 40°C (factory adjustment ½% for 1000 Hz).

Distortion: Less than 1% at any harmonic component.

Output Levels: After initial 0 dBm calibration, using the CAL SEND position of the FUNCTION switch with the attenuator in the CAL positions, TTS 4BNH fixed send levels are +10, +7, 0, -5, -10, -16, -20, -25, -30, -35, and -40. Levels of +5 and -15 can be provided on special order. Other send levels can be obtained by adjusting the CAL SEND control using the CAL SEND position of the FUNCTION switch.

Attenuator Accuracy: Better than 0.10 dB.

Level Variation with Frequency: Less than 0.10 dB for 10° to 40°C.

Output Impedance: Balanced output transformer with DC blocking; impedance selected by switch:
1-600Ω ±5%, ±5° from 300 to 3500 Hz
2-900Ω ±5%, ±5° from 300 to 3500 Hz
3-600P position: 600Ω ±5%, ±5° from 75 to 3500 Hz

Hold Coil: A low resistance hold coil similar to a 274J coil, is provided on the 600 and 900Ω positions of the SEND IMP switch; there is no hold coil in the 600P position.

Output Connections: On either 309 or 310 LINE jacks or LINE terminals when LINE switch is in SEND position. On either 309 or 310 SEND jack irrespective of LINE switch position.

RECEIVE SECTION

2.03 General

The amplifier level meter combination permits reading of signals from +13 dBm to -63 dBm in -0.2 dB divisions by using the attenuator and the scale markings between -3.0 and +3.0 dB. The range from -1.0 to +1.0 dBm is provided with 0.10 dB markings. The meter is individually calibrated. Markings in 0.50 dB from -3 to -10 dBm and 1.0 dB markings from -10 to -15 dBm make it possible to measure signal levels down to -75 dBm. With a 52A headset plugged into the jacks marked TEL SET, operation of the LINE/MON key to the MON position makes it possible to monitor the amplifier output without affecting the meter reading.

2.04 Performance

Data are for room temperature unless otherwise stated and for battery test readings within the green arc.

Input Connections:

1. On either 309 or 310 LINE jack when the the LINE switch is in the REC position. In this circuit a DC blocked, balanced transformer is provided and a low resistance hold coil can be switched in under the control of the LINE/MON switch.

2. On the 310 REC jack; no hold coil is provided in this connection; however, a DC blocked, balanced transformer is provided.

3. On the 310 REC DIR jack, a DC blocked direct access to the amplifier input attenuator is provided and a fixed pad matching the input transformer insertion loss is inserted.

CAUTION

The REC DIR input has DC blocking; however, to prevent internal damage, this input must NOT be used in circuits carrying DC voltages in excess of 100 volts.

NOTE

On the 310 NMS jack, a direct connection to the LINE jack is provided. When the LINE key is in the REC position a low resistance hold coil is provided on this circuit under the control of the LINE/MON switch.

Input Impedance: Balanced input transformer with DC blocking. Impedance selected by switch, 600Ω terminated, 900Ω terminated and bridging 600Ω. "Terminated" impedance is 600 or 900Ω, ±5%, ±5° over the frequency range from 100 to 5000 Hz, except for the LINE input, where the hold coil causes a 7° phase angle at 300 Hz.

Frequency Response: The following data are referred to the response at 1000 Hz at 25°C.

1. Through balanced transformer:
   a) LINE jack
      With hold coil, 600 or 900Ω
      Variation: Less than 0.1 dB from 300 to 8000 Hz
      Less than 0.2 dB from 200 to 10,000 Hz

   b) REC jack
      1 - Without hold coil, terminated, 600 or 900 Ω
      Variation: Less than 0.1 dB from 100 to 8000 Hz
      Less than 0.2 dB from 75 to 15,000 Hz

      2 - Bridging, (in excess of 15,000Ω)
      Variation: Less than 0.1 dB from 150 to 5,000 Hz
      Less than 0.2 dB from 75 to 10,000 Hz

   c) REC DIR jack
      Bridging (in excess of 50,000Ω)
      600Ω or 900Ω circuit selected by REC IMP switch
      Variation: Less than 0.2 dB from 50 to 20,000 Hz

d) Temperature Effect
Frequency response changes are negligible over the range 0° to 50°C.

Receive Levels: Receive levels of +10, +7, 0, -5, -10, -16, -20, -25, -30 -35, -40, -45, -50, -55 and -60 dB will produce a 0 dBm reading on the meter scale for either 600 or 900Ω input impedance, provided the attenuator has been moved to the corresponding position. Levels of +5 and -15 can be provided on special order. By using the meter scale, levels from +13.0 to -63.0 dBm may be read in 0.20 dB increments; readings to -75 dBm can be read at reduced accuracy.

Basic Accuracy: A- ±0.1 dB, 1000 Hz, 600Ω; 25°C to ±10°C.
B- ±0.2 dB, 1000 Hz, 0 dBm, 600Ω; 0°C to 50°C.

Attenuator Accuracy: Better than 0.10 dB.

Meter: A- Range: -15 to +3 dB.
B - Scale: Mirror scale, marked in 0.10 dB steps from -1.0 to +1.0 dB; 0.20 dB steps from +1.0 to +3.0 and -1.0 to -3.0; 0.50 dB steps from -3.0 to -10.0 and 1.0 dB steps below -10.0 dB.
Meter is individually calibrated.

Batteries

2.05 The set uses 18 type "D" flashlight cells for self-powered operation. Battery life is in excess of 200 hours for normal usage.

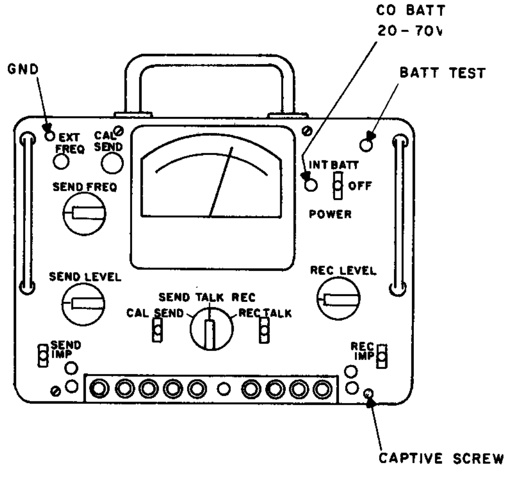
Battery Replacement

To replace batteries, remove the set from the case by loosening the four captive screws marked ➤ Disconnect the battery cable and remove the four screws which hold the battery protective plate. After replacing batteries, reassemble the set using the reverse order of the above steps.

NOTES

TTS 4BNH

MODEL TTS 4BNH TRANSMISSION
TEST SET OPERATION - GENERAL



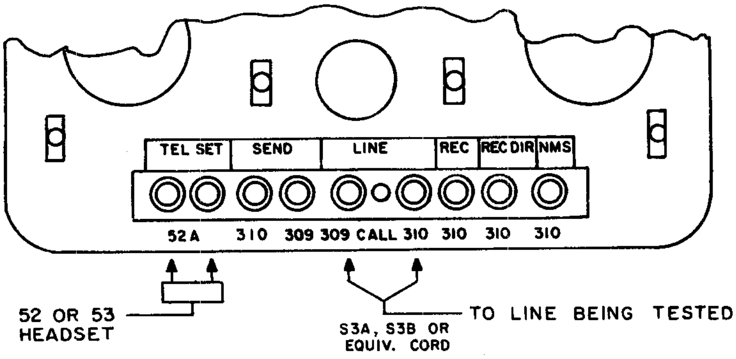
NOTE

The portable version of this instrument has been calibrated with the meter in the horizontal position and the rack-mounted version with the meter in the vertical position. To obtain the specified accuracy, the instrument must be operated in the same position in which it was calibrated. If it is desired to operate the instrument in another position, the instrument must be recalibrated while the meter is in the desired position.

(A) PREPARATION

STEP	PROCEDURE
1	Open lid. (May be removed by moving cover to the right.)
2	Set POWER switch to INT BATT or CO BATT
3	Set SEND FREQ for desired frequency.
4	Wait 90 seconds for warm up.
5	Set SEND LEVEL and REC LEVEL to 0 (CAL).
6	Set FUNCTION to CAL SEND.
7	Set the SEND IMP to 600 P.
8	Adjust CAL SEND for 0 dBm on meter.
9	Set FUNCTION to SEND + TALK + REC

TTS 4BNH



(B) GENERAL OPERATION USING LINE JACK

STEP	PROCEDURE
1	Complete all steps under (A) PREPARATION

(a) TO TALK

STEP	PROCEDURE
2	Connect line to be tested to LINE 310, LINE 309 jack, or LINE terminals depending on type of plug available.
3	Connect 52 or 53 type telephone set to TEL SET jack.
4	Operate LINE key to TALK. This connects the telephone set to line.

(b) TO SEND TONE

STEP	PROCEDURE
1	Set SEND FREQ to desired frequency.
2	Set SEND LEVEL to desired level.
3	Set SEND IMP to desired sending impedance.
4	Operate LINE key to SEND. This connects the output of the oscillator to the line.
5	After a predetermined length of time, restore the LINE key to TALK.

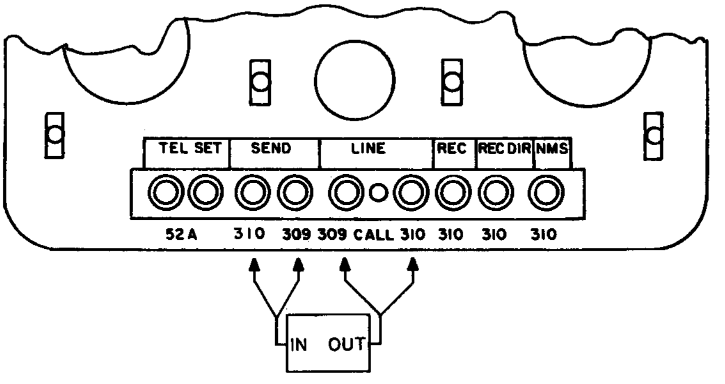
(c) TO MEASURE TONE

1	Set REC IMP to desired impedance.
2	Request tone to be sent.
3	When tone is heard in the telephone set, operate LINE key to REC.
4	Turn REC LEVEL switch to obtain a conventient reading on the meter (between the -3 and +3 marks, if possible) The level is the algebraic sum of the REC LEVEL switch and the meter ading.

Examples:

REC LEVEL	METER READING	LEVEL
+ 7	+2	+ 9
+10	-1	+ 9
0	-1.6	- 1.6
-10	+2.4	- 7.6
-16	-0.6	-16.6

STEP	PROCEDURE
5	To monitor the tone being measured, turn MONITOR key to ON.
6	When tone is removed, operate LINE/MON key to HOLD and LINE key to TALK.



(C) TO MAKE GAIN OR LOSS MEASUREMENTS

STEP	PROCEDURE
1	Complete all steps under (A) PREPARATION.
2	Set SEND FREQ, SEND LEVEL and SEND IMP switches as required.
3	Connect input of equipment to be measured to SEND 310 or SEND 309.
4	Connect output of equipment to be measured to LINE 310 or LINE 309.
5	Operate LINE key to REC.
6	Turn REC LEVEL switch to obtain convenient reading on meter.
7	Gain or loss is the difference between sending level and receiving level.

Example:

SEND LEVEL	REC LEVEL	METER READING	GAIN(+) or LOSS (-)
0	-5	-1.2	- 6.2
0	+7	-0.3	+ 6.7
-20	+10	-2.0	+28.0

TTS 4BNH

(D) TO OPERATE SET FROM CENTRAL OFFICE BATT.

STEP	PROCEDURE
1	Open lid. (May be removed by moving cover to the right.)
2	Insert cord in jack marked CO BATT 20-70V in transmission test set.
3	Insert jack in CO station appearance.

CAUTION: Do not reverse steps 2 and 3. The set is now ready for use.

STEP	PROCEDURE
4	Turn POWER switch to CO BATT position.
5	Wait 90 seconds for warm up.
6	Set SEND LEVEL and REC LEVEL to 0 (CAL)
7	Set FUNCTION to CAL SEND.
8	Adjust CAL SEND for 0 dBm on meter.
9	Set FUNCTION to SEND+ TALK +REC
10	To disconnect test set from station battery, first turn power switch to OFF, next remove cord from CO station appearance, finally remove cord from transmission test set.

CAUTION: Do not change the sequence of steps described here.

(E) TO USE HOLDING FEATURES OF TTS 4BNH IN CONNECTION WITH NOISE MEAS. EQUIP.

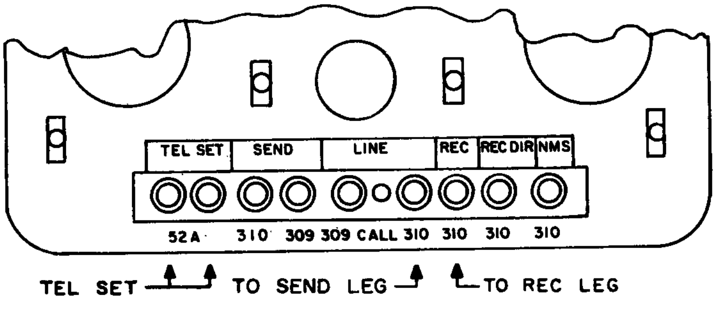
STEP	PROCEDURE
1	Connect the noise measuring set to a cord terminated in a type 310 plug.
2	Insert the cord from the noise measuring set in the jack marked NMS.

NOTE: This disconnects the RECEIVE circuit of the transmission measuring set.

STEP	PROCEDURE
3	At the completion of the noise measuring test, remove the cord from the NMS jack.

NOTE: This restores the RECEIVE section of the transmission measuring set to its normal operation.

TTS 4BNH



(F) TESTING 4-WIRE CIRCUITS

F.1 4-WIRE CIRCUITS IN GENERAL

STEP	PROCEDURE
1	Complete all steps under (A) PREPARATION.
2	Set SEND and RECEIVE impedance switches to the desired value.
3	Connect headset cord to TEL SET jack.
4	Set LINE/MON switch to MON AND 4W TALK position.
5	SET LINE switch to TALK position.
6	Insert a 4-wire cord into the LINE and REC jacks which are marked 4-W SND and 4-W REC.
7	Insert the other end of the 4-wire cord into the twin LINE jacks of the 4-wire telephone set.

F.2 DIALING ON 4-WIRE CIRCUITS

Multi-Frequency Dialing

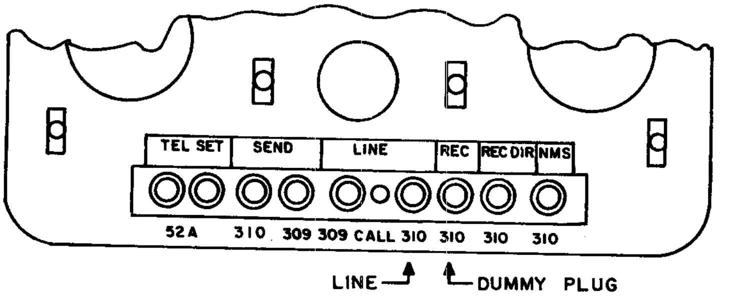
Some 4-wire systems are equipped with multi-frequency tone dialing generated in the subscriber set. If the TTS 4BNH Unit is to be used in such a circuit and it is desired to establish connection, complete all the steps 1-7 listed above and thereafter proceed as follows:

STEP	PROCEDURE
8	Insert a 2-wire cord into the EQUIP-SEND jack of the telephone set and remove its hand set.
9	Insert the other end of the 2-wire cord into the NMS jack of the TTS 4BNH.
10	Move the LINE switch in the TTS 4BNH set to the REC position.
11	Establish the desired connection by dialing the desired number in the 4-wire telephone set.
12	Move the LINE switch to the TALK position and check that

TTS 4BNH

F.2 DIALING ON 4-WIRE CIRCUITS

STEP	PROCEDURE
12	the desired number has been reached.
13	Return the hand set of the 4-wire telephone set to the ON HOOK condition.
14	The TTS 4BNH is now ready to make transmission measurements.
15	Upon completion of measurements; move the LINE switch to TALK and the LINE/MON switch to LINE OPEN. This releases the circuit.

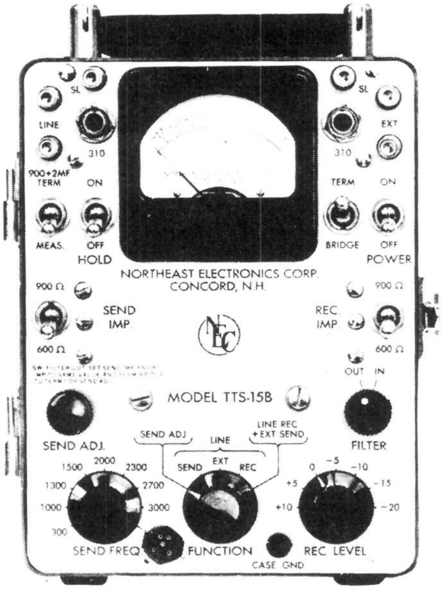


(G) TO USE PRECISION TERMINATION

STEP	PROCEDURE
1	Select desired terminating impedance on REC IMP key.
2	Connect circuit to be terminated to LINE 310 jack.
3	Insert a "dummy" plug in the REC 310 jack.
4	Move the LINE key to the REC position. The circuit under test is now terminated in either $600\Omega+2\mu F$ or $900\Omega+2\mu F$.

MODEL 15B AND 15C TRANSMISSION TEST SETS (NORTHEAST ELECTRONICS CORPORATION)

OPERATING PROCEDURES



TTS 15B

TTS 15C

1. GENERAL

1.01 This section provides the operating procedures for Northeast Electronics Corporation Model 15B and 15C transmission test sets.

1.02 The section is reissued to add procedures for the 15C transmission test set, and to make extensive changes in the practice format. Arrows have been omitted.

1.03 In general use, the test sets require no routine maintenance other than the periodic replacement of batteries and the occasional calibration of the mechanical meter "zero". Should problems develop that indicate that the test set is not functioning properly, accuracy checks and repair service are available at Western Electric service centers under the "Red Ball" program.

1.04 The Northeast Electronics Corporation Model TTS 15B is a portable test set that measures signal levels from +13 dBm to -37 dBm over a range of eight fixed frequencies. The send and receive test functions may be performed separately or simultaneously for either "end-to-end" or "loop" testing. Specifications for the TTS 15B and TTS 15C are shown in Table B.

1.05 The Model TTS 15C is identical to the TTS 15B, however, it provides for the following additional features:

(a) Output transformer.

(b) Battery test circuit. (Under control of the BATT TEST pushbutton.)

(c) Power may be supplied by an internal battery or the 48V central office battery.

2. FRONT PANEL CONTROLS

2.01 Table A indicates the functions of all of the front operating controls and indicators. The numbers on the photographs of the TTS 15B and TTS 15C, as shown in Fig. 2, relate to the index numbers provided in the index number column of Table A.

2.02 The TTS 15B and 15C may be operated in either the vertical or horizontal position. When the lid is closed on either the 15B or 15C, a projection inside the lid will automatically turn off the power switch, thus preventing the batteries from running down when the set is not in use.

Note: When the test set is not in use, the cover should be latched closed to protect the set from dust and damage. When the cover is to be left open, it may be removed from the base by sliding it upward.

2.03 CAUTION: When applying external power to the TTS 15C, the power supply cord should be jacked into the TTS 15C FIRST and then connected to the 48V central office battery. Conversely, for the REMOVAL of the external power, the power supply cord should be disconnected from the central office battery supply FIRST and then removed from the TTS 15C jack.

3. INTERNAL BATTERY TESTS

3.01 To prevent false' and erroneous meter readings, the condition of the test set internal batteries should be checked prior to starting transmission tests. In addition, if the test set is employed for an extensive series of tests, the condition of the batteries should be checked periodically.

3.02 Exhausted batteries should be replaced as soon as possible, to prevent damage to the test set because of corrosion. In the event that the test set is to be held in storage, the batteries should be removed and the test set tagged accordingly.

3.03 To test the condition of the batteries in the TTS 15B, proceed as follows:

(1) Operate the SEND IMP and REC IMP switches to 600 ohms.

(2) Turn the FUNCTION switch to SEND ADJ.

(3) Operate the TERM/BRIDGE switch to the TERM position.

(4) Turn the FILTER switch to the OUT position.

(5) Turn the SEND ADJ control knob in a clockwise direction, as far as it will rotate.

(6) Operate the POWER switch to ON.

(7) Read the meter; it should read +1.5 or higher in the red portion of the scale. If the meter reading meets or exceeds the +1.5 requirement, the batteries are in satisfactory condition.

(8) In the event that the +1.5 requirement cannot be met, replace both internal batteries with new Eveready #2356 or equivalent batteries.

(9) To replace the batteries, remove the unit from the case and replace the batteries by removing the screw holding the battery clamp plate to the bottom of the case. When refastening the clamp plate, check to make certain that the battery leads are not short circuited.

3.04 To test the condition of the batteries in the TTS 15C, proceed as follows:

(1) Operate the POWER switch to ON.

(2) Depress the BATT TEST pushbutton.

(3) The meter needle should read in the GREEN sector or beyond (toward the right hand portion of the meter).

(4) In the event that this requirement cannot be met, replace all (10) D type battery cells. The replacement may be accomplished by removing the battery cover on the back of the case without removing the unit from the case.

4. THE FUNCTION OF THE HOLD CIRCUIT AND THE FILTER CIRCUIT

4.01 Hold Circuit: Facilities connected to the line jack or test set binding posts may be held regardless of any other switch position by operating the HOLD switch to the ON position.

4.02 Filter Circuit: The high pass filter minimizes the affects of power line related interference at the input of the test set. Signals appearing at the input of the receive circuitry will be processed by the high pass filter regardless of any other switch position, by operating the FILTER switch to the ON position.

5. "DATA-PHONE" OR DIAL TELEPHONE FACILITIES - TELEPHONE TEST SET CONNECTIONS

5.01 To arrange to dial, talk or monitor on a dial-up type telephone (DATA-PHONE) facility in conjunction with a TTS 15 type test set proceed as follows:

(1) Operate the POWER switch to ON.

(2) Operate the HOLD switch to OFF.

(3) Set REC IMP at 900 ohms.

(4) Connect the telephone test set to the EXT jack or binding posts.

(5) Turn the FUNCTION switch to the LINE-EXT position.

(6) Connect the circuit to the LINE jack.

(7) Dial test number(s).

(8) To hold the circuit for transmission measurements, operate the HOLD switch to the ON position before changing the position of the FUNCTION switch.

6. CALIBRATION OF METER ZERO AND SEND LEVEL

6.01 The mechanical meter zero is adjusted at the factory, however, it may require periodic minor adjustment. The adjustment screw is located on the front of the meter. The zero calibration should always be checked prior to starting transmission tests and readjusted if necessary.

6.02 The calibration of the send level is usually made at 1000 Hz. When it is necessary to make tests at frequencies other than 1000 Hz, the level variation from a calibration at 1000 Hz is less than 0.2 dB for the fixed step frequencies. In most instances, a variation of less than 0.2 dB allows for a change in testing frequency without recalibration at each frequency.

6.03 The send level may be calibrated to any required value between 0 dB and -37 dBm. While it is possible to set it for values above 0 dBm, this is likely to introduce distortion and is not recommended. To calibrate the send level, proceed as follows:

(1) Turn POWER switch ON.

(2) Test the condition of the batteries.

(3) Set the MEAS/900 OHM TERM switch to MEAS.

(4) HOLD switch OFF.

(5) TERM/BRIDGE switch at TERM.

(6) SEND IMP switch at 600 or 900 ohms.

(7) REC IMP switch at same impedance as SEND IMP switch.

(8) FILTER switch at OUT.

(9) SEND FREQ switch at 1000 Hz or as required.

(10) REC LEVEL switch at nearest value to desired sending level.

(11) FUNCTION switch at SEND ADJ.

(12) Adjust SEND ADJ control.

Note: For 0 dBm obtain 0 on the meter. For other levels, adjust so the algebraic sum of the REC LEVEL switching setting and the meter reading equals the required value.

(13) This completes the calibration of the send level. As long as the SEND ADJ control is not changed, resetting the REC LEVEL switch for subsequent tests has no effect upon the send level.

7. TRANSMIT TEST SIGNAL

7.01 To transmit a test signal "On-Line", proceed as follows:

(1) Turn POWER switch ON.

(2) Test the condition of the batteries, if it has not been done previously.

(3) Set the MEAS/900 OHM TERM switch at MEAS.

(4) HOLD switch OFF.

(5) TERM/BRIDGE switch (not involved).

(6) SEND IMP switch at circuit impedance.

(7) REC IMP switch (not involved).

(8) FILTER switch (not involved).

(9) FREQ switch at required frequency.

(10) REC LEVEL switch at correct level.

(11) FUNCTION switch at SEND ADJ.

(12) Adjust the SEND ADJ potentiometer for desired send level on meter.

(13) FUNCTION switch at LINE - SEND.

(14) Patch the circuit under test into the LINE jack or binding posts. At this point, the TTS 15 is transmitting a tone at the desired frequency and level into the circuit.

8. RECEIVE TEST SIGNAL

8.01 To arrange for the test set to receive "On-Line" test signals from a distant end oscillator, on a private line basis, proceed as follows:

(1) Turn POWER switch ON.

(2) Test the condition of the batteries, if it has not been done previously.

(3) Set the MEAS/900 OHM TERM switch at MEAS.

(4) HOLD switch OFF.

(5) TERM/BRIDGE switch as required.

(6) SEND IMP switch (not involved).

(7) REC IMP switch at circuit impedance.

(8) FILTER switch as required.

(9) FREQ switch (not involved).

(10) REC LEVEL switch at +10.

(11) FUNCTION switch at LINE REC.

(12) SEND ADJ control (not involved).

(13) If it is necessary to monitor the incoming signal, connect a (1011) telephone test set to the extension jack or binding post.

(14) Patch the circuit under test (tip & ring) into the LINE jack or binding posts of the TTS 15B or 15C test set.

(15) Adjust the REC LEVEL switch setting to obtain a meter reading between +3 and -3 if practicable, otherwise as close to this range as the set will permit. The transmission measurement in the algebraic sum of the REC LEVEL switch setting and the meter reading as long as the send level corresponds to the design level of the circuit at the point of application.

9. LOCAL LOOP MEASUREMENTS - SENDING AND RECEIVING SIMULTANEOUSLY

9.01 The loss of a circuit or portion of a circuit (measured in dBs) is the output power of the oscillator minus the power read on the measuring set (in dBm) provided the test sets have purely resistive impedances and are matched to the circuit. Example: 600:600, 900:900 ohms.

9.02 Impedance mismatches between the circuit and the test sets cause the circuit under test to measure more loss than is actually present in the circuit. If impedance mismatches cannot be avoided, the error caused by commonly encountered mismatches should be subtracted from the measured circuit loss.

IMPEDANCE MISMATCH	CORRECTION (For each mismatch)
600 : 1200	0.5 dB
600 : 900	0.2 dB
900 : 600	0.2 dB
900 : 1200	0.2 dB

9.03 The TTS 15B and 15C test sets may be used for local measurements requiring the test set to send and receive simultaneously. It is possible to make repeater gain tests (maximum of 13 dB when sending at zero level), and test for insertion gain or loss on four-wire facilities, etc. To arrange the TTS 15B or 15C for simultaneous operation, proceed as follows:

(1) Turn POWER switch ON.

(2) Test the condition of the batteries, if it has not been done previously.

(3) Set the SEND IMP and REC IMP switches to correspond to the input impedance of the facility or equipment to be tested. Calibrate the send level (as described in 6.02). For the balance of this test, do not change the setting of the SEND IMP switch.

(4) Set the MEAS/900 OHM TERM switch at MEAS.

(5) TERM/BRIDGE switch at TERM.

(6) SEND IMP switch, as described in step 3 above. (Do not change setting during subsequent steps.)

(7) REC IMP switch at the setting of the output impedance of the line or equipment to be tested.

(8) FILTER switch - as required.

(9) FREQ switch at the desired frequency setting. For a test at a frequency other than 1000 Hz, a variation of up to 0.2 dB may be encountered as described in 6.02. If recalibration is required, steps 3 through 7 above, should be checked.

(10) REC LEVEL switch at +10.

(11) FUNCTION switch at LINE REC + EXT SEND.

(12) SEND ADJ unchanged from calibration sequence.

(13) Patch the input of the circuit or equipment to be tested into the EXT jack or binding posts.

(14) Patch the output of the line or equipment under test to the LINE jack or binding posts. The test set is now sending into the input of the line or equipment to be tested and receiving from the output.

(15) Adjust the REC LEVEL switch setting to obtain a meter reading between +3 and -3 if practicable, otherwise as close to this range as the set will permit. The transmission measurement is the algebraic sum of the REC LEVEL switch setting and the meter reading.

10. SUMMARY OF PROCEDURES

10.01 General transmission requirements for Bell System equipment and facilities may be found in the 300 Division series of Bell System Practices. Specific transmission parameters for a particular item of equipment will usually be found in the installation and maintenance practices associated with the equipment.

10.02 For the end-to-end transmission measurements on DDD and private line facilities, there are four basic steps that should be applied to obtain accurate results:

(1) Calculate the desired oscillator output contingent upon the test level for the type of circuit involved.

(2) Calibrate and adjust the oscillator to the desired output.

(3) Read and record the transmission measurement.

(4) Correct the reading for impedance mismatches and verify test level.

10.03 A transmission level point (TLP) is a point in a circuit at which the transmission level (expressed in dB) is defined as the nominal or design gain (or loss) at 1000 Hz referenced to an arbitrary point in the system called the zero transmission level point or 0 TLP. The use of a standard reference point in Bell System channels makes it possible to compare the signal power at two or more points in the channel even though the points are many miles apart.

10.04 With the establishment of the 0 TLP concept, the power present in a channel is described by stating what the power would be if it were accurately measured at the 0 TLP. The standard notation used to describe the power in this instance is dBm0. As an example, the term -13 dBm0 means that the power at the

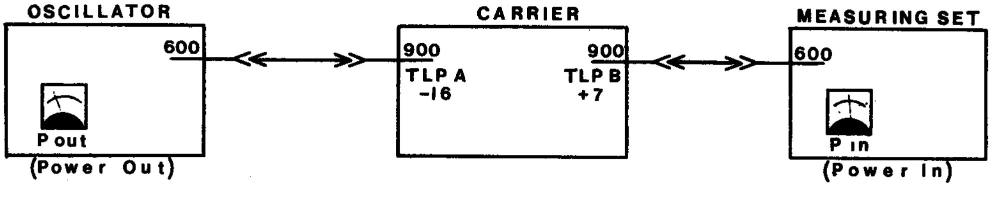
0 TLP is -13dBm; if a -13 dBm0 signal were measured at the 0 TLP, the meter of the test set would indicate -13 dBm.

10.05 The TLPs and the test level of the circuit provide the information needed to set the oscillator output and to interpret the reading on the transmission measuring set. The test level of a circuit, expressed in dB0, is the level at which the circuit should be tested relative to the TLPs. Common test levels are as follows:

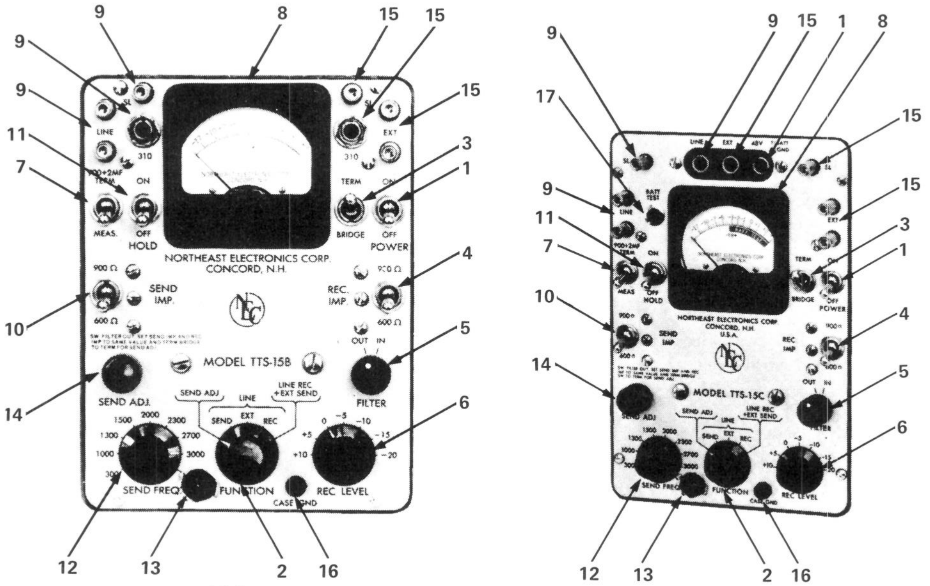
TEST FOR	TEST LEVEL (In dB0)
DATA	-13
SF SIGNALING	-20
VOICE	0 (Zero)

10.06 The test level must be added to each TLP pertinent to a test. For example, for the circuit diagram, Fig. 1 (assuming the test level to be -13 dB0) the test level added to TLP "A" indicates the oscillator (power) setting at "P" out. The test level added to TLP "B" minus any impedance mismatch corrections indicates the expected measuring set reading at "P" in.

FIGURE 1
(TEST LEVEL -13dBO)



A. P out is set to: -13, -16= -29dBm
B. The reading on the transmission measuring set is expected to be: +7 -13 -0.2 -0.2 = -6.4dBm, taking the two impedance mismatches into account.
C. If "P" in were to read -8 dBm, the facility would be 1.6dB too long.
D. If "P" in were to read -4 dBm, the facility would be 2.4dB too hot.



15 B   15 C

Fig. 2

FRONT PANEL CONTROLS

TABLE A

TTS 15B & 15C FRONT PANEL CONTROLS

Photo Index No.	CONTROL or INDICATOR	Type of Test Set	DESCRIPTION
(1)	POWER ON/OFF switch:	TTS 15B	Applies internal battery power to the circuitry within the set.
	POWER ON/OFF switch and 48V jack:	TTS 15C	Provides power switching and input connections.
(2)	FUNCTION switch:	TTS 15B & C	Determines one of the following five modes of operation: (1) SEND ADJ - connects SEND SECTION to the level measuring section to permit calibration of the SEND level. (2) LINE/SEND - connects the SEND SECTION to the LINE jack. (3) LINE/EXT - connects the LINE jack directly to the EXT jack.

TABLE A (Continued)

Photo Index No.	CONTROL or INDICATOR	Type of Test Set	DESCRIPTION
(2) (Cont.)	FUNCTION switch (Cont.)	TTS 15B & C	(4) LINE/REC - connects the level measuring section to the LINE jack and connects the EXT jack to the receiver output for monitoring. (5) LINE REC/EXT SEND - connects the level measuring section to the LINE jack and simultaneously connects the SEND SECTION to the EXT jack.
(3)	BRIDGE/TERM switch:	TTS 15B & C	Enables maintenance personnel to bridge or terminate the connections appearing at the LINE jack or binding posts.
(4)	REC IMP switch:	TTS 15B & C	Selects the terminating impedance of the receiving circuitry within the set (600 or 900 ohms)
(5)	FILTER IN/OUT switch:	TTS 15B & C	Switches the high pass filter into or out of the receive circuitry.
(6)	REC LEVEL rotary Attenuator switch:	TTS 15B & C	Adjusts the sensitivity of the receive circuitry over a range of 30 dB in steps of 5 dB
(7)	MEAS/900 Ohm TERM switch:	TTS 15B & C	Switches the receive circuitry or the 900 ohm termination across the LINE jack or binding posts.
(8)	METER:	TTS 15B	Provides a visual indication of received levels and instrument calibration.
		TTS 15C	Provides visual indication of receive levels, instrument calibration and condition of the power source.
(9)	LINE jack and binding posts:	TTS 15B & C	Provides for access to the SEND or RECEIVE circuitry within the test set.
(10)	SEND IMP switch:	TTS 15B & C	Selects the output impedance for the send circuitry within the set.

TABLE A (Continued)

Photo Index No.	CONTROL or INDICATOR	Type of Test Set	DESCRIPTION
(11)	HOLD ON/OFF switch:	TTS 15B & C	Switches a hold coil across the LINE jack or binding posts.
(12)	SEND FREQ rotary switch:	TTS 15B & C	Selects either one of eight internal fixed frequencies or the external frequency determining network accessory. *
(13)	External Frequency Network Connector (*Optional Equipment):	TTS 15B & C	Provides for the insertion of an external frequency determining network.
(14)	SEND ADJ potentiometer:	TTS 15B & C	Provides an adjustment of output level.
(15)	EXT jack and binding posts:	TTS 15B & C	Provides access to the send or receive circuitry within the test set.
(16)	CASE GND jack:	TTS 15B & C	Provides access to the case ground of the test set.
(17)	BATT TEST pushbutton:	TTS 15C	Provides a means of checking the condition of the test set's power source.

TABLE B

TTS 15B & 15C SPECIFICATIONS

RECEIVING SECTION	Specifications
Input Impedance:	600 Ohms and 900 Ohms ±5% at 1000 Hz.
Bridging Impedance:	Filter OUT = 15,000 Ohms Minimum. Filter IN = 8,000 Ohms Minimum.
Frequency Response: (Filter Out)	±0.25 dB from 200 to 15,000 Hz. ±0.50 dB from 100 to 20,000 Hz.
Frequency Response: (Filter In)	±0.25 dB from 500 to 15,000 Hz. 60 Hz attenuated at least 30 dB.
Range of Measurements:	+13 dBm to -37 dBm.
Division of Meter Scale:	0.2 dB divisions from +3 dB to -3 dB. 0.5 dB divisions from -3 dB to -7 dB. 1.0 dB divisions from -7 dB to -17 dB.
Stability of Calibration:	±A maximum of 0.1 dB from 50° to 120° F using 70° F as a reference. ±A maximum of 0.1 dB with a supply voltage change ranging from 18V dc to 12V dc.

SENDING SECTION	
Output Impedance:	600 Ohms and 900 Ohms ±5% at 1000 Hz.
Output Frequencies:	300, 1000, 1300, 1500, 2000, 2300, 2700 and 3000 Hz. All frequencies ±2% from 50° F to 100° F.
Distortion:	Less than 1% at any harmonic.
Level Variation with Frequency:	Less than ±0.2 dB.
Output Level:	Variable from 0 dB to -37 dBm.

NOTES

ABRIDGED

25B AND 25BR VOICEBAND GAIN AND DELAY SETS (J94025B AND J94025BR) DESCRIPTION, OPERATION, AND MAINTENANCE

CONTENTS PAGE

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 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.

1.03 The 25B and 25BR sets replace the 25A voiceband gain and delay measuring set (J94025A). The 25B-type sets are compatible with the 25A set and can be used interchangeably with the 25A set, except if recorder measurements are required (only the 25B-type 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 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, if the test signal has the same frequency as the single-frequency signaling system, operation of the signaling system can occur and cause loss (dropping) of the test connection.

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 size rack from 19 inches up. The 25BR set does not have dialing and holding features or facilities for interchanging the transmitting and receiving lines. Connectors are provided at the rear of this set for connecting power 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 In many cases of delay measurements, and whenever the maximum possible accuracy of delay value is not required, the loop method of measurement is usually used. 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), since the total measured delay of the loop divided by 2 will usually give only an approximation of the actual delay for each direction. However, the rapidity of the loop method and the fact that no delay set and no testing help are required at the far end make the method useful in many cases, eg, when delay trouble is suspected or when only an approximate measurement is required. The loop method is also used in measurements on networks or equipment components where both in and out terminals are in the same office.

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 of 25BR set at one end.

(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

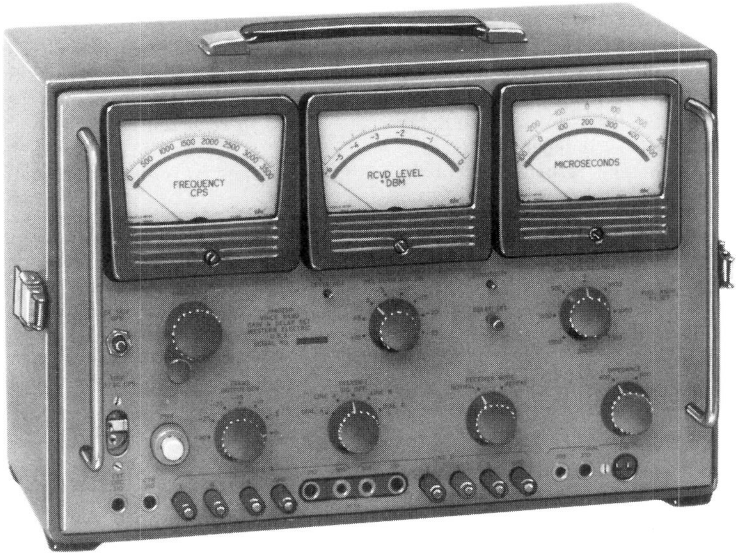


Fig. 1 — 25B Portable Set

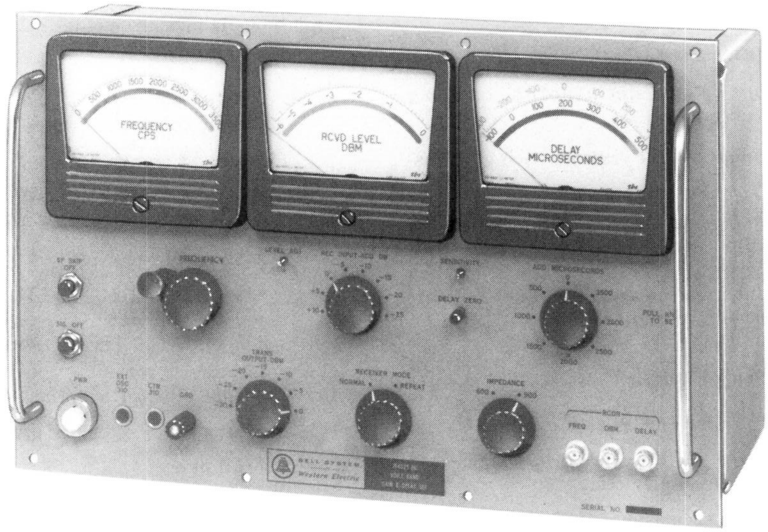


Fig. 2 — 25BR Rack-Mounted Set

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. 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.

2.12 Proportional outputs of the measured data are 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.

2.13 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.

(c) ***Loss or gain*** of the return path from the far-end set. Note that this loss or gain is, in normal operation, only a single frequency measurement, not the entire frequency characteristic of the return facility.

Far-End Set (Repeat Mode):

(a) ***Loss or gain*** of 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 measuremnt accuracy (See Note below):	
600 to 3500 Hz (internal oscillator)	±10 μsec

600 to 25,000 Hz (external oscillator)	±10 μsec
300 to 600 Hz (internal or external oscillator)	±20 μsec

Note: Accuracies of ±5 μsec can be obtained for equalized facilities having an envelope delay distortion of 100 μsec or less and a gain distortion of ±1 dB or less over the frequency range of 1000 to 2600 Hz. Accuracies of ±5 μsec 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: This is the minimum separation between ripples, in a given delay characteristic, which can be resolved.

2.17 ***Impedance***

Input and output impedance:	600 or 900 ohms
Impedance accuracy (input and output):	
Magnitude	±10 percent
Phase	±6 degrees

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/μsec
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 4.12 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 3A noise measuring set having 3-kc 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 frequencis 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 which 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-μsec 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 warmup 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.

4.02 ***Calibrate as follows:***

(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 warmup period of at least 20 minutes.

(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 check 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 6.09.

(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 in order to make this adjustment.

(9) Pull out on the ADD MICROSECONDS knob and re-engage 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 (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 through 6.12).

LOOP MEASUREMENTS

4.03 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.

4.04 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 where delay trouble is suspected and only an approximate measurement is required. The loop method is also used in measurements on networks or equipment components where both input and output terminals are in the same office.

4.05 ***Loop Measurement Procedure***

(1) Switch the RECEIVER MODE control to NORMAL.

(2) Warm up and calibrate the set as described in 4.02.

(3) If recorder measurements are to be made, calibrate the recorder as described in 4.14. If oscilloscope measurements are to be made, calibrate the oscilloscope as described in 4.18.

(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.)

(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 which 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 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. These features must be supplied separately if desired.

(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.)

(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.

(9) Set the RCVR INPUT-ADD DB control to a position that causes the RCVD LEVEL meter to read on scale.

> *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-μsec 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 predominantly 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, then 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 dBm gain.

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-μsec 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 signal frequency units having frequencies other than 2600 Hz, the TRANSMIT control on a 25B set can be set to the SIG OFF position or the SIG OFF pushbutton on a 25BR set can be depressed, while sweeping the test frequency through the critical signaling frequency region.

STRAIGHTAWAY MEASUREMENTS

4.06 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.

4.07 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.

4.08 The far-end set operates in the ***repeat*** mode; that is, 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) which 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 a minimum at this frequency.

4.09 Both sets should be warmed up and calibrated, as described in 4.01 and 4.02, 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 utilized. In some cases, however, it may be desired to reverse the direction of measurement in order 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.

4.10 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.

4.11 ***Straightaway Measurement Procedure***

Near-End Set

(1) Connect the power, warm up, and calibrate as described in 4.01 and 4.02.

(2) If recorder measurements are to be made, calibrate the recorder as described in 4.14. If oscilloscope measurements are to be made, calibrate the oscilloscope as described in 4.18.

(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 level (usually −10 dBm0).

(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 (10) of 4.05.

(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, warm up, and calibrate as described in 4.01 and 4.02.

(2) If recorder measurements are to be made, calibrate the recorder as described in 4.14. If oscilloscope measurements are to be made, calibrate the oscilloscope as described in 4.18.

(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 4.10.

(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 appropriate 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.)

(12) Record the frequency and the level as received over the test line from the originating set.

ABRIDGED

6F AND 6FR VOICEBAND NOISE MEASURING SETS

(J94006F AND J94006FR)

DESCRIPTION, OPERATION, AND MAINTENANCE

CONTENTS **PAGE**

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.

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 C-message filter which was supplied with the 6F and 6FR sets has been replaced with a C-notched filter. An additional network for measurements on 50-kilobit wideband facilities is available.

1.03 The 6F and 6FR sets provide a means for measuring impulse noise distribution and the rms value of message circuit noise in the frequency range of 50 Hz to 25 kHz. 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.

1.04 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.

1.05 A timer provides for measuring impulse counts over a preset time interval while the set 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.

1.06 The 6F portable set (see 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.

1.07 The 6FR rack-mounted set (see Fig. 2) can be mounted in a rack ranging in size from 19 inches up. It operates from the −48 volt office battery.

1.08 Plug-in weighting networks provide a means for selecting the passband of frequencies to be measured. One network, having ♦C-notched♦ weighting on one side and flat weighting on the other, is supplied with each set. ♦C-message or 50-kilobit/second networks (with flat weighting on the other side) are also available for measurements.♦ These networks have about 5 dB of flat loss and variations of this flat loss are compensated for in the calibration of the sets.

1.09 An internal calibration oscillator generates a standard signal for checking the sensitivity

Fig. 1—6F Portable Set

of the meter circuit amplifier and for adjusting the threshold levels of the counter circuits. Once it is adjusted, it provides a stable calibration source for several months without readjustment regardless of dc supply voltage and ambient temperature variations.

1.10 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.

1.11 A pushbutton switch (CTR STOP) provides for disconnecting signals from the trigger circuits while the counters are being reset.

1.12 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).

Fig. 2—6FR Rack-Mounted Set

1.13 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 frequency (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 are itemized in Tables A and B, 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. When using filters other than the flat filter, the measurement accuracies listed in Tables A and B must be modified to include the frequency characteristic of the particular filter being used. Figure 3 shows the ideal frequency characteristic for the C-message ►(497D)◄ weighting network.

♦Figure 4 shows the typical frequency characteristics for the C-notched weighting network (497G). The C-notched weighting network has a frequency characteristic similar to that of the C-message filter but indicates a band rejection filter centered about 2800 Hz to permit measurements on compandored or mixed compandored-noncompandored circuits. Figure 5 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.♦

1.14 Table C shows the electrical specifications for the 6F and 6FR sets.

TABLE A

MEASUREMENT ACCURACY FOR IMPULSE NOISE MEASUREMENTS

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

2. OPERATING INSTRUCTIONS

2.01 ***Calibration of Set:*** 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 calibration procedure is simple and requires no external equipment. It is as follows.

(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. Verify that the meter indicates in the BAT GOOD area. If it does not, replace the batteries in a 6F set per 3.03 and 3.04 or check the office battery connection for a 6FR set.

(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 CAL controls by depressing the associated pushbutton switch and adjusting the associated CAL control until the counter just counts, as in (4).

TABLE B

MEASUREMENT ACCURACY FOR MESSAGE CIRCUIT NOISE MEASUREMENTS

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

Note: During this calibration procedure only .inter will operate at a time. For

TABLE C

ELECTRICAL 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 1.13).

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.

(6) Set the FUNCTION switch to CAL-MTR and adjust the meter CAL control for a meter indication at the CAL marking.

(7) 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 3.02.

2.02 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. 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. Multipled jacks and binding posts on the front panel

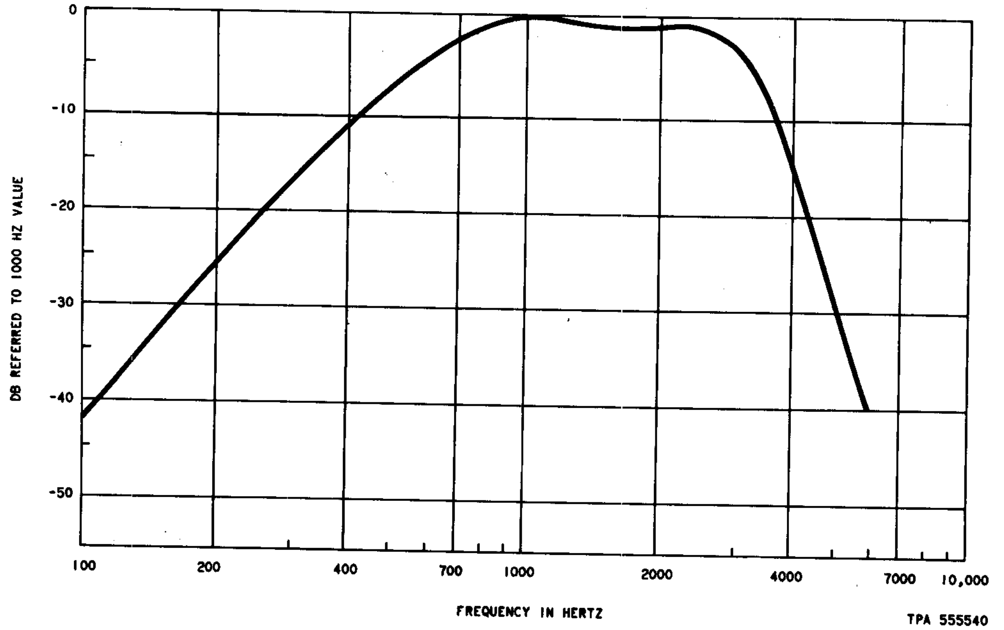


Fig. 3—Ideal Frequency Characteristic of C-Message Weighting Network

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. 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.

2.03 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. 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. 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. 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

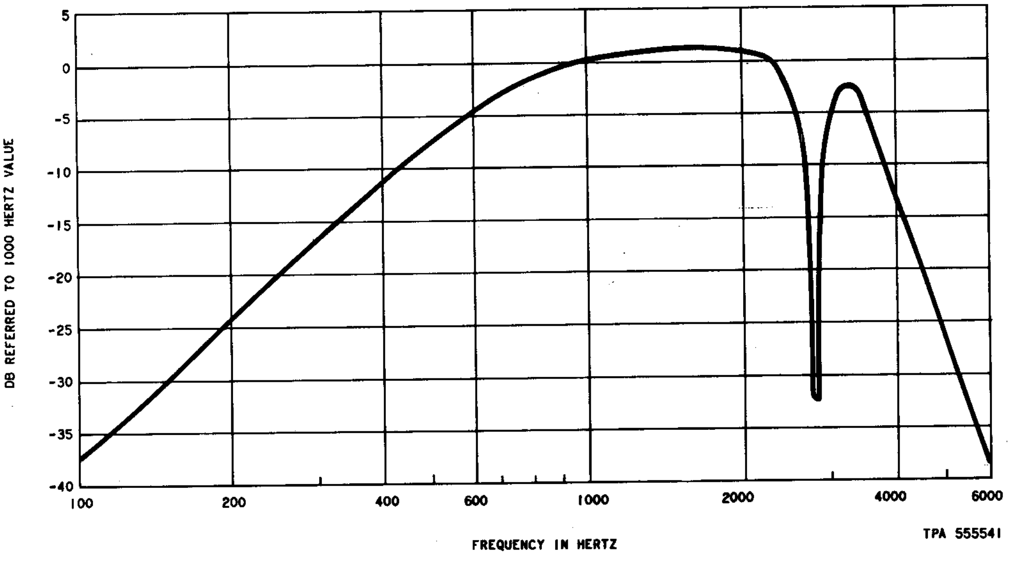


Fig. 4—♦Typical Frequency Characteristic With C-Notched Weighting♦

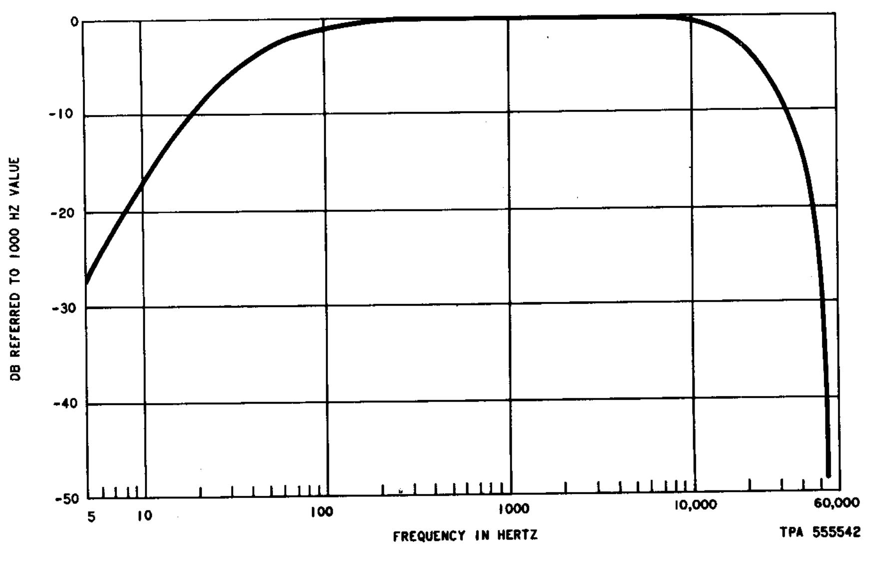


Fig.5—♦Typical Frequency Characteristic of Impulse Noise Circuits with 50-Kilobit/Second Weighting♦

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 DRBN 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.

2.04 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. 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.

2.05 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. 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.

> ***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.

2.06 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.

2.07 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. 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.

> ***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.

2.08 Figures 6 and 7 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. Both curves are very similar and have 3-dB points at about 50 Hz and 25 kHz.

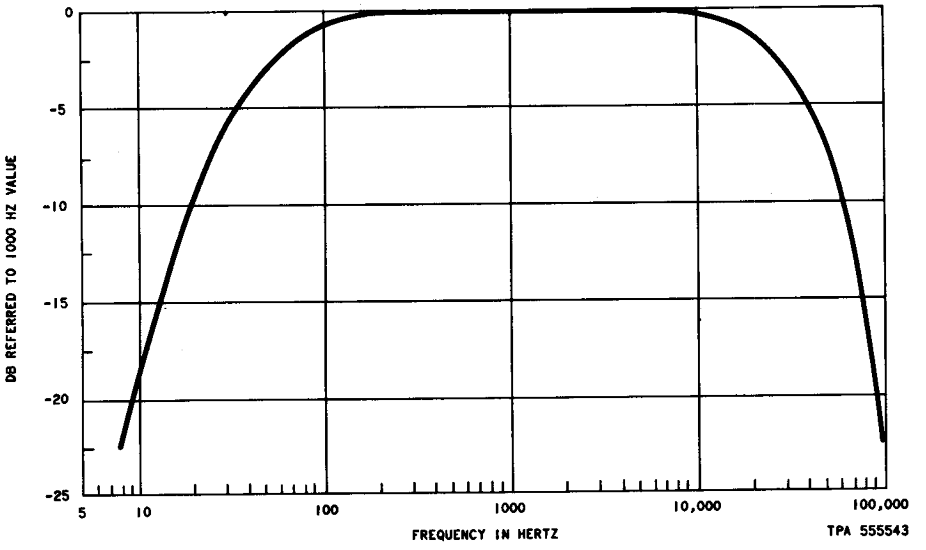


Fig. 6—Typical Frequency Characteristic of Impulse Noise Circuits With Flat Weighting

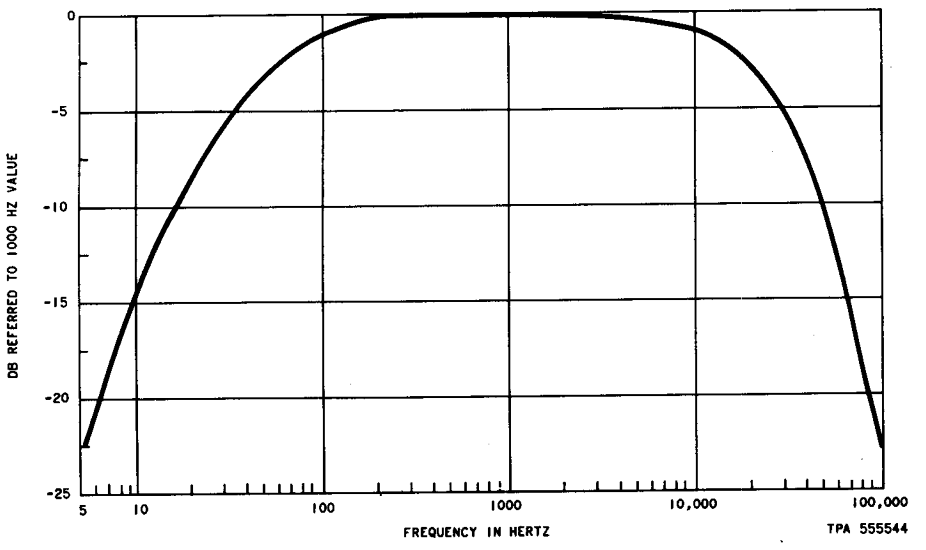


Fig. 7—Typical Frequency Characteristic of Message Circuits With Flat Weighting

2.09 Following is the operating procedure for a typical measurement.

(1) Calibrate the set per 2.01.

(2) Connect the circuit to be measured to the input of the set.

(3) Set the FUNCTION switch to the proper setting.

(4) Measure the message circuit noise by adjusting the DBRN dial for an on-scale meter reading. Use the upper half of the meter scale whenever possible. The message circuit noise level in dBrn will be the sum of the meter reading and the DBRN dial setting.

(5) Set the DBRN dial, for measuring impulse noise, as follows.

DBRN dial setting = (Lowest threshold level) − (30).

The threshold level of each counter in dBrn will be the sum of the DBRN dial setting and the number in the window near the associated counter.

Note: Whenever the COUNTER SEPARATION switch is changed, the counters should be recalibrated per 2.01 to insure the best measurement accuracy.

(6) If desired, 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.

(7) 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.

(8) Depress the CTR STOP pushbutton and reset the counters to zero. Release the CTR STOP pushbutton.

(9) 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.

3. ADJUSTMENTS AND MAINTENANCE

3.01 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.

4.09 ***Weighting Network:*** Plug-in weighting networks provide a means for selecting the passband of frequencies to be measured.

➧Networks available are:

497D for C-message and flat weighting

497F for 50-kilobit/second and flat weighting

497G for C-notched and flat weighting.

The 497G network is supplied with each set. This network has a 600-ohm impedance and about 5 dB of flat loss.➧ The set is calibrated through the weighting network and therefore any variation in flat loss between the networks can be be calibrated out. The desired weighting is obtained by proper orientation of the network when plugging it into the set.

ABRIDGED

6H AND 6HR IMPULSE COUNTERS (J94006H AND J94006HR) DESCRIPTION, OPERATION, AND MAINTENANCE

CONTENTS PAGE

1. GENERAL

1.01 This section covers the description, operation, and maintenance of the 6H and 6HR impulse counters (J94006H and J94006HR).

1.02 The 6H set is portable, and the 6HR set is arranged for modular rack-mounting. These sets have similar electrical specifications; therefore, information contained in this section will pertain to both sets unless specified otherwise.

1.03 The 6H and 6HR sets replace the 6A and 6E impulse counters (J94006A and J94006E), respectively.

2. GENERAL DESCRIPTION AND OPERATION

A. Purpose of Instrument

2.01 The 6H and 6HR sets provide a means for counting impulse noise peaks that exceed a single adjustable threshold level in the frequency range of 20 Hz to 80 kHz.

2.02 A 735-ohm balanced, terminating input impedance is provided for making metallic impulse noise measurements normally made at 600 or 900 ohms.

B. General Operation

2.03 Dialing (6H set only) and holding are provided for setting up a connection preparatory to making measurements.

2.04 A timer provides a preset time interval for counting impulses. The timer is adjustable from 0 to 15 minutes. An adjustable stop on the timer provides for repeating a selected interval.

2.05 The 6H portable set (Fig. 1) is self-contained and operates from eight, AA-type, 1.5-volt alkaline flashlight batteries connected in series. In normal use (less than 250 counts per hour), the batteries should provide a minimum of 100 hours of operation. Pin jacks on the front panel are available for checking the condition of the batteries with an external voltmeter.

2.06 The 6HR set (Fig. 2) is arranged for modular rack-mounting and operates from the −48 volt office battery.

2.07 A weighting network selects the passband of frequencies to be measured. One network, having a ***C-notched*** filter on one side and a ***flat*** filter on the other, is supplied with each set. The ***C-notched*** filter has a characteristic similar to that of the ***C-message*** filter but includes a band rejection filter centered about 2750 Hz to permit measurements on compandored or mixed compandored-noncompandored circuits. The network is normally oriented for ***C-notched*** weighting. It plugs into a connector and is secured in place by a clamp. The network is accessible only by removing the set from its case.

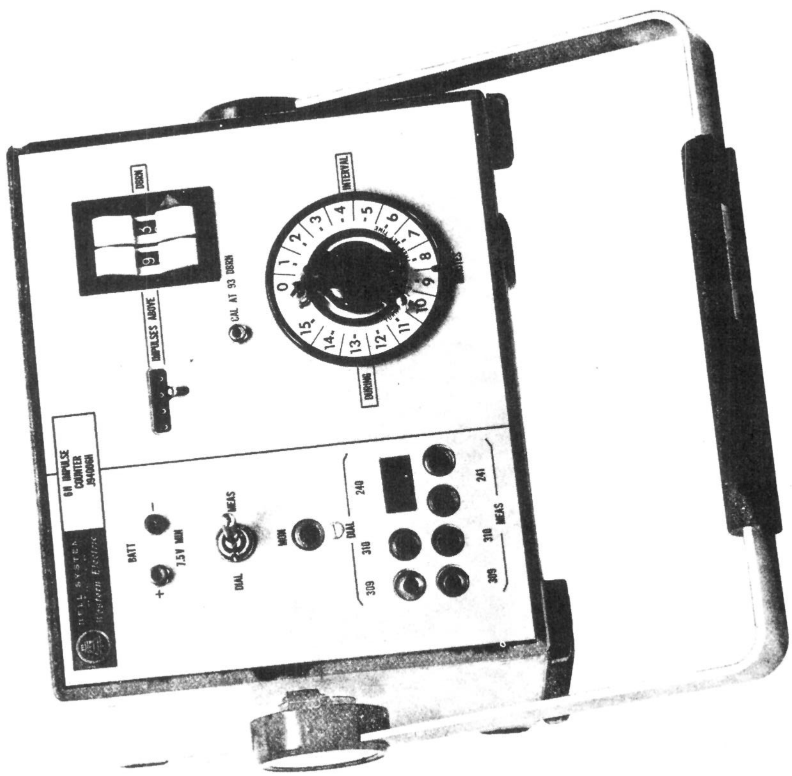


Fig. 1 – 6H Portable Set

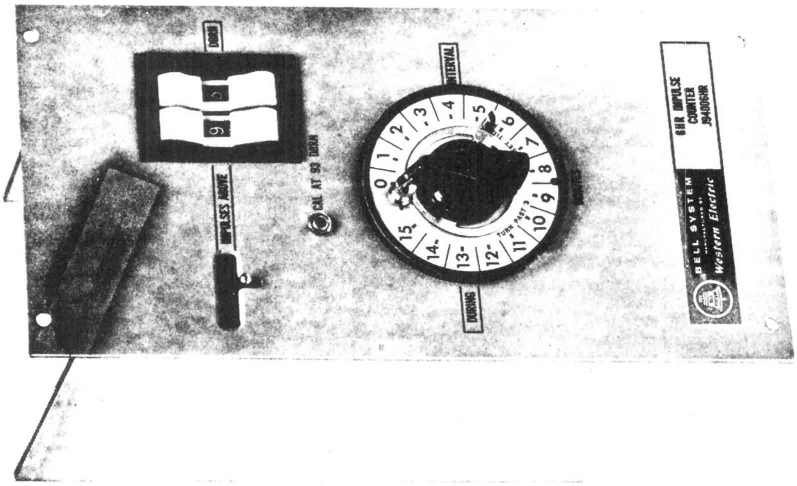


Fig. 2 – 6HR Rack-Mounted Set

2.08 An amplified output of the received noise is provided for monitoring purposes. A 723A receiver with a W2FS cord is supplied with each 6H set for listening to the measured noise. It can be plugged into a jack on the front panel of the 6H set. The monitor output appears at a jack at the rear of the 6HR set for wiring it to a separate jack field if desired.

C. Equipment Features

2.09 The 6H portable set weighs 13 pounds and measures 9 inches wide, 7-1/2 inches high, and 11-1/4 inches deep (including cover). The case is equipped with a sling-type handle which pivots about the left-right geometric axis. The handle automatically locks into any of 16 radial positions. This provides for carrying the set and for tilting it to a convenient operating angle. The 6H set cover contains simplified instructions for calibrating and operating the set. It also provides a space for storing the monitor receiver and cord when they are not in use.

2.10 The 6HR modular rack-mounted set weighs 11-1/2 pounds and measures 5 inches wide, 10 inches high, and 8-7/8 inches deep (including case, jack on rear of set, and 1-1/8 inch forward projections on front panel). With available brackets, ED-99987-( ), this set can be mounted in any size rack from 19 inches up. A plug and jack arrangement on the rear of the 6HR set provides for wiring the input, office battery, and monitor connections to the set and also provides for easy removal of the set from its case.

D. Electrical Specifications

2.11 Table A shows the electrical specifications for the 6H and 6HR sets.

TABLE A

ELECTRICAL SPECIFICATIONS

ITEM	SPECIFICATION
Sensitivity	40 to 99 dBrn, adjustable in 1-dB steps
Bandwidth	20 Hz to 80 kHz, normally modified by ***C-notched*** filter (see 2.12 and Fig. 4)
Input Impedance	735 ±15 ohms (20 Hz to 25 kHz) balanced for measurements normally made at 600 and 900 ohms
Holding	750 ohms dc resistance
Longitudinal Input Balance	(a) Greater than 80 dB at 1 kHz (b) Greater than 55 dB at 25 kHz
Maximum Counting Rate	7 counts per second
Maximum Counting Capacity	9999 counts, resettable to 0
DC Supply Voltage Range	(a) −7.5 to −12.5 volts for a 6H set (b) −44 to −52 volts for a 6HR set
Temperature Range	−10° to 150° F
Measurement Accuracy at 1000 Hz	(a) ±0.5 dB over temperature range of 32° to 122° F (see 2.13) (b) ±0.7 dB over temperature range of −10° to 150° F (see 2.13)

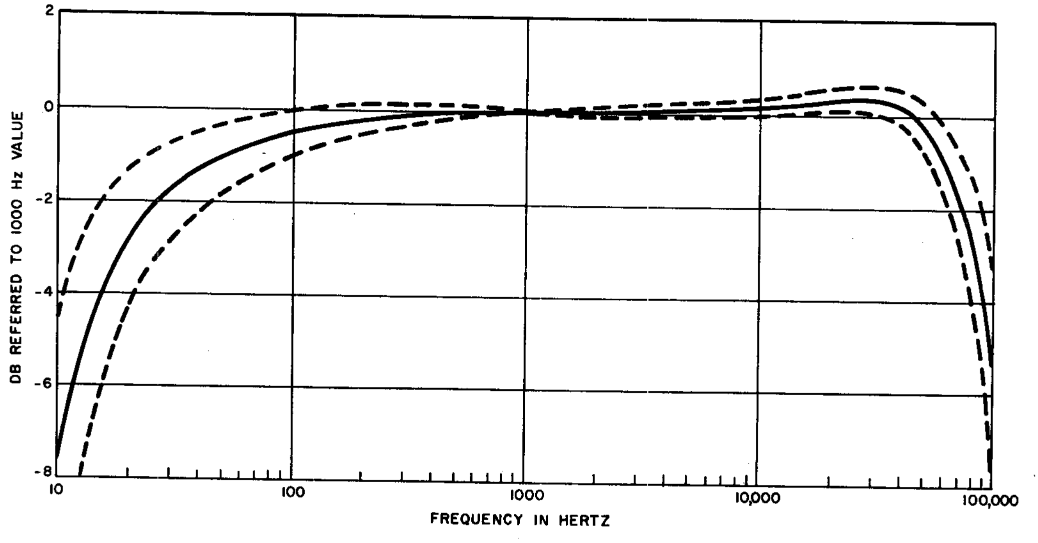


Fig. 3 – Frequency Characteristic With Flat Weighting

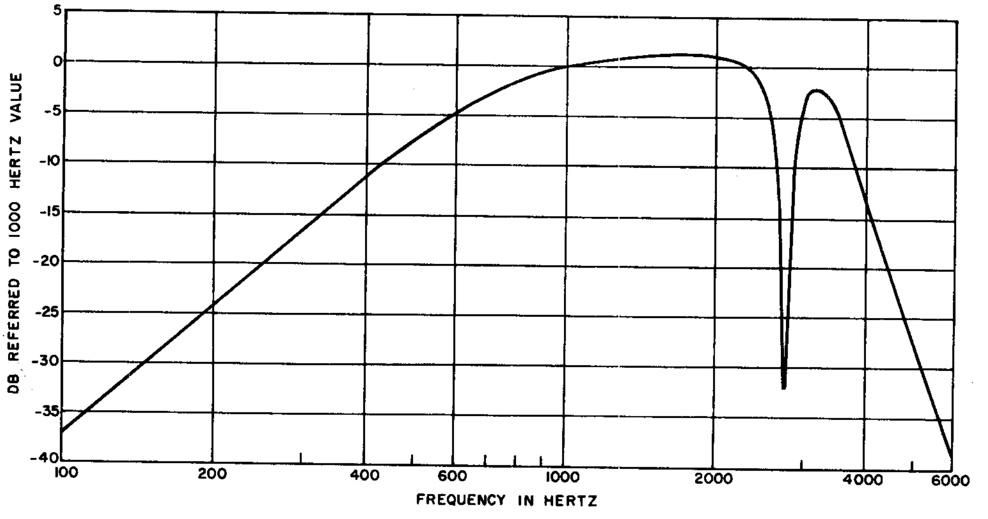


Fig. 4 – Typical Frequency Characteristic With C-Notched Weighting

2.12 Fig. 3 shows plots of the frequency characteristic for the 6H and 6HR sets with the weighting network oriented for ***flat*** weighting. The solid curve shows the typical response for these sets, and the dashed curves show the limits that result from component tolerances. The frequency characteristic is normally modified by means of the ***C-notched*** filter. Fig. 4 shows a typical plot of the resulting frequency characteristic with ***C-notched*** weighting. The characteristic is similar to that of the ***C-message*** filter but includes a band rejection filter centered about 2750 Hz to permit measurements on compandored circuits. In the band of 2736 to 2764 Hz, rejection greater than 30 dB is provided.

2.13 The measurement accuracy at the calibrating frequency (1000 Hz) for the 6H and 6HR sets will be ±0.5 dB in the temperature range of 32° to 122° F and ±0.7 dB in the temperature range of −10° to 150° F if the sets are properly calibrated (see 3.01). These accuracies apply for battery voltages of −7.5 to −12.5 volts for a 6H set and −44 to −52 volts for a 6HR set and for any DBRN dial setting.

3. OPERATING INSTRUCTIONS

A. Calibration of Set

3.01 To ensure good measurement accuracy, the set should be calibrated at least once every month, after changing batteries, or after changing the weighting network. When calibrating, the set should be in an environment of normal room temperatures (60° to 90° F). A 1000-Hz milliwatt generator, such as the 71-type generator (J94071), having either a 600- or 900-ohm source impedance and an accuracy of ±0.05 dB is required. The calibration procedure is as follows:

(1) For a 6H set, set the DIAL-MEAS control to MEAS.

(2) Set the DBRN control to 93.

(3) Connect the 1000-Hz generator, described above, to the input of the set.

(4) Turn the MINUTES control clockwise to the stop.

(5) For a 6H set, check the condition of the batteries by connecting a voltmeter to the BATT pin jacks. If this voltage is less than 7.5 volts, replace the batteries per 4.01, 4.02, and 4.03.

(6) Adjust the CAL control until the counter just counts. When this control is properly adjusted, the count will be erratic.

(7) This completes the calibration. Turn the MINUTES control fully counterclockwise and remove the milliwatt generator.

B. Operating Procedure

3.02 The 6H and 6HR sets are primarily intended for making metallic impulse noise measurements on voice-frequency circuits. In general, the receiving end of the circuit to be tested will be connected directly to the 6H or 6HR set (through a test pad when specified), and the far end will be terminated in a quiet termination equal to the office impedance. These sets provide a 735-ohm balanced input impedance for making measurements normally made at 600 or 900 ohms. This impedance is the geometrical mean of 600 and 900 ohms which makes the mismatch identical for 600- and 900-ohm measurements. The effect of this mismatch is corrected for when the set is calibrated (per 3.01). Multipled MEAS jacks on the front panel of the 6H set provide for connecting the circuit under test to the set with 309-, 310-, or 241-type plugs. Also, multipled DIAL jacks provide for connecting a telephone set or other dialing apparatus to the set with 309-, 310-, and 240-type plugs for establishing a connection on a circuit. A DIAL-MEAS switch on the 6H set connects the circuit under test to the DIAL jacks with this switch in the DIAL position and to the measuring circuitry with the switch in the MEAS position. The 6HR 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 6HR set provides for making the input connection, the monitor output connection, and office battery connections; this arrangement also allows the set to be removed from its case without disconnecting any wiring.

3.03 The 6H and 6HR sets measure impulse noise by counting the impulses having ***peak*** values exceeding a single threshold level. The threshold level is adjustable by an attenuator having 1-dB steps and a range of from 40 to 99 dBrn.

3.04 The timer provides for presetting the time interval during which impulse counts are measured. The timer, having dial markings at 1/2-minute intervals, is adjustable from 0 to 15 minutes. An adjustable stop on the timer provides for repeating a selected interval. At the end of a preset interval, the timer will disable the counting circuit by removing dc power from all circuits of the 6H or 6HR set. The register relay will not be reset so that the total number of impulses received in the preset interval can be read from the register before resetting it for another test.

Note: To insure accurate timing in intervals of 3 minutes or less, first adjust the timer to at least 5 minutes and then return it to the desired value.

3.05 The trigger and register circuit response time is limited electrically such that impulses, separated by approximately 140 msec (about 7 counts per second) or more, will be recorded on the register relay. This insures that the register relay, after counting, will have sufficient time to reset properly before it accepts another count.

3.06 The MON output provides an amplified output of the received noise. By listening with a headset or other monitoring device or by oscilloscope presentation, the type of noise or the location of the source may be deduced. A 723A receiver with a W2FS cord is supplied with each 6H set. It can be connected to a single jack on the front panel of the set. A jack on the rear of the 6HR set provides means for wiring the monitor output to a separate jack field, if desired.

Note: Monitoring a circuit is usually required to determine, if possible, the type of impulse noise interference present and whether any trouble condition exists that would make the measurement meaningless. However, to avoid possible measurement errors due to noise pickup from a monitoring device, remove any monitoring device from the MON jack before making the actual impulse noise measurement. While investigating noise sources, it may be desirable to monitor the circuit during the measurement period. To determine whether noise is being picked up by a monitoring device, 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 counter. This test should be performed with the set in both a grounded and an ungrounded condition.

3.07 The following is the operating procedure for a typical measurement:

(1) Connect the circuit to be measured to the input of the set.

(2) To set up a connection on a dialed-up basis, connect a telephone set or other dialing equipment to the DIAL jack field (6H set only).

Note: The 6HR set does not have the dialing feature. This feature must be supplied separately, if desired.

(3) Set the DIAL-MEAS control (6H set only) to DIAL and establish the connection.

(4) Set the DIAL-MEAS control to MEAS.

(5) Set the DBRN dial to the required level.

(6) If desired, connect a headset, oscilloscope, or other monitoring device to the MON jack; turn the MINUTES control clockwise and listen to or observe the measured noise as required (see Note in 3.06).

(7) Set the MINUTES control to the required time and measure the impulse noise counts. At the end of the preset time interval, the MINUTES switch will remove dc power from the set. The total number of impulses measured in this interval will be retained on the counter until it is reset for another test.

4. MAINTENANCE AND REPAIR

A. Battery Replacement

4.01 For a 6H set, the condition of the batteries should be checked periodically to insure that the dc supply voltage is within the normal operating range (−7.5 to −12.5 volts). This can be accomplished by connecting a voltmeter to the BATT pin jacks on the front panel. The MINUTES control must be turned clockwise before voltage appears at these jacks.

4.02 If the batteries require replacement, AA-type, 1.5 volt, ***alkaline batteries*** such as the RCA type VS-1334, or equivalent, should be used whenever possible. In normal use (less than 250 counts per hour), these batteries should provide a minimum of 100 hours of operation at ambient temperatures above 32° F. Below 32° F, the batteries will have a somewhat shorter life. If alkaline batteries are not available and if the ambient temperatures are above 32° F, type KS-14368 or equivalent carbon-zinc batteries can be used. These batteries, however, will provide only about one-half the life of the alkaline type. ***The carbon-zinc batteries will not provide satisfactory operation below 32° F.***

4.03 When replacing the batteries in a 6H set, care should be taken that the batteries are inserted properly in the holders. Designations near each holder show the correct polarities for each battery. To prevent possible overheating in the batteries and damage to the holders, batteries should be uniform, ie, they should be from the same manufacturer, should be of the same type, and should have about the same terminal voltage under load.

B. Trouble Indication and Repair

4.04 If any item of the set is malfunctioning or defective, the set should be sent to a repair and calibration center such as a Western Electric Distributing House.

4.05 Most trouble conditions will become apparent when calibrating the set. If a trouble condition is suspected, the calibration should be checked as described in 3.01. The calibration procedure is simple and can be accomplished with the use of a 0-dBm, 1000-Hz signal from a 600- or 900-ohm generator.

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4.12 ***Weighting Network:*** The weighting network provides a means for selecting the passband of frequencies to be measured. A 497E network, having a ***C-notched*** filter on one side (see 2.07) and a ***flat*** filter on the other side, is supplied with each set. The filters have a 600-ohm impedance and about 5 dB of flat loss. The set is calibrated through the weighting network and, therefore, any variation in flat loss between the filters is calibrated out.

NOTES

914-TYPE DATA TEST SETS
DESCRIPTION AND OPERATION

CONTENTS PAGE

1. GENERAL

1.01 This section provides a physical and functional description and operating theory necessary for effective use of the 914-type data test sets (DTSs).

1.02 This section is reissued to provide information on the 914C DTS and to show the 914B DTS as manufacture discontinued (MD). Because many 914B DTSs are still used in the field, information on this unit is retained. Since this reissue constitutes a general revision, arrows ordinarily used to indicate changes have been omitted.

1.03 The 914C and 914B DTSs will be referred to in this section as "the DTS" unless special applications make it necessary to refer to the specific nomenclature.

1.04 The DTS is a portable unit which facilitates dynamic and static tests of voiceband data sets. It is used for testing digital and analog data systems. It provides all the functions of the 901, 902, 903, and 913 series of data test sets and introduces several additional features not previously available. A high degree of flexibility is incorporated in the DTS which allows for accomodation of testing requirements of future data systems. Features of the DTS include the following:

- Flexibility in establishing all required interface connections
- Three types of test messages; dot signal, 63-bit, and 511-bit words are available
- Automatic and manual word synchronization
- Variable width window for sampling received data
- Bit and block error counting

- Time-interval measurement
- High-impedance ac voltmeter and loudspeaker amplifier to permit line signal monitoring and level measurements
- DC voltmeter and ohmmeter
- Tests of data services which operate in the range of 10 to 20,000 bits per second.

1.05 In addition to the features listed above, the 914C DTS includes the following additional features and improvements:

- Full-duplex testing capability
- Increased maximum pulse sampling window width
- Bridging input for the CONTROL SIGNALS lamp drivers
- Adjustable negative dc reference voltage
- An improved interval counter
- Appearance of individual error pulses on a test point
- A separate volume control for the loudspeaker
- An internal 600-ohm termination for the ac voltmeter
- Storage compartment in the test set cover
- An ac power plug with a built-in outlet
- Improved carrying handle
- Heavy duty rubber feet
- Writing surface for the temporary labeling of the control lamps and switches.

1.06 The DTS may be used at both transmitting and receiving stations of a data system. For an end-to-end test, one DTS is required at the transmitting data station and one at the receiving data station. The DTS may be used at either the transmit or receive station with 901, 902, 903, or 913-type data test sets at the opposite station; however, this reduces the test capability of the DTS. Since the 914C operates full-duplex it may be used by itself in full-duplex systems. The set may be utilized in situations where the far end may be looped back or in a back-to-back configuration where the output of a data set transmitter is fed directly back to the receiver.

1.07 The DTS contains a programmable crosspoint matrix which provides the ability to connect the DTS test circuits to the interface leads of a data set. By the application of control signals to the appropriate interface leads, the data set being tested is conditioned to go into the desired operating mode. The control signals from the data set are monitored by lamps in the DTS to determine whether the desired mode of operation has been achieved. Then, depending on the type of data system being tested, test messages are transmitted and/or received (the 914C can transmit and receive, while the 914B must transmit or receive), and the performance characteristics of the data set or data system are checked.

1.08 The program matrix of the DTS provides 25 vertical buses and 24 horizontal buses. The 25 vertical buses connect to the interface connector of the data set being tested; the 24 horizontal buses connect to the test circuits provided by the DTS. Connections from the input or output leads of the test circuits to the interface leads are made by inserting programming pins at the intersections of the appropriate vertical and horizontal buses of the matrix.

1.09 The DTS generates three different digital test messages for testing serial and certain parallel data services:

(a) A 63-bit test word that is compatible with that produced by the 903 series data test sets

(b) A 511-bit test word that conforms to the CCITT (Consultative Committee for International Telephone and Telegraph) standard

(c) A dot signal, ie, alternate marks and spaces.

The test messages are generated by word generators. The 914C has separate word generators and associated clocks for transmitting and receiving, while the 914B has a word generator and associated clock which functions as either a transmit or receive word generator and clock depending upon the mode of the test set.

1.10 Test messages are generated at bit rates determined either by the data set clock or by the internal clock(s) of the DTS. When driven by external clock signals (normally from the data set), the bit rate must be in the range of from 10 bits per second (bps) to 20,000 bps. When testing 402-type data sets, the DTS will generate the test messages at a rate of 75 bps. For tests of serial data sets, the DTS internal clock will produce test messages at bit rates of 150, 300, 600, 1000, 1200, 1400, 1600, 1800, 2000, and 2400 bps.

1.11 When testing serial asynchronous data sets, a bit synchronization signal is recovered from the received data at any of the ten bit rates listed in 1.10. This is accomplished by phase-locking the DTS receive clock oscillator to the transitions in the received data information. Synchronous data sets that recover their own clock signals may be tested at any bit rate in the range of from 10 to 20,000 bps as determined by the data set characteristics.

1.12 The test message is synchronized with the received data from the data set and a bit-by-bit comparison is made. Any errors detected are recorded and displayed by a 2-digit electronic counter. A lamp gives an indication when the counting capacity of the counter has been exceeded.

1.13 Word synchronization and error comparison may be accomplished either manually or automatically. In the manual mode, when the WORD SYNC switch is momentarily activated, the recorded error count will represent the true number of errors. In the automatic mode, the count recorded will equal approximately three times the true error count.

1.14 A comparator is provided to sample each received bit with a 0.5 μsec pulse centered at the midbit position. Any discrepancy between the received bit and the corresponding locally generated bit during the sampling interval is registered as an error. In addition, when testing asynchronous data sets, the width of the sampling pulses may be adjusted in 10-percent steps from 10 to 70 percent of the bit interval for the 914C DTS or from 10 to 50 percent for the 914B DTS. Any transition occurring within the selected sample width is registered on the counter. This provides a means of indicating the distortion of the received signal and, therefore, the margin against errors.

1.15 When testing 402-type data systems, combinations of three types of test signals (steady space, dot, and either the 63- or 511-bit word) are applied to the eight parallel data channels in the form of contact closures. The data channels may be tested either individually or simultaneously. In either case, the comparator circuit checks each bit or each parallel group of bits for errors, and records the total number of errors on the counter. One useful mode of operation consists of applying the test message on one channel and dotting signals on the other channels to check for interaction between channels.

1.16 In addition to measuring the average bit error rate of a data system, the DTS allows block error rates to be determined. In this mode, one or more bit errors in a block of preselected length are registered on the counter as a single count. The block length is selected in certain multiples of the test word length, ie, 63 or 511, and ranges from 63- to 8176-bit intervals.

1.17 The 914C provides three detector circuits which give visual indication of trouble conditions that may occur during testing: (a) the absence of a data output signal during tests of serial data systems while transmitting (TRANSMIT NO DATA lamp), (b) the absence of a received data signal from the data set (RCV NO DATA lamp), and (c) the absence of a clock signal to operate the receive portion of the test set (RCV NO CLOCK lamp). The 914B provides two detector circuits which indicate the absence of clock and data depending on the operating mode of the test set (transmit or receive).

1.18 Analog data sets may be tested by the DTS by applying precise dc voltages to the transmitter data leads and by measuring the receiver data output voltage. The voltages may be selected by a switch in steps or they may be obtained in a continuously adjustable mode from a high-resolution potentiometer circuit.

1.19 The DTS contains a dc voltohmmeter and a high impedance ac voltmeter capable of measuring line signals in the range from −50 to +2 dBm. A loudspeaker-amplifier circuit is also provided to permit audible monitoring of line signals for use in "hands free" operation.

1.20 Eight indicator lamps are provided to monitor control signals to and from the data set. Control signals may be applied by toggle switches to control leads of the data set. Both the indicator lamps and the control switches are compatible with voltage and contact interfaces.

1.21 An interval counter is incorporated in the DTS to indicate visually which of two input signals changes state first and to measure the time interval between the state transitions. The circuit is triggered by voltage transitions of either polarity or by contact closure or openings. In this manner an accurate measurement of elapsed time between two events occurring in the interface may be made.

1.22 Two 25-pin data interface connectors (A and B) are provided and are connected through a bank of push-pull switches (A and B selector switches) to the vertical buses of the program matrix. These selector switches permit tests of a data set on an in-service basis in either a bridging or terminating mode. In addition, they offer means of using the test set with data sets having more than 25 interface leads.

1.23 The voltage interface outputs from the test set are at levels close to the minimum EIA specifications for data sets. Similarly, series and shunt resistors incorporated in contact interface leads simulate the effects of cables used in the normal installation of data systems. These marginal test signals make the data set tests more stringent.

1.24 The 914C is provided with an internal 600-ohm terminating network under control of a switch. The network provides termination for the ac voltmeter and is useful in testing data access arrangements.

1.25 A 4-dB attenuator is provided with the 914B and can be connected in shunt with the telephone line at the transmitting end. As a result, the transmit level and thus the signal-to-noise ratio is reduced, thereby checking the margin of the observed error performance.

2. PHYSICAL DESCRIPTION

2.01 The 914C data test set shown in Fig. 1 and 2 is an integrated unit incorporating all instrumentation necessary to test both statically and dynamically most data services. The cover provides protection of the front panel of the test set and also serves as storage space for two interface connection cables, two test leads, and the programming pins (see Fig. 3). The test set with its cover in place measures approximately 18-1/2 inches wide, 15 inches high, 7-1/2 inches deep, and weighs about 35 pounds.

2.02 The 914B (Fig. 4) is physically similar to the 914C and has the same dimensions. The 914B weighs approximately 27 pounds.

2.03 The DTS is powered by a self-contained power supply which draws about 60 watts of 105- to 125-volt 50- to 65-Hz commercial power.

2.04 The DTS is designed to operate efficiently in an environment with an ambient temperature range of +40° to +120°F and a relative humidity of 20 to 95 percent.

2.05 Figures 5, 6, and 7 provide number key callouts of all components located on the front panel of the 914C. Associated Tables A, B, and C provide a cross-reference for each callout, identifying the respective part as to function, description, and/or designation. Table D shows the differences between 914C and 914B controls and indicators.

2.06 The functional designations for the program matrix and switches are abbreviated and stamped on the front of the matrix panel. These designations and their meanings are listed below:

Program Matrix

Designation	Meaning
GRD	Ground
SD	Send data output
RD	Receive data input
SCT	Serial clock transmit input
SCR	Serial clock receive input
DS1-DS8	Inputs to lamps DS1-DS8
S1-S8	Outputs from switches S1-S8
TP1-TP3	Test point connections

Fig. 1—914C Data Test Set—Cover in Place

STG	Program pin storage.

Switches

Designation	Meaning
CHAN	Parallel data channel
ALL RDM	Random test signal on all channels
ALL SPC	Spacing signal on all channels
ALL DOT	Dot signal on all channels
SER	Serial
WL, 2WL, etc	Word length; block length in multiples of the word length, ie, 63 or 511, selected
AUTO	Automatic word synchronization
MAN	Manual word synchronization.

3. FUNCTIONAL DESCRIPTION

3.01 The following functional description describes the 914C DTS. The functional description of the 914B DTS is similar with the exception of the SCT and SCR circuits and the interval counter. In the 914B the SCT and SCR circuits are combined and the operation of the TEST SET MODE switch determines whether the word generator and clock function as a receive word generator and clock or transmit word generator and clock. Differences in the operation of the interval counter will be noted in the text.

3.02 For a functional description of the 914C data test set, four major block diagrams are required. These four block diagrams are shown

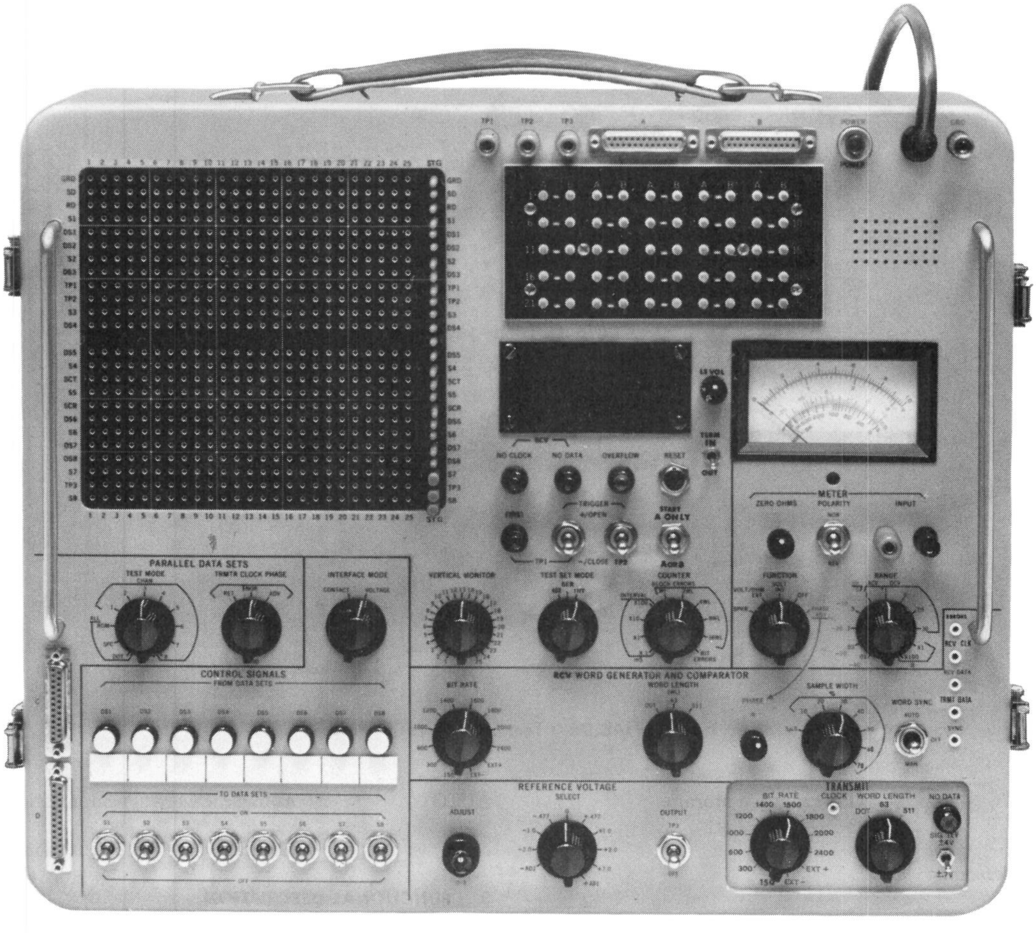


Fig. 2—914C Data Test Set—Front Panel

in Fig. 8, 9, 10, and 11 and represent (a) the overall function of the 914C, (b) the serial transmit and receive functions, (c) the parallel data transmit, and (d) the parallel data receive functions.

A. Overall Function (Figure 8)

3.03 Data sets to be tested are connected to the DTS via connectors A or B (connectors C or D for 402-type data sets). The leads of these connectors link through the interface selector switches to the vertical buses of the program matrix. With both the A and B sections of a particular interface selector switch closed, the corresponding pins of connectors A and B are interconnected. In the most common tests of a data set, either connector may be used to connect the data set interface to the test set.

3.04 Under some circumstances, it may be desirable to test a data set on an in-service basis, ie, with the business machine connected to the

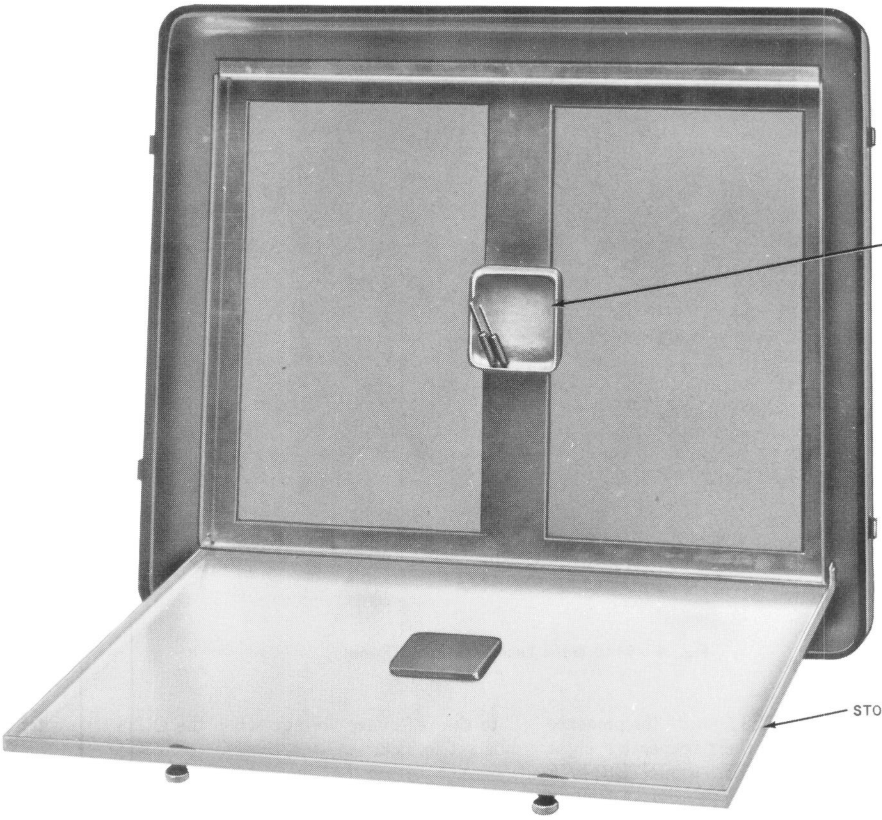


Fig. 3—914C Data Test Set—Cover

data set. In a test of this nature, connector A is connected to the data set and connector B to the business machine. When the A and B sections of the interface selector switch are closed, the signals passing through the data set/business machine interface are accessible on the program matrix in a bridging connection. By opening and closing the respective A and B sections of the interface selector switches of individual interface leads, access to the data set or business machine interface may be obtained, breaking the connection between the data set and the customer interface.

3.05 The program matrix is a 2-deck array of 25 vertical and 24 horizontal buses. The vertical buses are connected to the interface leads of the data set, while the horizontal buses connect to the various test circuits in the DTS. Interconnections are made by inserting a programming (shorting) pin at the intersection of the corresponding vertical and horizontal buses. Plugs having built-in resistances can be used when it is desired to make a connection through a series resistance. Refer to Table E for the programming pin complement of the DTS.

3.06 Eight of the horizontal buses of the program matrix carry control signals from the DTS. The signals are controlled by toggle switches S1 through S8. These signals are either ± 4 volt voltage levels or contact closures, depending on the position of the INTERFACE MODE switch.

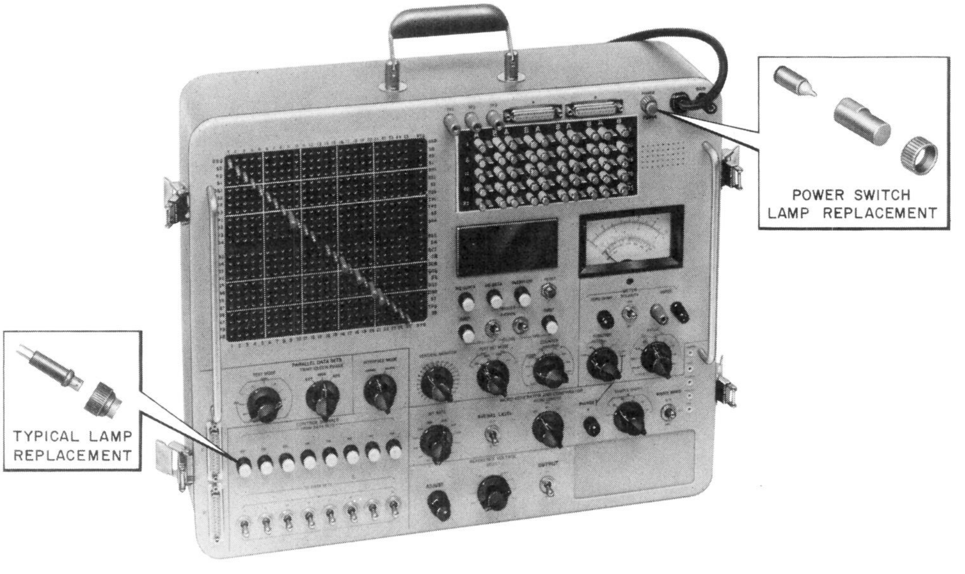


Fig. 4—914B Data Test Set—Front Panel

3.07 Lamps DS1 through DS8 indicate the presence of control signals on their respective eight horizontal buses of the matrix. With the INTERFACE MODE switch in the CONTACT position, a contact closure to ground on a horizontal bus lights the corresponding indicator lamp. When the INTERFACE MODE switch is in the VOLTAGE position, a +4 volt signal present on a horizontal bus activates the respective lamp driver which in turn lights the corresponding lamp. The lamp drivers in the 914C have a series impedance of 3 kohms. If a higher impedance is desirable, a blue (10-kohm) programming pin may be inserted into the matrix in the appropriate row to provide a total impedance of 13 kohms. This increased impedance may be required where the 914C is connected between a data set and business machine and the lamps are used in a bridging configuration.

3.08 The first horizontal bus supplies ground to the matrix. TP1, TP2, and TP3 buses are accessible at test points on the front panel of the DTS. Additionally, TP1 and TP2 are connected to the interval counter circuit. TP3 is also connected to the reference voltage when the OUTPUT switch is set to TP3.

3.09 The SD and RD buses carry the send and receive data signals and the SCT and SCR buses carry the transmit and receive clock signals. In the 914B the signals are carried on their respective buses when the TEST SET MODE switch is in the TRMT or RCV position.

3.10 Each of the 25 interface leads is shunted by a 300-kohm resistor to provide marginal open-circuit loading for contact interfaces.

3.11 The VERTICAL MONITOR switch connects to the dc voltmeter and facilitates dc voltage measurements on any of the interface leads of the data set being tested.

3.12 The meter circuit permits the measurement of dc voltage, ac voltage, resistance and signal level in dBm (referenced to a 600-ohm load). In addition, it makes possible monitoring of line signals with a loudspeaker. The dc signals to be measured may be applied to the metering circuits by means of the VERTICAL MONITOR switch or from INPUT terminals on the front of the test set. The ac volts, ohms, and loudspeaker signals may be applied to the metering circuits only from the METER INPUT jacks. The type of signal to be measured determines the required position of the FUNCTION switch.

3.13 The reference voltage circuit develops fixed voltages of +7, ±2, ±1, and ±0.477 volts. In addition, a voltage adjustable over the range of 0 to ±8 volts is available for the 914C DTS or 0 to +8 volts for the 914B DTS. The voltage is selected by the SELECT switch and may be applied through the OUTPUT switch to the TP3 jack or the TP3 horizontal matrix buses for use in testing analog-type data sets.

3.14 The interval counting circuits in the 914C monitors the state of two leads TP1 and TP2 (A and B), and recognizes the one on which a preselected signal first occurs. This signal, depending on the position of the TRIGGER switches, may be a positive or negative transition or a contact opening or closing. The circuit also permits selection of the lead which controls the start of the counter through the position of the START A ONLY—A OR B switch and allows measurement of the time interval between signal occurrences on the two leads. The time interval is read out on the counter display. Time intervals from 0.1 ms to 10 seconds may be measured. The functions to be measured can be connected by using the TP1 and TP2 jacks on the front panel of the set or the TP1 and TP2 horizontals in the program matrix. In either case the TEST SET MODE and COUNTER switches must be in the INTERVAL positions.

3.15 As previously mentioned, the lead which starts the counter may be selected by the START A ONLY—A OR B switch. In the START A ONLY position, the counter will start when the preselected signal first appears on TP1. The occurrence is indicated by the lighting of the FIRST TP1 lamp. In the A OR B position, the counter will start when the preselected signal first appears on either TP1 or TP2. If the FIRST TP1 lamp lights, the signal first appeared on TP1. If the FIRST TP1 lamp does not light but the counter starts, it indicates the signal first appeared in TP2. The 914B does not allow selection of which lead starts the counter and has a FIRST TP2 lamp to indicate when the preselected signal first appears on TP2.

B. Serial Transmit Function (Figure 9)

3.16 Timing control for the transmit clock is determined by the position of the TRANSMIT BIT RATE switch. With the TRANSMIT BIT RATE switch set to EXT, timing is supplied by the data set clock. The clock signal (either internally generated or externally) is applied to the transmit word generator.

3.17 The transmit word generator produces three different digital test messages under control of the TRANSMIT WORD LENGTH switch:

(a) Dot signal, ie, alternate marks and spaces

(b) 63-bit test word

(c) 511-bit test word.

The bit rate, established by the applied transmit clock signals, must be in the range from 10 to 20,000 bits per second.

3.18 The EIA output driver conditions the locally generated word for application to the SD lead to drive a transmitting data set in an end-to-end test.

C. Serial Receive Function (Figure 9)

3.19 Timing control for the receive clock is determined by the position of the RCV BIT RATE switch. The bit sync recovery circuit generates signals which are used to drive the receive clock circuit at a rate determined by the incoming data signal. The PHASE control is adjusted to achieve precise synchronism with the incoming data signal. The receive word generator is identical to the transmit word generator and is under control of the RCV BIT RATE switch. When the RCV BIT RATE switch is set to EXT, timing is supplied by the data set clock.

3.20 The word sync circuits provide synchronization between the locally generated word and the received data word. These two words are identical except for discrepancies due to transmission impairments or malfunctions in the data sets under test. Word synchronization is accomplished either manually or automatically, depending on the position of the WORD SYNC switch. The manual sync mode is initiated by momentarily operating the spring-loaded WORD SYNC switch to the MAN position. In the comparator a bit-by-bit comparison is made between the received word and the locally generated word and differences are read out as errors on the counter display.

3.21 When the DTS is used in a manual synchronous mode, (WORD SYNC switch momentarily set to MAN) the comparator and receive word generator are synchronized with the data set output on the first available information bit. Random noise may cause loss of synchronization resulting in an extremely high error rate, indicated by a counter display overflow. Automatic synchronization (WORD SYNC switch set to AUTO) causes the test set to resynchronize with every information bit, resulting in a nominal error count and indicating the presence of random noise pulses. With the WORD SYNC switch in the AUTO position the error count displayed is approximately three times the true error count.

3.22 The sample pulse generator normally provides a 0.5 μsec sampling pulse centered in the midbit position. Any discrepancy between a received bit and the corresponding locally generated bit during a sampling interval is registered as an error. For testing asynchronous data sets there are additional variable sampling widths available which allow the sampling interval to be adjusted in 10-percent steps from 10 to 70 percent of the bit interval by the SAMPLE WIDTH switch. This provides a means of indicating the data error signal margin. Any transition occurring within the selected sample width is registered on the counter. This provides a means of indicating the distortion of the received signal and, therefore, the margin against errors.

3.23 The error counting circuit will indicate the average bit error rate or the block error rate of the system. In the block error mode, the number of blocks of a certain length containing one or more errors is counted. The block lengths are multiples of the word length, ie, 63 or 511 bits. The multiples are 1, 2, 4, 8, and 16, as selected by the COUNTER switch.

3.24 The EIA output driver conditions the locally generated word for application to the parallel data circuits.

D. Parallel Transmit Function (Fig. 10)

3.25 The clock signal generated by the transmit clock multivibrator is applied to the dot generating circuits. The clock signal is a 75-Hz signal and the dotting signals are 75 bps.

3.26 One of the dot signals under control of the TRMT CLOCK PHASE switch is applied to the timing channel of the parallel data set. This signal may, by the use of the ADV or RET switch, be advanced or retarded in phase by 1.5 ms with respect to the data signal. This is used to simulate a change in phase relationship between the clock and data signals that might occur due to transmission impairments.

3.27 The signal from the data dot generator in combination with the test word is applied to some of the eight parallel data channels. The TEST MODE switch determines the output of the eight parallel data channels, allowing the channels to be tested individually or simultaneously. With the TEST MODE switch in the ALL DOT position, all data channels are driven by the dot generator which provides a signal of alternate marks and spaces. An ALL SPC (constant spacing signal) may also be applied to the data channels. Other positions of the TEST MODE switch allow applying the test word to all channels (ALL RDM) or to any individual channel (CHAN/1-8), while the remaining channels carry a dot signal.

3.28 The output drivers provide the contact closure type interface required for data sets 402-type. All data channels and the timing channel are accessible through the C connector on the front panel.

E. Parallel Receive Function (Fig. 11)

3.29 The receiving parallel data set is connected to connector D on the front panel. The receiving data channels may be tested individually or simultaneously under control of the TEST MODE switch. When the data channels are tested on an individual basis, the received data signal is checked for errors as described previously in this section.

3.30 When all channels are tested simultaneously (ALL RDM position of the TEST MODE switch), the test word is transmitted on all channels by the transmitting data set. The inputs from all channels are combined and compared to the local word from the word generator. If one or more channels are in error, an error signal is fed to the data comparator and registers as an error on the COUNTER display.

3.31 The timing signal on the parallel receive data timing channel is applied to the level converter and eventually to the external clock input of the local word generator.

F. Power Supply

3.32 The power supply produces all of the voltages required by the circuits of the test set. It converts 115-volt 60-Hz power into three regulated dc outputs of +12, −12, and +5 volts and two unregulated outputs of +23 and +200 volts.

4. OUTPUT SPECIFICATIONS AND INPUT REQUIREMENTS

4.01 The signal outputs of the test set are accessible at the program matrix and the various test points on the front panel. Table F lists these outputs and their characteristics.

4.02 The input requirements of the test set are shown in Table G.

5. OPERATION AND TYPICAL TEST ARRANGEMENTS

5.01 The intent of Part 5 is to give general information on testing which will allow the user to better understand the use of the test set. It should be noted that the tests in this section make use of the 914C. However, tests using the 914C and another data test set such as 901, 902, 903, 913, 914B, or data test center, are possible and should be considered. It should be noted that a 903-type DTS is capable of providing a 63-bit random word or dotting signal at bit rates compatible with a 914B DTS. Full duplex capability can therefore be added to a 914B by using a 903-type DTS as a transmit word generator and the 914B as a receive word generator and comparator. The output of the 903-type DTS, which appears at the SIGNAL OUT jacks, may be patched to the TP1 and TP2 jacks of the 914B and, therefore, accessible at the matrix. Test procedures shown in this part are typical for serial, parallel, and analog types of data sets and will specify switch settings, connections, operating instructions, and any additional test equipment required. For detailed instructions for test of a particular data system, refer to the appropriate test section.

A. Matrix

5.02 A unique feature of the DTS is the programmable matrix which provides flexibility in connecting the test circuits to the interface leads. In most tests, the data set is connected to connector A via a furnished cable. This connects the data set interface leads to the vertical buses of the matrix through the interface A selector switches. Appearing on the horizontal buses of the matrix are the inputs and outputs of test circuits contained in the DTS. Shorting pins (red), when inserted in the matrix face, connect the desired horizontal and vertical buses. Resistance pins are also provided which make the connection through an internal resistance in the pin (Table E). The assignment of the input-output leads to the horizontal buses is such that in general the location of the programming pins will be along the diagonal of the matrix face. Figure 12 shows one way the matrix can be programmed for testing data set 202C. It can be seen that the send request (SR) lead is connected to S1 switch so that the send request function is controlled by S1. The clear-to-send (CS) signal, located on pin 5 of the interface, is connected to the DS-1 lamp; therefore, DS-1 provides an indication of the CS signal from the data set. The send data (SD) lead is connected to the SD bus on the matrix which carries the transmit word generator output. Similarly, receive data (RD) appears on pin 3 of the matrix and is connected to the comparator. To measure the 202C power supply voltage appearing on pins 9 and 10 (or any other dc voltage) the meter FUNCTION switch must be set to INT and the VERTICAL MONITOR switch set to the desired number of the interface lead.

B. Selector Switch

5.03 The interface selector switch shown in Fig. 13 consists of an A and B section, each of which is a combination switch and test point. When both A and B switches are closed, the respective pins (pin 1, for example) on connectors A and B are connected to A1 and B1 test points and also to the test point located between the switches. By proper use of the interface selector switches, each lead of the A and B connectors may be connected in a bridging or terminating mode for testing on an in-service basis. This flexibility also allows testing of data sets having up to 50 interface leads.

C. Meter

5.04 A dc voltmeter is an integral part of the DTS and may be used to monitor dc interface signals by placing the FUNCTION switch in the VOLT INT position, selecting the proper DCV RANGE switch setting and operating the VERTICAL MONITOR switch to the position corresponding to the desired vertical lead. Only the dc portion of the meter can be used with the VERTICAL MONITOR switch.

5.05 External circuits may be monitored by attaching test leads to the INPUT terminals and setting the FUNCTION switch to the VOLT/OHM EXT position. In this position ac signals, dc voltages, and resistance to ground may be measured. The INPUT TERMINALS in the 914C may be terminated in 600 ohms by use of the TERM IN-OUT switch. In the 914B a 4-dB attenuation pad may be physically placed across the INPUT terminals.

One side of the ohmmeter is permanently grounded to the DTS, therefore, all readings are taken with respect to test set ground.

5.06 The ac meter input is a balanced high impedance circuit so that the meter may be connected to a telephone line with negligible loading effect.

Damage may result to the meter when measuring line signals (FUNCTION switch set to EXT) if the RANGE switch is inadvertently placed in the DCV or X1, X100 (ohms) position. The FUNCTION switch should be set to OFF when the meter is not being used or when the test set is being transported.

5.07 With the FUNCTION switch set to SPKR and the RANGE switch set to any of the ACV positions, ac signals applied to the INPUT terminals are audible in the loudspeaker. The loudspeaker volume is controlled by the LS VOL control on the 914C or on the 914B by setting the RANGE switch to any of the five ACV positions.

D. Interval Counter

5.08 The DTS contains an interval counter circuit which monitors the state of the TP1 and TP2 leads. The circuits function to detect and provide a lamp indication of the first occurrence of a preselected signal on either TP1 or TP2 leads. The lead on which the signal first occurs results in either lighting or not lighting the FIRST TP1 lamp on the 914C or lighting either the FIRST TP1 or FIRST TP2 lamp in the 914B. In addition, time between signals and signal duration may be measured using the counter display. The signals to be monitored may be either a positive or negative voltage transition or the closing or opening of a contact. By setting the TRIGGER TP1 and TRIGGER TP2 switches to detect the proper signal transition, the time interval between pulses on the two leads may be read out on the display counter. The duration of a single pulse may be measured by applying the same signal on both TP1 and TP2 leads and setting the TRIGGER TP1 and TRIGGER TP2 switches to detect the plus and minus transitions of the pulses, respectively. The interval measured is the width of the pulse. In the 914C the lead which starts the counter may be selected by the START A ONLY—A OR B switch.

5.09 Signals to be measured may be applied to the interval counter circuits in two ways: (a) from the TP1 and TP2 horizontal matrix buses or (b) from the TP1 and TP2 test points on the front of the test set. The following controls and indicators are used with the interval counting circuits:

- COUNTER—Set to desired time interval.
- RCV BIT RATE—Set to any of the internal bit rate positions.
- TEST SET MODE—Set to INTERVAL.
- TRIGGER, TP1, and TP2 switches—set in accordance with type of signal to be detected (+/OPEN or −/CLOSE).
- TRIGGER FIRST TP1 lamp—Indicate on which lead the preselected signal first occurs.
- START A ONLY—A OR B switch—Set to lead which controls start of counter.
- RESET—Operate momentarily to clear count.

- Display counter—Read duration interval when event occurs.

To estimate the period of a periodic signal (square wave, for example), apply the signal to both TP1 and TP2 leads and set the following controls:

- COUNTER—Set to X.1 MS or appropriate setting on lower frequencies to keep counter from overflowing.
- RCV BIT RATE—Set to any of the internal bit rate positions.
- TEST SET MODE—Set to INTERVAL.
- TRIGGER TP1 and TP2 switches—Set both the same to measure one period, opposite to measure half period.
- START A ONLY—A OR B switch—Set to START A ONLY.
- RESET—Operate momentarily to clear count.
- Display counter—Counter displays time interval of period or half period as selected. Frequency may then be calculated.

E. Serial Data Sets

5.10 Connect the data set to be tested to the A or B connector and ensure that the matrix has been programmed for the data set under test. Set the INTERFACE MODE switch to VOLTAGE or CONTACT as required (normally VOLTAGE for serial data sets). Set switches S1 through S8 to properly condition the data set. Observe indicator lamps DS-1 through DS-8 for the proper indication.

5.11 Interface voltage measurements are made by setting the meter FUNCTION switch to VOLT INT and the RANGE and POLARITY switches to the proper position. The VERTICAL MONITOR switch may be set to any one of the 1 through 25 positions to monitor the dc voltages on the interface leads. ***The NO DATA and NO CLOCK indicator lamps should remain extinguished during all error rate tests unless a data or clock malfunction occurs. The data or clock signal must be absent for several seconds for the lamps to illuminate.***

5.12 Controls and switch settings listed under the following three headings are used when testing all types of serial data sets in transmitting and receiving modes. ***The COUNTER switch must be in the BIT ERRORS or BLOCK ERRORS position when transmitting in the SERIAL mode.***

Transmitting Tests—Synchronous or Asynchronous Data Sets

- TEST SET MODE—SER.
- COUNTER—Set to BIT ERRORS or BLOCK ERRORS.
- TRANSMIT BIT RATE—Set to appropriate BIT RATE for asynchronous data sets. Set to EXT+ or EXT− for synchronous data sets, depending on phase relationship of clock signal to data signal (normally EXT+).
- SIGNAL LEVEL—Set to ± 0.7V or ± 4V as required.
- TRANSMIT WORD LENGTH—Set to desired test signal.

Receiving Tests—Synchronous Data Sets

- TEST SET MODE—Set to SER.
- COUNTER—Set to BIT ERRORS or BLOCK ERRORS as required.
- RCV WORD LENGTH—Set to agree with transmitted word.
- RCV BIT RATE—Set to EXT+ or EXT−, depending on phase relationship of clock signal to clock signal (normally EXT+).
- WORD SYNC—Operate momentarily to MAN or set to AUTO.
- RESET—Operate momentarily to clear counter.
- Counter display—Observe recorded error count.

Receiving Tests—Asynchronous Data Sets

- TEST SET MODE—Set to SER.

- COUNTER—Set to BIT ERRORS or BLOCK ERRORS as required.
- RCV WORD LENGTH—Set to agree with transmitted word.
- PHASE—Set to mid position (dot pointing up).
- RCV BIT RATE—Set to agree with transmitted bit rate.
- FUNCTION—Set to PHASE ADJ.
- PHASE—Adjust for zero indication on METER.
- FUNCTION—Set to position other than PHASE ADJ (do not return to PHASE ADJ during remainder of test).
- SAMPLE WIDTH—Set to .5μS.
- WORD SYNC—Operate momentarily to MAN or set to AUTO.
- SAMPLE WIDTH—Set to desired sampling interval for marginal testing.
- RESET—Operate momentarily and observe recorded error count on counter display.

F. Parallel Data Sets—402-Type

5.13 Connect the data set to be tested to the C (transmit) or D (receive) connector and ensure that the matrix has been programmed for the data set under test. Set the INTERFACE MODE switch to the CONTACT position. Set switches S1 through S8 to properly condition the data set. Observe indicator lamps DS-1 through DS-8 to ascertain that the data set is responding properly. To test for interaction between any particular data channel and other data channels set the TEST MODE switch to the desired channel (CHAN 1 through 8). Setting the TEST MODE switch to the ALL SPC position applies a spacing condition to all data channels; the ALL DOT position applies alternate marks and spaces to all channels. ***The NO DATA and NO CLOCK indicator lamps should remain extinguished during all error rate tests. A NO DATA lamp indication indicates a trouble condition, not necessarily a lack of data.***

5.14 Controls and switch settings listed under the following two headings are used when testing all 402-types of parallel data sets in transmitting and receiving modes.

Transmitting Tests

- TRANSMIT WORD LENGTH—Set to 63 or 511 bits as required.
- SIGNAL LEVEL—Set to ± 4 volts.
- TRANSMIT BIT RATE—Set to EXT+.
- TEST SET MODE—Set to 402.
- TEST MODE—Set to ALL RDM to test all eight channels individually or simultaneously.
- TRMT CLOCK PHASE—Set to RET, NOR, or ADV as required. In an end-to-end test this control at the transmitting data test set may be set to the ADV or RET position, which will change the phase relationship between the clock signal and the data signal by 1.5 msec. This establishes a marginal condition which will normally result in increased errors at the receiving data set.

Receiving Tests

- TEST SET MODE—Set to 402.
- COUNTER—Set to BIT ERRORS or BLOCK ERRORS as required.
- TEST MODE—Set to ALL RDM to test all eight channels simultaneously. Set to CHAN/1-8 to check any channel individually.
- WORD SYNC—Operate momentarily to MAN or set to AUTO.
- RESET—Operate momentarily to clear counter.
- Counter display—Observe recorded error count.

G. Analog Data Sets

5.15 Precision reference voltages generated by the DTS may be used to make tests on analog data sets. Generally the procedure is to program the matrix, set switches S1 through S8 as required to condition the data set, apply a known voltage to the SD lead of the transmitting data set and measure the voltage on the RD lead at the receiving data set. The voltmeter is used to measure the signal on the RD lead. At the transmitting end, the voltage may be applied to the TP3 bus on the matrix by setting the OUTPUT switch to TP3. The voltage may then be monitored with the meter through contacts of the VERTICAL MONITOR switch.

Transmitting Tests—Analog Data Sets

- REFERENCE VOLTAGE—Set to desired voltage or ADJ position.

- OUTPUT—Set to TP3. Insert programming (shorting) pin at matrix intersection of TP3 horizontal bus and SD lead.

- VERTICAL MONITOR—Set to monitor interface SD lead, using meter circuit.

- ADJUST—Adjust to the desired voltage, using meter circuit when REFERENCE VOLTAGE switch is set to ADJ.

Receiving Tests—Analog Data Sets

- VERTICAL MONITOR—Set to monitor interface RD lead, using meter circuit. Meter indication should agree in magnitude and polarity with transmitted voltage.

6. MAINTENANCE

6.01 Maintenance tests in this section should be performed in accordance with local instructions. Maintenance and repair of the DTS in the field should be limited to the replacement of fuses, lamps, and calibration of the ac voltmeter. Some tests are provided in this section which will aid the user in determining if the test set is operating within tolerances, and to isolate minor malfunctions to a particular lamp or fuse which needs replacement. In some instances it may be possible to isolate the trouble to one or more or the six (914B) or 8 (914C) replaceable circuit packs. Replacement circuit packs are available but must be ordered separately. Repairs beyond those mentioned above should be referred to the appropriate Western Electric Company organization.

6.02 The DTS has features which permit self-testing of most of its functions without the use of additional test equipment. Part 6 provides test methods which will give an indication of the operational status of the test set. Certain of the tests are general in nature and should not be considered conclusive.

THINK ***Before proceeding with any test in this section, ensure that all test leads and matrix pins have been removed, all interface selector switches are depressed, all interface connecting cables are free of shorts, opens and crosses, and the FUNCTION switch is in the OFF position.***

6.03 To gain access to R17 (for ac voltmeter calibration), fuses, and circuit packs, it is necessary to remove the rear cover of the test set. This is done by loosening the four quick release fasteners at the rear of the test set. With the test set front panel facing up, lift the test set chassis out of the case. Figure 14 shows the locations of the test set fuses. Figure 15 provides information for circuit pack location and R17.

6.04 Test procedures in 6.05 through 6.13 permit testing the DTS without additional test equipment. Tests in 6.14 and 6.15 require additional equipment.

THINK ***Circuit pack and lamp reference designations shown in parentheses in the VERIFICATION column provide a troubleshooting aid for identifying the most probable cause of failure for that particular step in the test.***

6.05 ***Fuses:*** Failure of one or more fuses may be detected from indications at the front panel of the test set. To gain access to the fuses, remove the rear cover as explained in 6.03. The following procedure gives indications of ***open*** fuses. If the fuse has failed, the condition under PROCEDURE should be observed.

Fuse Test

STEP	PROCEDURE
	F1
1	Operate the POWER switch. The POWER lamp will remain extinguished and the set will be inoperative with the exception of the dc voltmeter.
	F2
2	Set the TEST MODE switch to SER and the RCV BIT RATE switch to EXT+. The RCV NO DATA and RCV NO CLOCK lamps remain extinguished.
	F3
3	Set the FUNCTION switch to VOLT INT and the RANGE switch to DCV/10. Set the SELECT switch to +2.0 and the OUTPUT switch to TP3. Set the VERTICAL MONITOR switch to 1 and the POLARITY switch to NOR. At the matrix, insert a programming (shorting) pin in row TP3, column 1. The meter indicates 0 dc volts with the SELECT switch in any of the plus voltage positions. Remove the programming pin.
	F4
4	Set the FUNCTION switch to VOLT INT and the RANGE switch to DCV/10. Set the SELECT switch to -2.0 and the OUTPUT switch to TP3. Set the VERTICAL MONITOR switch to 1 and the POLARITY switch to REV. At the matrix, insert a programming (shorting) pin in row TP3, column 1. The meter indicates 0 dc volts with the SELECT switch in any of the minus voltage positions. Remove the programming pin.
	F5
5	Set FUNCTION switch to VOLT/OHM EXT. Set the RANGE switch to X1. Strap across INPUT terminals with test lead. Adjust ZERO OHMS control. The meter pointer will not indicate zero and remains near midscale.

6.06 ***Reference Voltage:*** The reference voltage circuit is a precision supply and divider circuit that develops fixed selectable voltages of +7, ±2, ±1, and ±0.477 dc volts. In addition, a voltage adjustable over a 0 to ±8 dc volt range is available for the 914C or 0 to +8 dc volts for the 914B. The following test permits checking these voltages with the test set meter.

Reference Voltage

STEP	ACTION	VERIFICATION
1	At test set— Insert a programming (shorting) pin in matrix, row TP3, column 1.	
2	Set OUTPUT switch to OFF.	
3	Operate POWER switch.	POWER lamp lit.
4	Set FUNCTION switch to VOLT INT.	
5	Set RANGE switch to DCV/10.	
6	Set POLARITY switch to NOR.	
7	Set VERTICAL MONITOR switch to 1.	
8	Set both coarse (outer) and fine (inner) ADJUST controls fully counterclockwise.	
9	Set SELECT switch to +ADJ.	
10	Set OUTPUT switch to TP3.	Meter indicates 0 dc volts.
11	Rotate both coarse and fine ADJUST controls fully clockwise.	Meter pointer varies smoothly and indicates +10.0, ±0.5 dc volts with both controls fully clockwise.
12	Rotate fine (small) control fully counterclockwise.	Meter indicates at least 0.5 volt dc less than value read in Step 11.
13	If test set is a 914B proceed to Step 21. If test set is a 914C proceed to Step 14.	
14	Set OUTPUT switch to OFF.	
15	Set POLARITY switch to REV.	
16	Set both coarse and fine ADJUST controls fully counterclockwise.	
17	Set SELECT switch to −ADJ.	
18	Set OUTPUT switch to TP3.	Meter indicates 0 volts.
19	Rotate both coarse and fine ADJUST controls fully clockwise.	Meter pointer varies smoothly and indicates −10.0 ±0.5 dc volts with both controls fully clockwise.
20	Rotate fine control fully counterclockwise.	Meter indicates at least 0.5 volts dc less than value read in Step 19.

STEP	ACTION	VERIFICATION
21	Observing meter polarity— Rotate SELECT switch through succeeding positions as shown in Table H.	Meter indications as shown in Table H.
22	Operate POWER switch.	POWER lamp extinguished.
23	Remove test connections.	

6.07 ***Control Signals:*** The control signal portion of the test set consists of DS1 through DS8 indicator lamps and S1 through S8 toggle switches. The INTERFACE MODE switch permits control with either contact closures or application of control voltages. It should be noted that the toggle switches are independent of the lamps. By properly programming the matrix, any lamp may be controlled by any switch. The following test verifies that the eight lamps may be operated by a contact closure or voltage as controlled by switches through programmed matrix connections.

Control Signals

STEP	ACTION	VERIFICATION
1	At test set— Insert shorting pin in matrix, row S1, column 1.	
2	Insert shorting pin in matrix, row DS1, column 1.	
3	Set S1 through S8 toggle switches to OFF.	
4	Operate POWER switch.	POWER lamp lit.
5	Set INTERFACE MODE switch to CONTACT.	DS1 through DS8 lamps extinguished.
6	Set S1 toggle switch to ON.	DS1 lamp lit. (DS1 lamp).
7	Set S1 toggle switch to OFF.	DS1 lamp extinguished.
8	Test circuits for the switches and lamps as shown in Table I.	DS2 through DS8 lamps operate as shown in Table I. (DS2 through DS8 lamps, CP8).
		Note: If an indicator lamp fails to light with the INTERFACE MODE switch set to CONTACT, the corresponding position may be tested with the voltmeter. Set the FUNCTION switch to VOLT INT, RANGE switch to DCV/30 and select the desired matrix connection using the VERTICAL MONITOR switch. The meter will indicate 0 volts for a lamp failure. If the meter indicates +23 dc volts, the trouble internal to the DTS.
9	Set INTERFACE MODE switch to VOLTAGE.	DS1 through DS8 lamps extinguished.

STEP	ACTION	VERIFICATION
10	Repeat Steps 6, 7, and 8.	Same as in Steps 6, 7, 8, and Table I. (DS1 through DS8 lamps, CP8). *Note:* If an indicator lamp fails to light with the INTERFACE MODE switch set to VOLTAGE, the corresponding position may be tested with the voltmeter. Set the FUNCTION switch to VOLT INT, RANGE switch to DCV/10, and select the desired matrix connection using the VERTICAL MONITOR switch. A meter indication of +4.0 ±0.3 dc volts should be observed for toggle switches that are ON and −4.0 ±0.3 dc volts for switches that are OFF.
11	Operate POWER switch.	Power lamp extinguished.
12	Remove test connections.	

6.08 ***Interval Counter:*** The DTS provides an interval counter which may be used to detect the first occurrence of a preselected signal transition, measure time between pulses or measure pulse length. The following test checks the first occurrence feature and provides a test of the counter display. A letter a or b added to a step number of this section indicates an action which may or may not be required depending on local conditions. The condition under which a lettered step or a series of lettered steps should be made is given in the ACTION column, and all steps governed by the same condition are designated by the same letter within the test. Where a condition does not apply, all steps designated by that letter should be omitted.

STEP	ACTION	VERIFICATION
Interval Counter		
1	At test set— Set S1 through S8 toggle switches to OFF.	
2	Insert shorting pin in matrix, row TP1, column 1.	
3	Insert shorting pin in matrix, row S1, column 1.	
4	Insert shorting pin in matrix, row TP2, column 2.	
5	Insert shorting pin in matrix, row S2, column 2.	
6	Operate FUNCTION switch to OFF.	
7	Operate POWER switch.	POWER lamp lit.
8	Set INTERFACE MODE switch to CONTACT.	

STEP	ACTION	VERIFICATION
9a	If DTS is 914C— Set TRANSMIT and RCV BIT RATE switches to 2400.	
10b	If DTS is 914B— Set BIT RATE switch to 2400.	
11a	Set TEST SET MODE switch to INTERVAL.	
12b	Set TEST SET MODE switch to TRMT SER.	
13	Set TRIGGER TP1 and TRIGGER TP2 switches to −/CLOSE.	
14a	Set START A ONLY—A OR B switch to START A ONLY.	
15	Set COUNTER switch to INTERVAL/X100.	
16	Momentarily operate RESET switch.	Counter display reads 00.
17a	Place S2 to ON and then back to OFF.	Counter display reads 00.
18	Using a suitable timer— Set S1 toggle switch to ON.	Counter display starts.
19	After 5 seconds— Set S2 toggle switch to ON.	Counter display stopped at approximately 50. FIRST TP1 lamp lit. (FIRST TP1 lamp.)
20	Set TRIGGER TP1 and TRIGGER TP2 switches to +/OPEN.	
21	Momentarily operate RESET switch.	
22a	Set START A ONLY—A OR B switch to A OR B.	Counter display reads 00.
23	Using a suitable timer— Set S2 toggle switch to OFF.	Counter display starts.
24	After 5 seconds— Set S1 toggle switch to OFF.	Counter display stopped at approximately 50. On 914C FIRST TP1 lamp should not be lit. On 914B FIRST TP2 lamp lit.
25	Operate POWER switch.	POWER lamp extinguished.
26	Remove shorting pins from matrix.	
27	Remove all test connections.	

6.09 ***Word Generators, Clocks, and Sync Circuits:*** The 914C word generators will produce three different test messages: a dot signal, a 63-bit test message, and a 511-bit test message. The bit rate of these signals may be determined by the test set clocks, which may be varied in steps from 150 to 2400 bps. The following procedure determines that the test set will generate the required test signals and that the clock rate is variable. This test may be run using two 914B DTSs: one to function as a transmitter and the other as a receiver.

STEP	ACTION	VERIFICATION
Word Generator, Clock, and Sync Circuits		
1	At test set— Set controls and establish test connections as shown in Fig. 16.	
2	Operate POWER switch.	POWER indicator lamp lit. Counter runs. RVC NO CLOCK and NO DATA lamps lit.
3	Insert shorting pin in matrix, row SD, column 2.	Meter pointer deflects. (CP1, CP2, CP3, CP4, CP6, and CP7).
4	Adjust PHASE control of test set for zero meter indication.	Zero indication on meter (CP1, CP2, CP3, CP4).
5	Set FUNCTION switch to OFF.	RCV NO DATA and RCV NO CLOCK lamps are extinguished. Counter display starts. (CP3, CP4).
6	Momentarily operate WORD SYNC switch to MAN	Counter display stops.
7	Operate TRANSMIT WORD LENGTH switch to 511 then return to 63.	Counter display starts.
8	Set WORD SYNC switch to AUTO.	Counter display stops.
9	Set TRANSMIT and RCV WORD LENGTH switches to 511.	Counter display may run momentarily then stop. (CP3).
10	Set TRANSMIT and RCV BIT RATE switches to 300.	
11	Set FUNCTION switch to PHASE ADJ.	
12	Adjust PHASE control for zero indication.	Meter pointer indicates 0.
13	Set FUNCTION switch to OFF.	Counter display may run momentarily, then stop. (CP1).
14	Repeat Steps 10 through 13 for each TRANSMIT and RCV BIT RATE switch position through 2400.	Same as Steps 10 through 13.

STEP	ACTION	VERIFICATION
15	Set WORD SYNC switch to OFF.	
16	Set TRANSMIT WORD LENGTH switch to 63.	
17	Set COUNTER switch to BLOCK ERRORS/WL.	Counter display runs at slower rate. (CP5, CP8).
18	Advance COUNTER switch through each BLOCK ERROR position through 16 WL.	Counter display runs at decreasing rate for each increasing word length position. (CP5, CP8).
19	Operate POWER switch.	POWER lamp extinguished.
20	Remove all test connections.	

6.10 ***Parallel Data Circuits:*** The 914C develops an output signal for testing data set 402-type. The signal represents either an open or closed contact. The following procedure checks that the test set will generate either a dotting signal or a random test message and that the signal will appear on the proper leads. This test may be run using a 914B DTS.

STEP	ACTION	VERIFICATION
Parallel Data Circuits		
1	At test set— Set controls and establish test connections as shown in Fig. 17.	
2	Operate POWER switch.	POWER indicator lamp lit.
3	Set FUNCTION switch to VOLT/OHM EXT.	
4	Insert shorting pin in matrix, row TP1, column 2.	Meter indicates 0.7 to 0.9 volt ac. (CP5, CP8).
5	Repeat Step 4 for columns 3, 4, 5, and 7, 8, 9, 10.	Same as Step 4.
6	Insert shorting pin in matrix, row TP1, column 6.	Meter indicates 0.5 to 0.6 volt ac. (CP5, CP8).
7	Set TRANSMIT WORD LENGTH switch to 63.	
8	Set TEST MODE switch to ALL RANDOM.	
9	Remove shorting pin in matrix, row TP1, column 6.	
10	Repeat Steps 4 and 5.	Meter indicates 0.4 to 0.7 volt ac. (CP5, CP8).

STEP	ACTION	VERIFICATION
		Note: Meter pointer "jitters" as result of random test message.
11	Set TEST MODE switch to CHAN/1.	
12	Insert shorting pin in matrix, row TP1, column 2.	Meter indicates 0.35 to 0.55 volt ac.
13	Set TEST MODE switch to CHAN/2.	
14	Insert shorting pin in matrix, row TP1, column 3.	Meter indicates 0.35 to 0.55 volt ac.
15	Set TEST MODE switch to CHAN/3.	
16	Insert shorting pin in matrix, row TP1, column 4.	Meter indicates 0.35 to 0.55 volt ac.
17	Set TEST MODE switch to CHAN/4.	
18	Insert shorting pin in matrix, row TP1, column 5.	Meter indicates 0.35 to 0.55 volt ac.
19	Set TEST MODE switch to CHAN/5.	
20	Insert shorting pin in matrix, row TP1, column 7.	Meter indicates 0.35 to 0.55 volt ac.
21	Set TEST MODE switch to CHAN/6.	
22	Insert shorting pin in matrix, row TP1, column 8.	Meter indicates 0.35 to 0.55 volt ac.
23	Set TEST MODE switch to CHAN/7.	
24	Insert shorting pin in matrix, row TP1, column 9.	Meter indicates 0.35 to 0.55 volt ac.
25	Set TEST MODE switch to CHAN/8.	
26	Insert shorting pin in matrix, row TP1, column 10.	Meter indicates 0.35 to 0.55 volt ac.
27	Operate POWER switch.	POWER lamp extinguished.
28	Remove all test connections.	

6.11 ***Parallel Data Circuits:*** This test provides a check of both the transmitting and receiving capabilities of a 914C conditioned for testing data sets 402-type. This test may be run using two 914B DTSs: one to function as a transmitter and the other as a receiver.

STEP	ACTION	VERIFICATION
Parallel Data Circuits		
1	Set controls and establish test connections as shown in Fig. 18.	
2	Operate POWER switches.	POWER lamp lit. Counter display runs.
3	Momentarily operate WORD SYNC switch to MAN.	Counter display stops.
4	Set TEST MODE switches to CHAN 1.	Counter display runs.
5	Momentarily operate MODE SYNC switch to MAN.	Counter display stops.
6	Repeat Steps 4 and 5 for each TEST MODE/CHAN position 2 through 8.	Same as Steps 4 and 5.
7	Operate POWER switch.	POWER lamp extinguished.
8	Remove all test connections.	

6.12 ***Clock Circuits:*** The following test uses an electronic counter to provide a readout of the internal test set clocks. A test of the 75-Hz parallel data clock is also provided. The same test may be run using a 914B DTS.

STEP	ACTION	VERIFICATION
Clock Circuits		
1	At test set and counter— Set controls and establish test connections as shown in Fig. 19.	
2	Operate POWER switch.	POWER lamp lit and counter energized. ***Note:*** Allow test set and counter a 5-minute warm-up period before proceeding with test.
3	Set TRANSMIT BIT RATE switch to each 150 through 2400 position and observe counter readings as shown in BIT RATE AND CLOCK chart on test diagram.	Counter reads within tolerances for each setting of TRANSMIT BIT RATE switch. (CP2, CP6.)
4	Set COUNTER switch to each INTERVAL/X.1 through X100 position and observe counter readings as shown in BIT RATE TEST table on Fig. 19.	Counter reads within tolerances for each setting of COUNTER switch. (CP2, CP6.)

STEP	ACTION	VERIFICATION
5	Move test lead from TRANSMIT CLOCK test point to RCV CLK test point.	
6	Repeat Steps 3 and 4 using the RCV BIT RATE switch.	Same indications as Steps 3 and 4 (CP1, CP2).
7	Move test lead from RCV CLK test point to TRANSMIT CLOCK test point.	
8	At test set— Set TRANSMIT BIT RATE switch to EXT+.	
9	Set COUNTER switch to BIT ERRORS.	
10	Set TEST SET MODE switch to 402.	At counter— Counter reads 75 ± 4 Hz. (CP5).
11	At test set and counter— Operate POWER switches.	POWER lamp extinguished and counter de-energized.

6.13 ***Data and Sample Circuits:*** This test uses a dual trace oscilloscope equipped for external sync and a variable time base to monitor the data, sync, and clock outputs. Nominal pulse deviation and amplitudes are given on the test connection diagram. The dual trace feature permits checking the phase relationship of the data and clock signals. This test may be run using a 914B DTS.

STEP	ACTION	VERIFICATION
Data and Sample Circuits		
1	At test set and oscilloscope— Set controls and establish test connections as shown in Fig. 20.	
2	Operate POWER switches.	POWER lamp lit and oscilloscope energized.
3	At oscilloscope— Set controls to observe channel 2 input.	Observe waveform A on test diagram. (CP5, CP4).
4	Set controls to observe channel 1 input.	Observe waveform B on test diagram.
5	At test set— Set TRANSMIT WORD LENGTH switch to 511.	
6	At oscilloscope— Set controls to observe channel 1 and 2 inputs.	Waveforms observed in Steps 3 and 4 do not change. (CP7).
7	Remove test lead connection between oscilloscope sync connector and channel 2 input, leaving SYNC of test set connected to sync of oscilloscope.	

STEP	ACTION	VERIFICATION
8	At test set— Connect test lead from oscilloscope channel 2 input to TRMT DATA jack.	
9	At oscilloscope— Using external sync— Set controls to observe channel 1 and 2 inputs.	Observe waveform C shown on test diagram.
10	At test set— Set TRANSMIT WORD LENGTH switch to 63.	At oscilloscope— Observe waveform D shown on test diagram. (CP7).
11	At test set— Set TRANSMIT WORD LENGTH switch to DOT.	At oscilloscope— Using internal sync— Observe waveform E shown on test diagram. (CP7).
12	At test set— Remove oscilloscope test lead (channel 1 input) from CLOCK jack and connect to CP2, TP1 (see Fig. 15 for circuit pack location).	
13	Remove oscilloscope sync lead (sync input) from SYNC jack and connect to CLOCK jack.	
14	At oscilloscope— Set controls to adjust time base so that one bit interval of the data signal occupies a 10 CM sweep on the graticule.	Observe waveform F shown on test diagram. (CP3).
15	At test set— Operate SAMPLE WIDTH switch through each 10-70% position.	At oscilloscope— The pulse width of channel 1 input shall be within ±4 percent of the value for each switch position. Each pulse is centered within 2 percent along the vertical axis of the oscilloscope. (CP6, CP2).
16	At test set and oscilloscope— Operate POWER switches.	POWER lamp extinguished and oscilloscope de-energized.
17	Remove test connections.	

6.14 ***AC Voltmeter:*** The ac voltmeter portion of the meter circuit facilitates the measurement of voice-frequency signals in five 10-dB ranges (from 10 millivolts to 1 volt full-scale). The following test provides a method of calibrating the meter with a known ac reference voltage. Since the type of signal generator will vary at different telephone company locations, the test procedure is of a general nature.

STEP	PROCEDURE
1	Energize a reference generator (a 71-type milliwatt generator is suitable) having a known output.
2	Energize the 914C test set and set the FUNCTION switch to VOLT/OHM EXT.
3	Set TERM IN-OUT switch to IN.
4	Connect the reference generator output to the DTS INPUT terminals and read the applied signal on the lowest ac meter scale which will permit the nearest full-scale indication.
5	If the indication is not the same as the known reference, remove the rear cover as explained in 6.03 and adjust R17 (Fig. 15) until the meter indicates the same value as the applied signal.
6	Remove test connections and restore test equipment to normal operating conditions.

7. REFERENCES

7.01 Additional information on the DTS may be obtained from the following sources:

(a) SD- and CD-73056-01

(b) EL 278

(c) J-79914B-1.

TABLE A

914C CONTROLS AND INDICATORS

KEY	CONTROL	FUNCTION
1	Program Matrix	Provides access to interface leads of data set being tested.
2	Interface Selector Switches	Provide access to program matrix for in-service testing of data sets.
3	TP1 Test Point	Provides access to interval counter and matrix.
4	TP2 Test Point	Provides access to interval counter and matrix.
5	TP3 Test Point	Provides access to reference voltages and matrix.
6	A Connector	Connected to serial-type data set interface during tests.
7	B Connector	Connected to business machine interface during in-service tests of serial-type data sets.
8	POWER Switch and Lamp	Turns test set on and off and provides power on indication.
9	GRD Terminal	Provides external ground for test set.
10	Loudspeaker	Provides audible monitor of signals on telephone line.
11*	LS VOL Control	Allows loudspeaker volume to be varied.
12	Meter	Provides visual indication of ac and dc voltage and resistance.
13*	TERM IN-OUT Switch	Places an internal 600-ohm termination across METER INPUT terminals.
14	ZERO OHMS Adjustment	Provides ohmmeter calibration for 0 ohms.
15	POLARITY Switch	Facilitates reversal of dc meter polarity.
16	INPUT Terminals	Allow input to speaker and meter from an external circuit. Black terminal is negative and red terminal is positive with respect to the meter when POLARITY switch is in NOR position.
17	FUNCTION Switch	Controls the mode for meter circuit.
18	RANGE Switch	Selects desired meter range for signal measurements.
19	VERTICAL MONITOR Switch	Facilitates dc-voltage measurements on any of the interface leads.

* Refer to Table D for differences in 914B DTS controls.

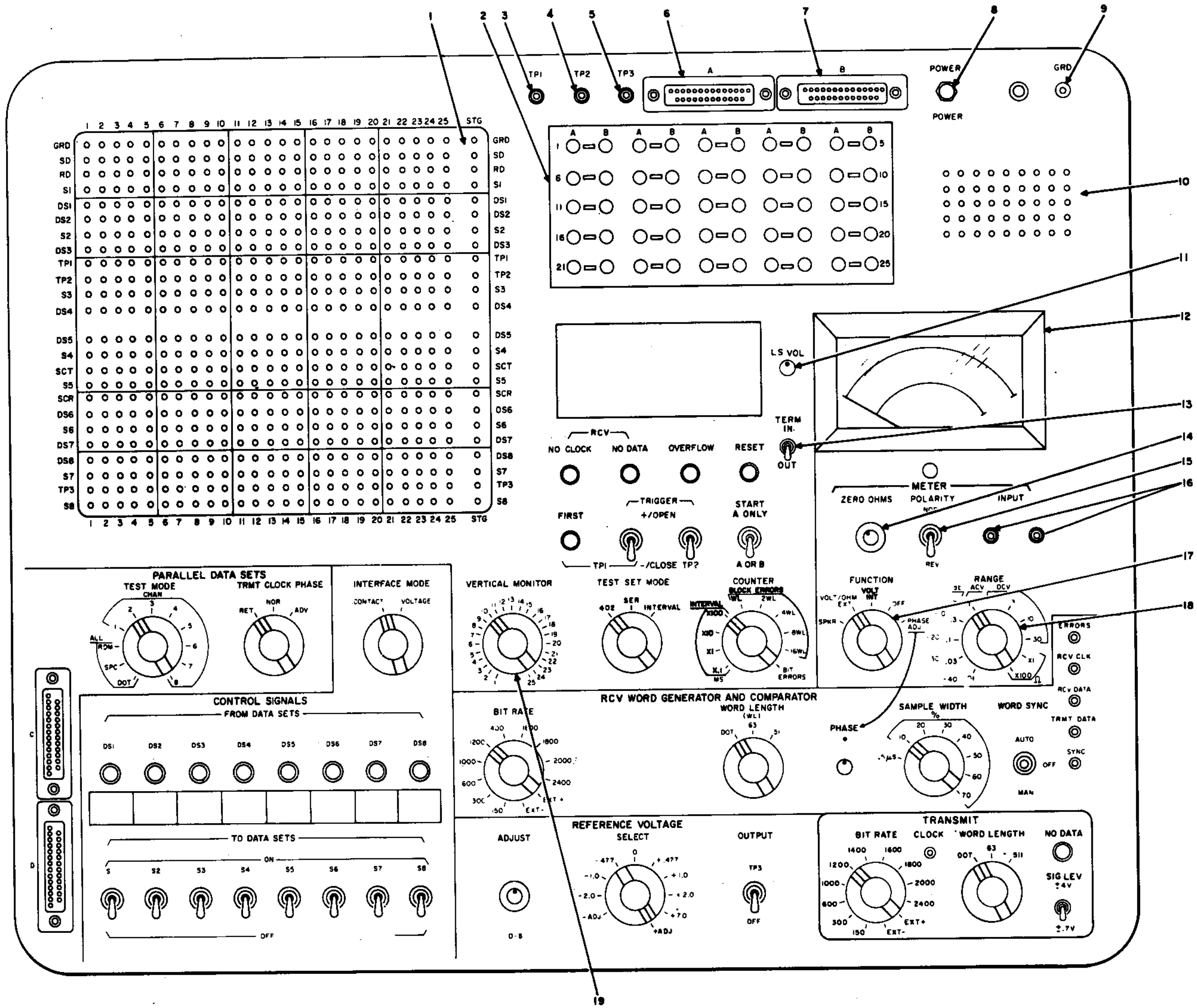


Fig. 5—914C Data Test Set—Controls and Indicators

TABLE B

914C CONTROLS AND INDICATORS

KEY	CONTROL	FUNCTION
1	Counter Display	Provides decade counter readout from 0 to 99.
2	OVERFLOW Lamp	Lit when counter capacity has been exceeded.
3	RESET Switch	Clears error and interval counter circuits.
4	FIRST TP1 Lamp	Lit when preselected signal appears first on TP1 lead.
5	TP1 TRIGGER Switch	Selects triggering mode on TP1.
6	TP2 TRIGGER Switch	Selects triggering mode on TP2.
7*	START A ONLY — A OR B switch	Selects lead which controls start of counter.
8	COUNTER Switch	Provides for either block or bit error rate or interval count.
9*	TEST SET MODE Switch	Selects the required test mode (parallel or serial) for a particular data set or interval count.
10	OUTPUT Switch	Applies selected reference voltage to TP3 and the TP3 horizontal of the matrix.
11*	SELECT Switch	Provides for selection of a desired fixed reference voltage.
12	ADJUST Control	Provides coarse and vernier adjustment of a variable reference voltage.
13*	RCV NO CLOCK lamp	Lit during absence of received clock signal.
14*	RCV NO DATA lamp	Lit during absence of received data.

* Refer to Table D for differences in 914B DTS controls.

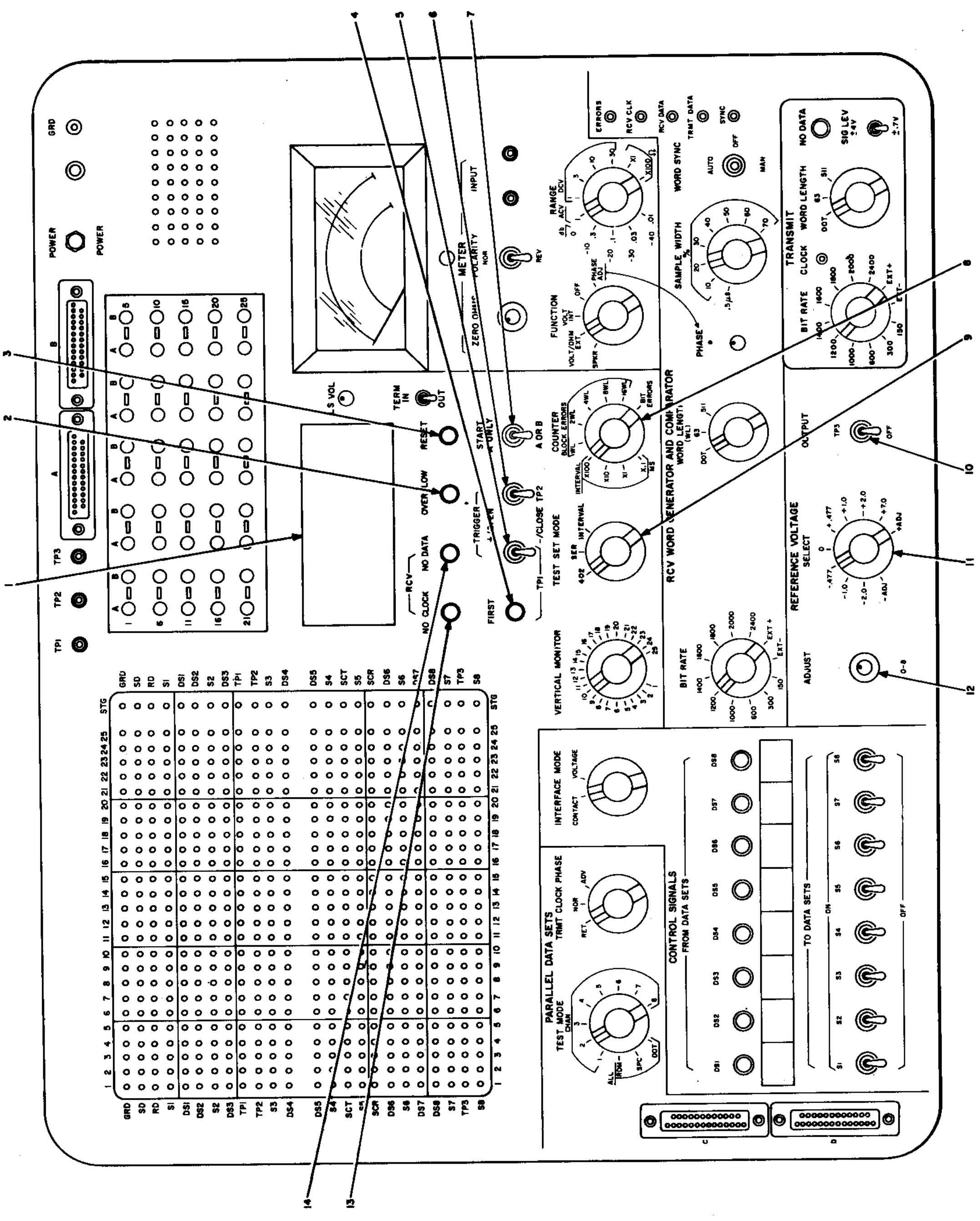


Fig. 6—914C Data Test Set Controls and Indicators

TABLE C

914C CONTROLS AND INDICATORS

KEY	CONTROL	FUNCTION
1*	ERRORS Test Point	Provides access to a pulse produced for every error detected.
2*	RCV CLK Test Point	Provides access to a symmetrical square wave, +4.5 volts in amplitude and equal in frequency to the receive bit rate.
3	RCV DATA Test Point	Provides access to the data signal applied to the RD horizontal row of the program matrix.
4*	TRMT DATA Test Point	Provides access to the bi-polar data signal produced by the transmit word generator.
5	SYNC Test Point	Provides access to the positive word sync signal, one bit interval in length, occurring once per work (RCV WORD GEN).
6	WORD SYNC Switch	Provides for selecting either manual or automatic word synchronization.
7*	TRANSMIT NO DATA Lamp	Lit during absence of data signal from 914C data test set.
8*	SIGNAL LEVEL Switch	Allows selection of either ±0.7 or ±4 volts for transmit word generator (SD) output level.
9*	TRANSMIT WORD LENGTH Switch	Provides selection of dot, 63-bit or 511-bit transmit test word.
10*	CLOCK Test Point	Provides access to a symmetrical square wave, +4.5 volts in amplitude and equal in frequency to the transmit bit rate.
11*	TRANSMIT BIT RATE Switch	Determines rate of timing signal used to drive transmit word generator.
12*	SAMPLE WIDTH Switch	Provides for selection of sample pulse width.
13	PHASE Adjustment	Provides a fine adjustment of the voltage-controlled oscillator.
14	WORD LENGTH Switch	Provides selection of dot, 63-bit or 511-bit receive test word (TRANSMIT and RECEIVE switches).
15	BIT RATE Switch	Determines rate of timing signal used to drive receive word generator and comparator.
16	INTERFACE MODE	Selects contact or voltage mode for control signals.
17	DS1-DS8 Lamps	Indicate presence of control signals on eight of the matrix horizontal buses.
18*	Temporary Labeling Strip	Writing surface for temporary labeling of lamps and switches.
19	S1-S8 Switches	Provide control signals.
20	D Connector	Connected data set during testing of receiving 402-type data sets.
21	C Connector	Connected to data set during testing of transmitting 402-type data sets.
22	TEST MODE Switch	Determines output of eight parallel data channels.
23	TRMT CLOCK PHASE Switch	Determines relationship of clock and data signals for parallel data set tests.

*Refer to Table D for differences in 914B DTS controls

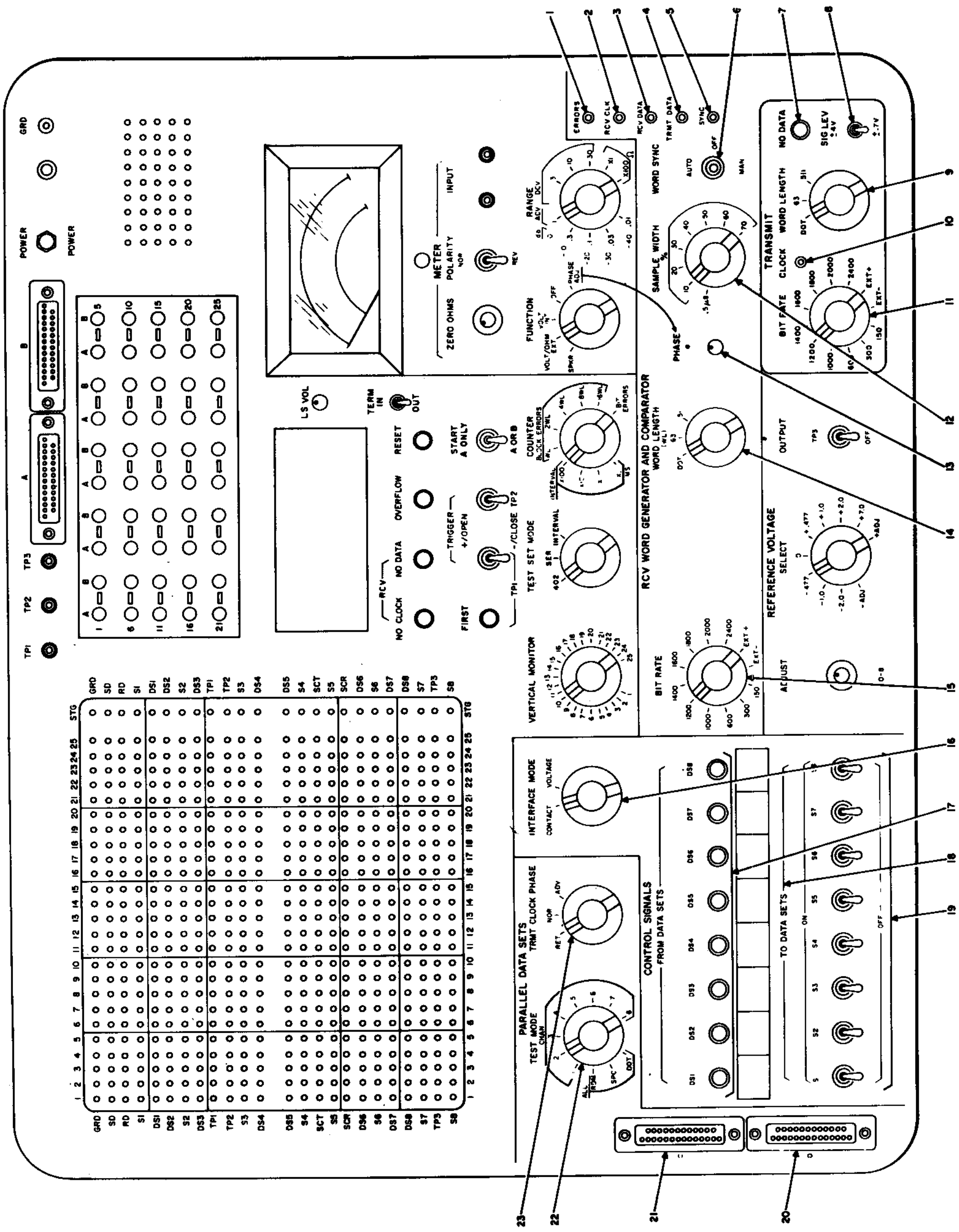


Fig. 7—914C Data Test Set Controls and Indicators

NOTES

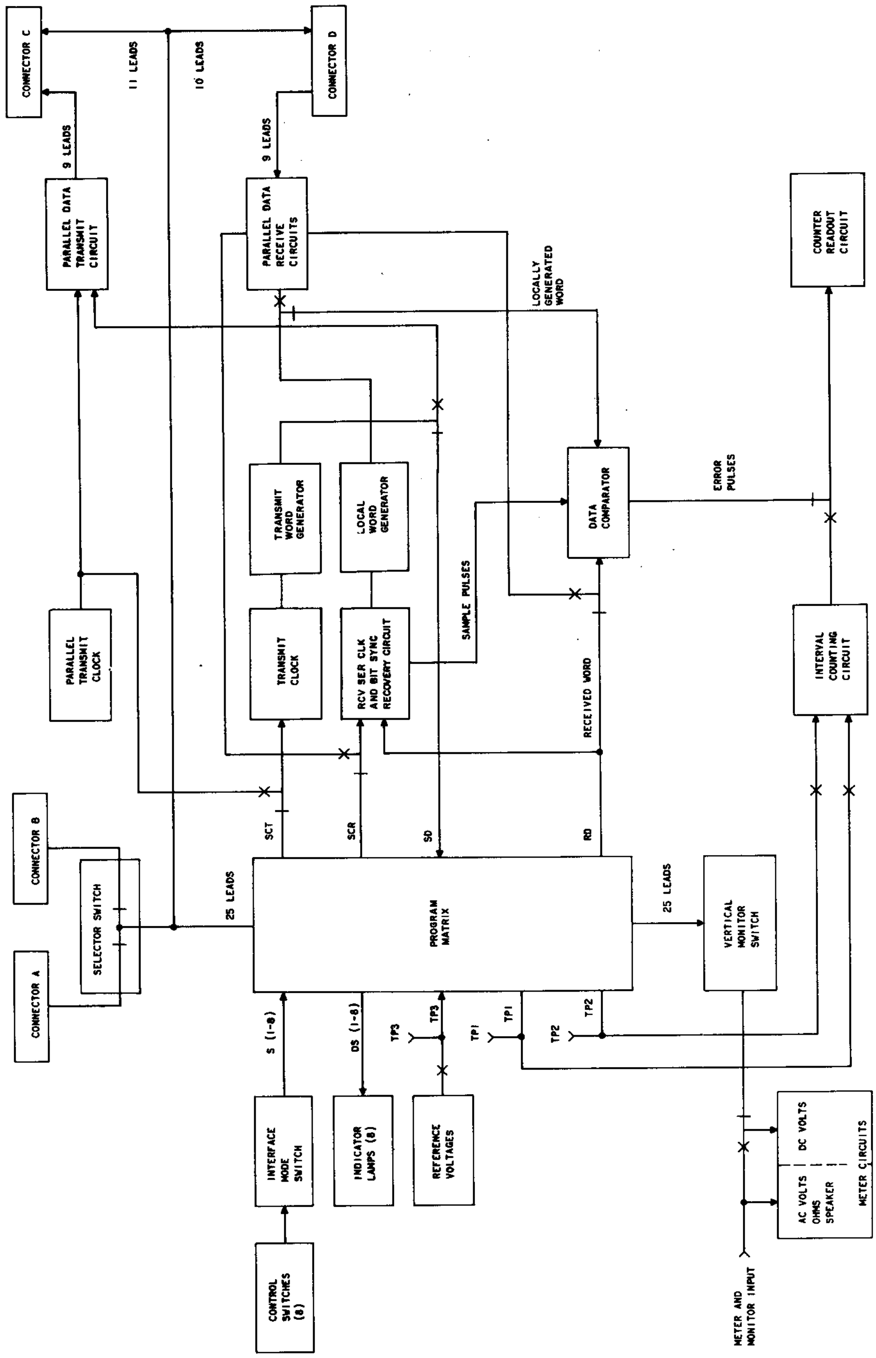


Fig. 8—914C DTS Overall Functional Block Diagram

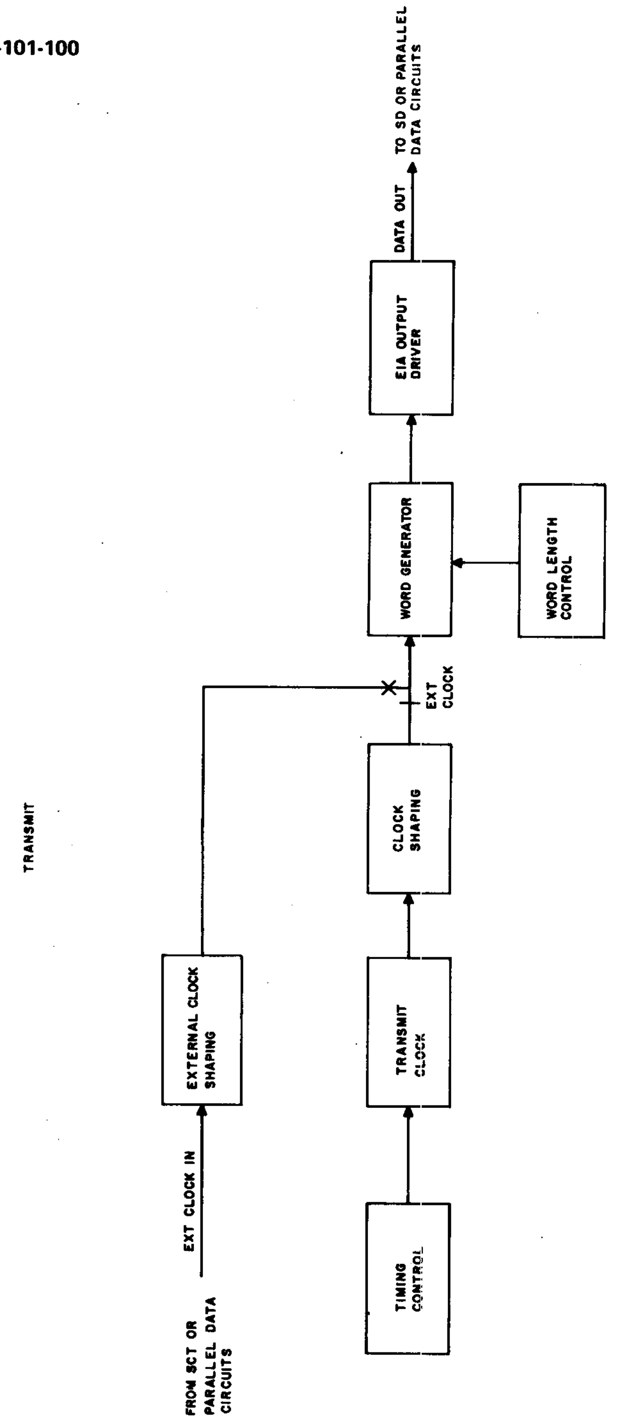


Fig. 9A–914C Serial Transmit Circuit

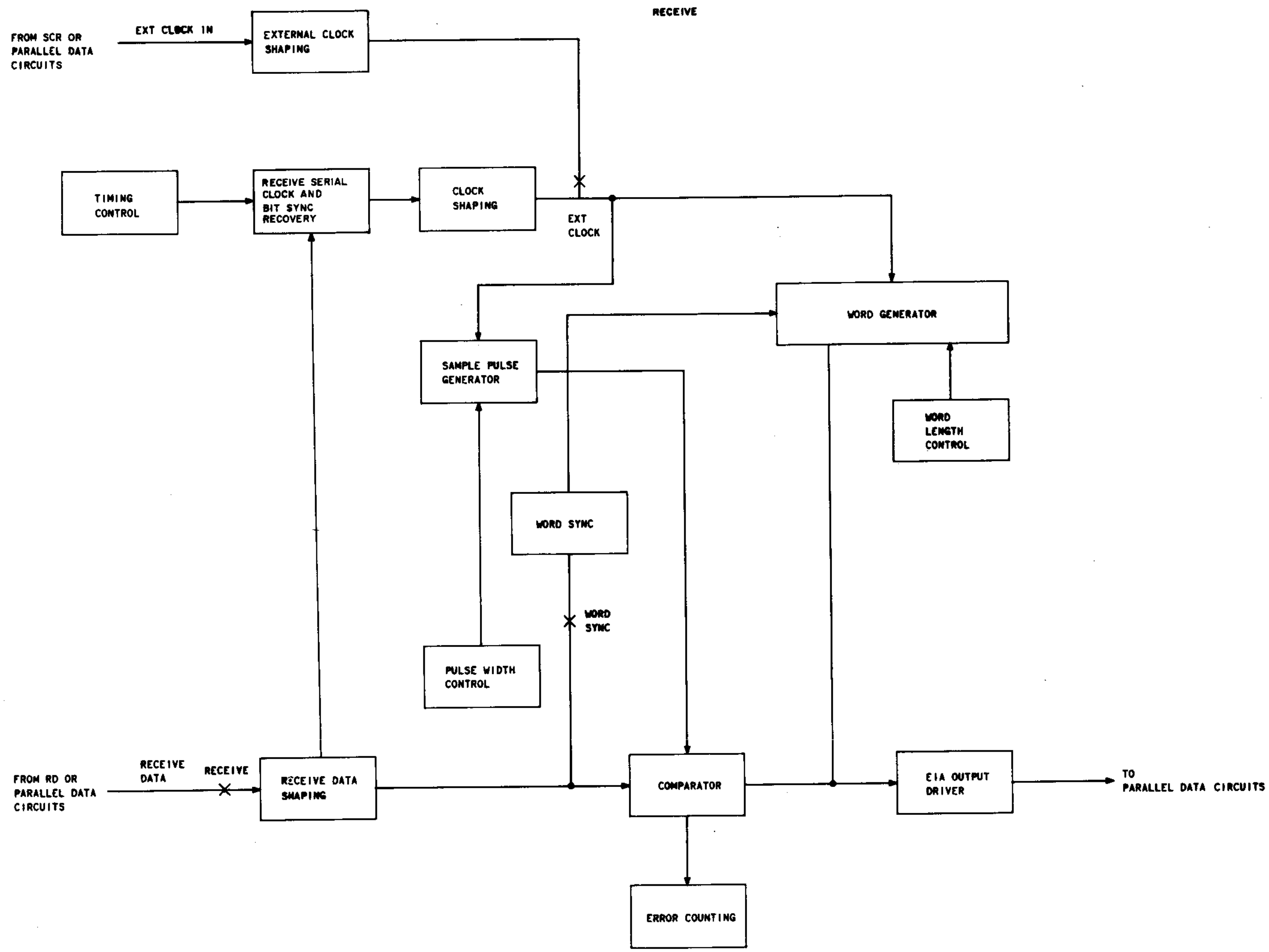


Fig. 9B–914C DTS Serial Transmit and Receive Circuits

NOTES

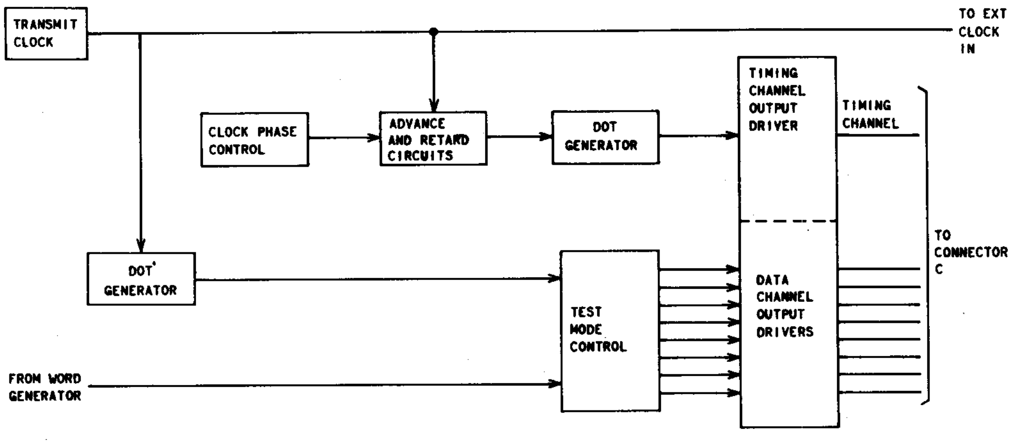


Fig. 10—914C Parallel Data Transmit Circuit

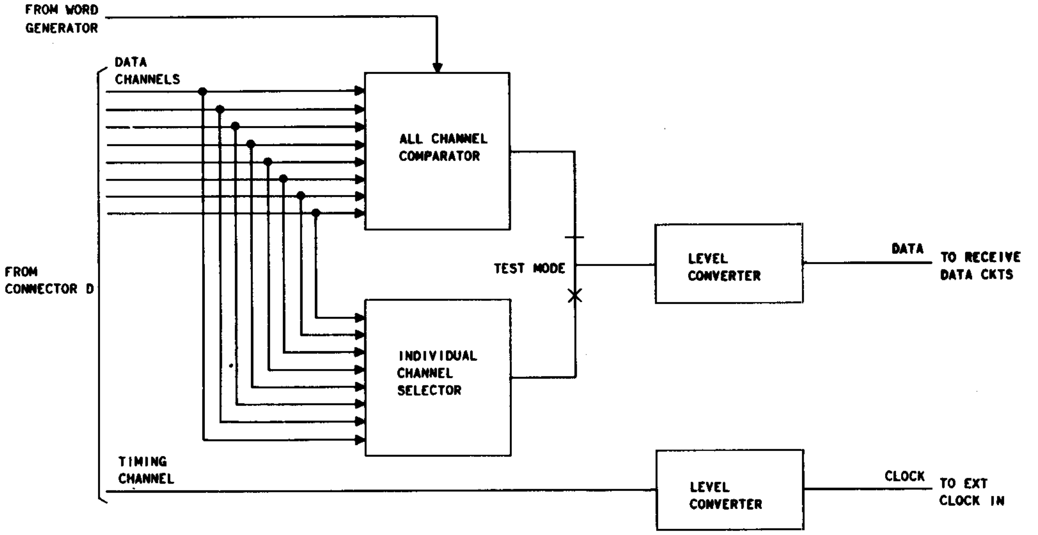


Fig. 11—914C Data Test Set Parallel Data Receive Circuits

TABLE D

DIFFERENCES BETWEEN 914C AND 914B CONTROLS AND INDICATORS

KEY*	CONTROLS		914B FUNCTION
	914C	914B	
11A	LS VOL Control		RANGE switch controls loudspeaker volume when FUNCTION switch is set to SPKR position.
13A	TERM IN-OUT Switch		Separate attenuator provided.
7B	START A ONLY—A OR B Switch	FIRST TP2 lamp	Lit when preselected signal appears first on TP2 lead.
9B	TEST SET MODE Switch	Same	Selects the required test mode (transmit, receive, serial, or parallel) for a particular data set.
11B	SELECT Switch	Same	No provision for negative voltage adjust.
13B	RCV NO CLOCK Lamp	NO CLOCK lamp	Lit during absence of clock signal.
14B	RCV NO DATA Lamp	NO DATA lamp	Lit during absence of data signal from data set.
1C	ERRORS Test Point	COUNTS Test Point	Provides access to a pulse produced for every 100 errors recorded on the external counter.
2C	RCV CLOCK Test Point	CLOCK Test Point	Provides access to a symmetrical square wave, +4.5 volts in amplitude and equal in frequency to the test set bit rate.
4C	TRMT DATA Test Point	DATA OUT Test Point	Provides access to the bi-polar data signal produced by the word generator.
7C	TRANSMIT NO DATA Lamp		See 14B.
8C	TRANSMIT SIGNAL LEVEL Switch	SIGNAL LEVEL switch	Same function. ±0.7 volts located on top. Switch located on WORD GENERATOR AND COMPARATOR section.
9C	TRANSMIT WORD LENGTH Switch	WORD LENGTH switch	Same function but is used for transmit or receive word and is located on the WORD GENERATOR AND COMPARATOR section.
10C	CLOCK Test Point		See 2C.
11C	TRANSMIT BIT RATE Switch	BIT RATE switch	Determines rate of timing signal used to drive word generator and comparator.
12C	SAMPLE WIDTH Switch	Same	Provides up to 50% of sample pulse width.
18C	Temporary Labeling Strip		Not provided.

* Number indicates key, letter indicates table and figure.

TABLE E

PROGRAMMING PIN COMPLEMENT

DESIGNATION	QUANTITY	COLOR	VALUE IN OHMS	USE
P1	31	Red	0	Used to interconnect (short) vertical and horizontal buses of the matrix
P2	9	Green	18±5%	Used to simulate contact resistance in tests of 400-type data sets
P3	9	Gray	10±5%	
P4*	8	Blue	10K	Used to increase impedance of lamp drivers when test set is bridged between data set and business machine

* Not supplied with 914B DTS.

TABLE F

OUTPUT SPECIFICATIONS

OUTPUT	CHARACTERISTIC
SD	Bipolar, NRZ (nonreturn to zero) signal ±3.5 to ±5 volts or ±0.7 volt in amplitude from an impedance of 200 ohms with rise and fall times not exceeding 1 μsec.
S1-S8 CONTROL SIGNALS	±3.5 to ±5 volt dc levels in the voltage mode, contact closures to ground and open circuits in the contact mode.
REFERENCE VOLTAGES	+7, ±2, ±1, ±0.477 volts dc within ±1 percent of specified value; the ±1 and ±2 volt outputs are balanced within ±0.5 percent. Maximum source resistance 330 ohms.
ERRORS	A pulse issued for every error recorded on the internal counter; +4 volt amplitude, 70 μsec width, from a resistance of 3500 ohms. On 914B the test point is labeled COUNTS and a pulse is issued for every 100 errors recorded on the internal counter.
RCV CLK	A symmetrical square wave +4.5 volts in amplitude, frequency equal to the bit rate of the test set. The positive clock transitions coincide with the transitions of the generated data signal. On 914B this test point is labeled CLOCK and is the bit rate of the set.
RCV DATA	In the SER mode the signal applied to the RD horizontal of the program matrix appears on this test point. In the 402 mode the bipolar ±6 volt output of the level converter is present on this test point. On 914B the modes are SER RCV and 402 RCV respectively.
TRMT DATA	The bipolar data signal produced by the transmit word generator; ±4 volts or ±0.7 volt in amplitude, as selected by the SIGNAL LEVEL switch. Labeled DATA OUT on 914B and is signal produced by word generator.
SYNC	A positive pulse, one bit interval in length, occurring once per word. The amplitude is 4.8 volts from a resistance of 1000 ohms.
TRANSMIT CLOCK	A symmetrical square wave +4.5 volts in frequency equal to the transmit bit rate. The positive clock transition coincide with the transitions of the generated data signals.

TABLE G

INPUT REQUIREMENTS

INPUT	REQUIREMENT
RD	Bipolar NRZ (nonreturn to zero) signal, minimum amplitude ±3 volts; input resistance 2400 ohms in series with a silicon diode junction.
SCR	Bipolar square wave, minimum amplitude ±3 volts; input resistance 2400 ohms in series with a silicon diode junction.
SCT	Same as SCR.
DS1-DS8 VOLTAGE MODE	+3 volts dc level to light lamp; input resistance 3000 ohms in series with a silicon diode junction.
DS1-DS8 CONTACT MODE	Contact closure to ground to light lamp; lamp current 40 mA, lamp voltage +23 volts.

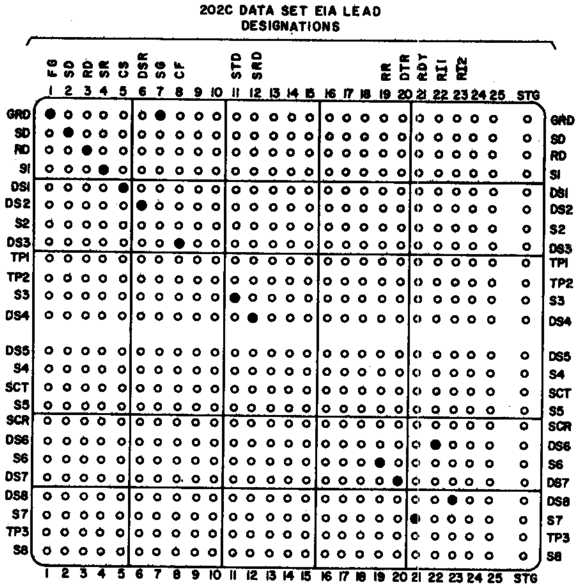


Fig. 12—Matrix Programmed for Data Set 202C

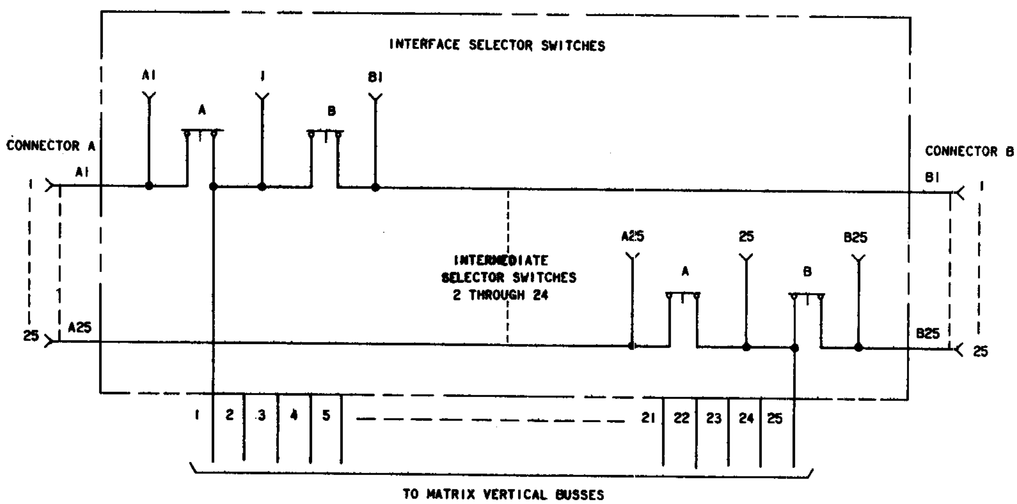


Fig. 13—A and B Interface Selector Switches—Schematic

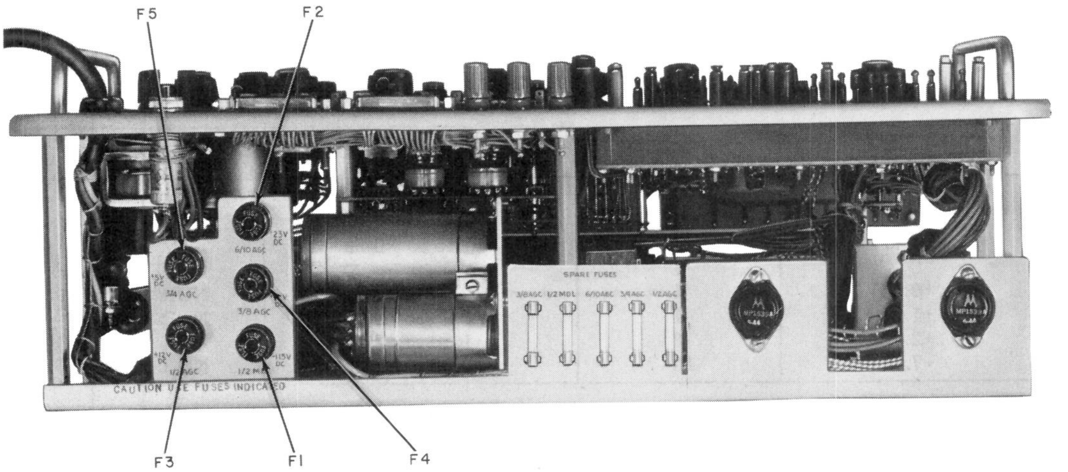


Fig. 14—Fuse Location

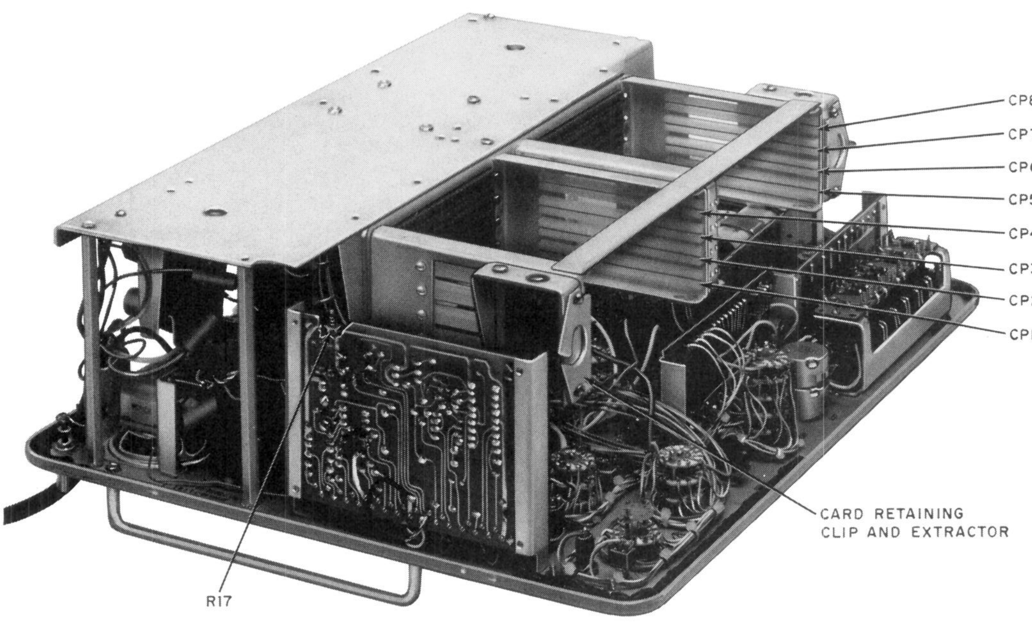


Fig. 15—914C Data Test Set Circuit Pack and AC Calibration Location

TABLE H

REFERENCE VOLTAGES

SET SELECT SWITCH TO:	SET RANGE DCV SWITCH TO:	METER INDICATES BETWEEN:	SET POLARITY SWITCH TO:
−2.0	3	−1.90 to −2.10	REV
−1.0	1	−0.95 to −1.05	REV
−0.477	1	−0.45 to −0.5	REV
0	1	0	—
+0.477	1	+0.45 to +0.5	NOR
+1.0	1	+0.95 to +1.05	NOR
+2.0	3	+1.90 to +2.10	NOR
+7.0	10	+6.65 to +7.35	NOR

TABLE I

CONTROL SIGNALS

CONNECT MATRIX		OPERATE		OBSERVE	
ROW	COLUMN	SWITCH	POSITION	LAMP	INDICATION
DS2 S2	2 2	S2	ON OFF	DS2	Lit Extinguished
DS3 S3	3 3	S3	ON OFF	DS3	Lit Extinguished
DS4 S4	4 4	S4	ON OFF	DS4	Lit Extinguished
DS5 S5	5 5	S5	ON OFF	DS5	Lit Extinguished
DS6 S6	6 6	S6	ON OFF	DS6	Lit Extinguished
DS7 S7	7 7	S7	ON OFF	DS7	Lit Extinguished
DS8 S8	8 8	S8	ON OFF	DS8	Lit Extinguished

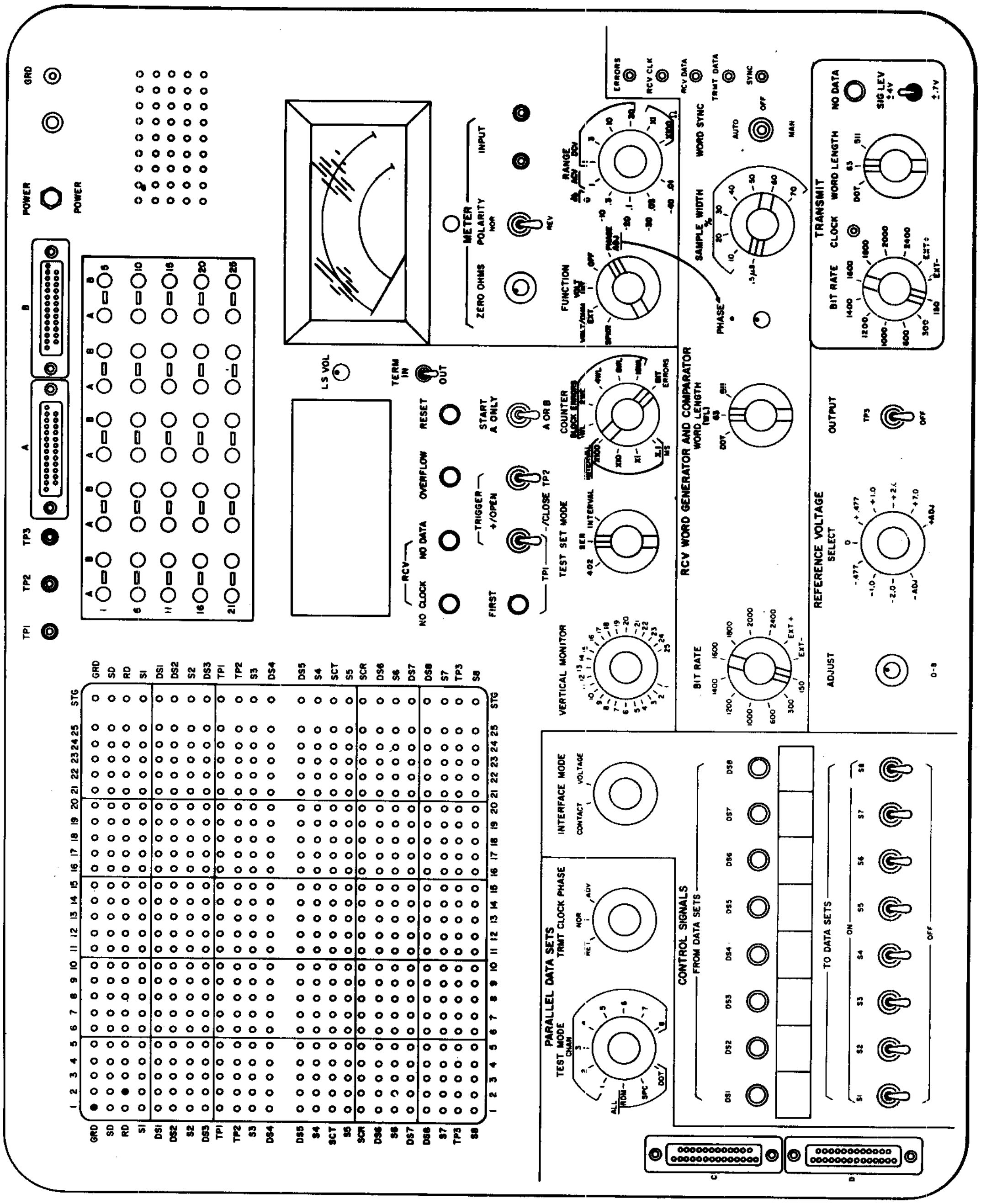


Fig. 16—Word Generators, Clocks and Sync Circuits—Test Connections

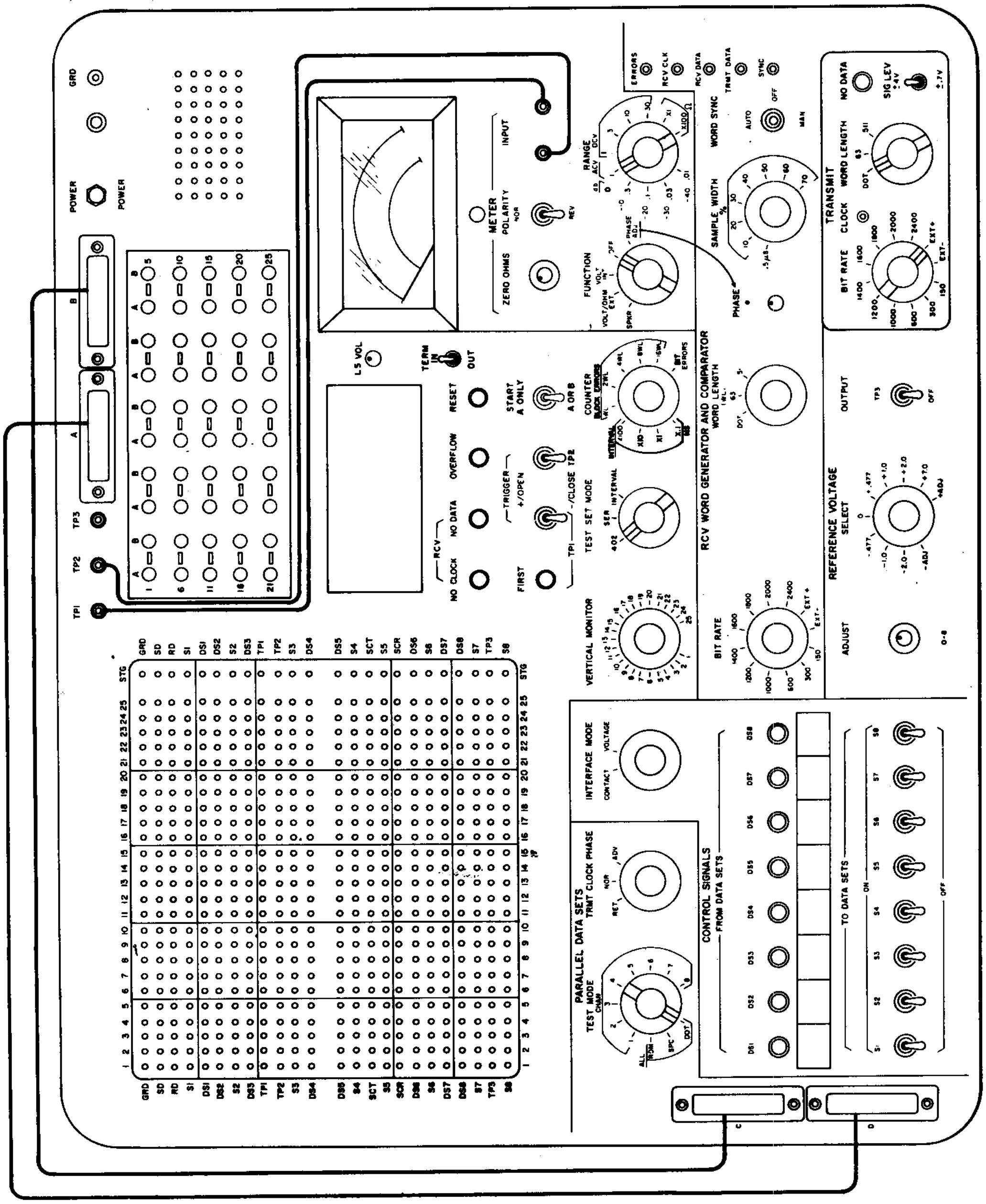


Fig. 17—Parallel Data Circuits—Test Connections

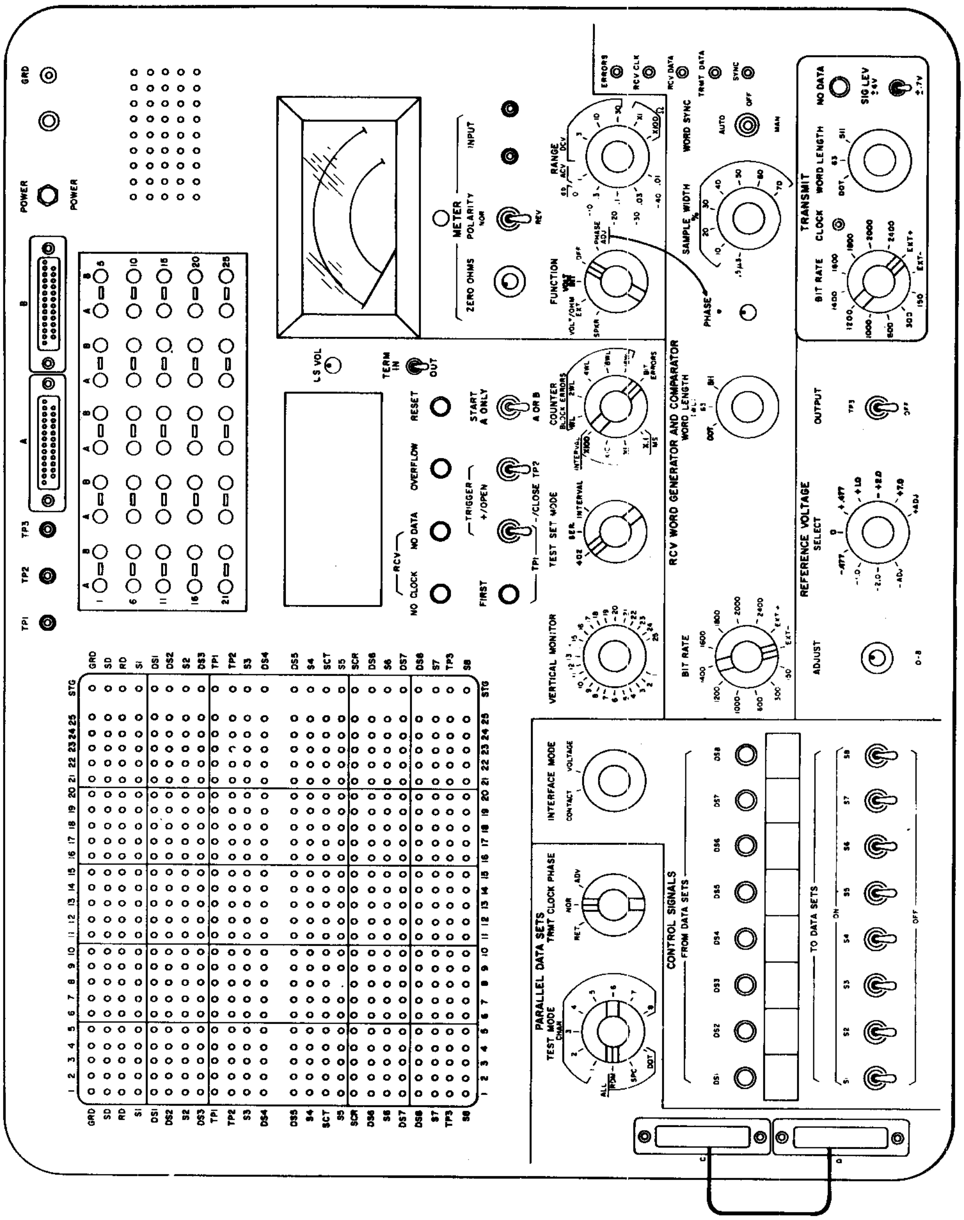
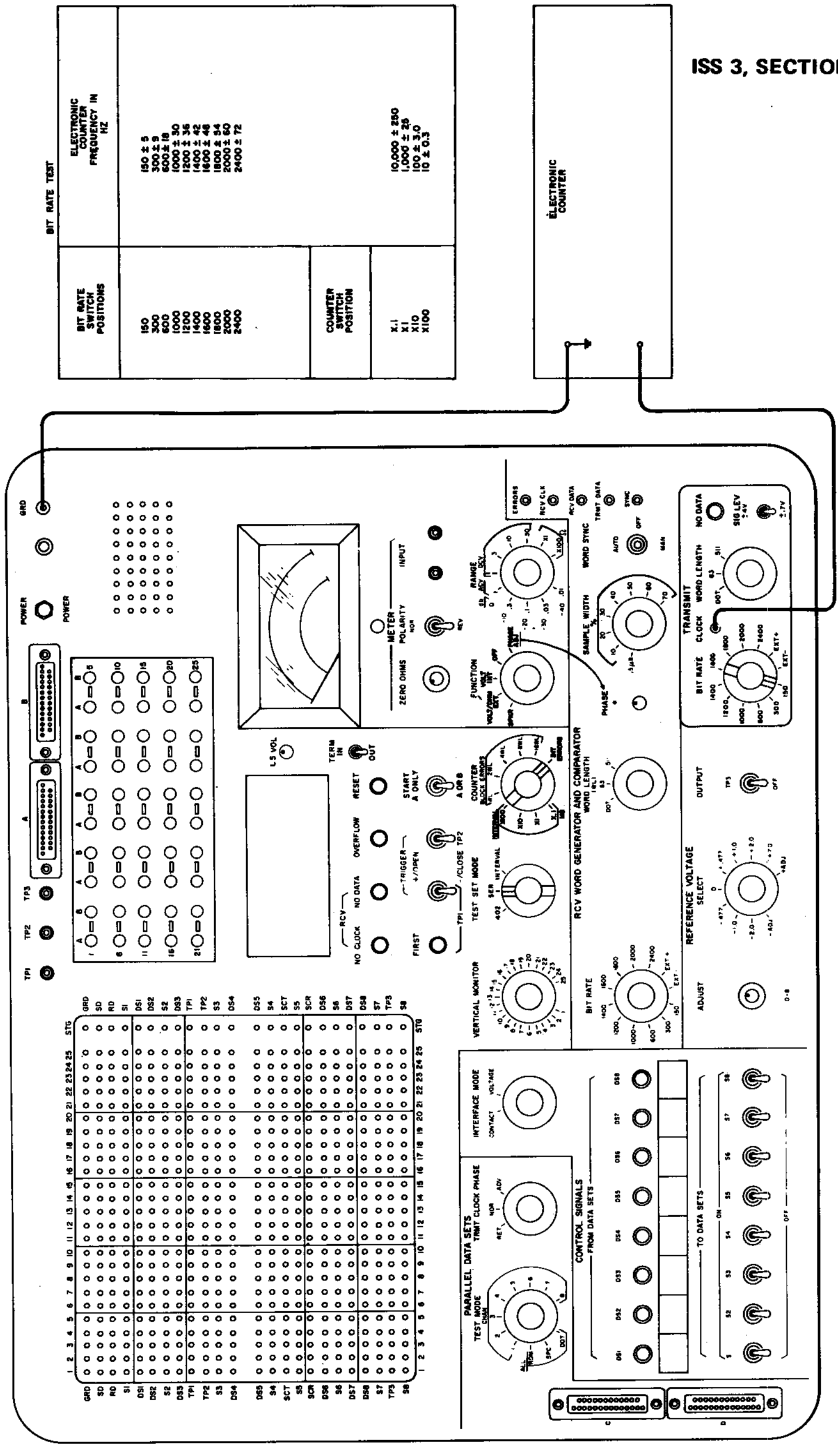


Fig. 18—Parallel Data Transmit and Receive Circuits—Test Connections



BIT RATE TEST

BIT RATE SWITCH POSITIONS	ELECTRONIC COUNTER FREQUENCY IN HZ
150	150 ± 5
300	300 ± 9
600	600 ± 18
1000	1000 ± 30
1200	1200 ± 36
1400	1400 ± 42
1600	1600 ± 48
1800	1800 ± 54
2000	2000 ± 60
2400	2400 ± 72
COUNTER SWITCH POSITION	
X.1	10,000 ± 250
X1	1,000 ± 25
X10	100 ± 3.0
X100	10 ± 0.3

Fig. 19—Clock Circuits—Test Connections

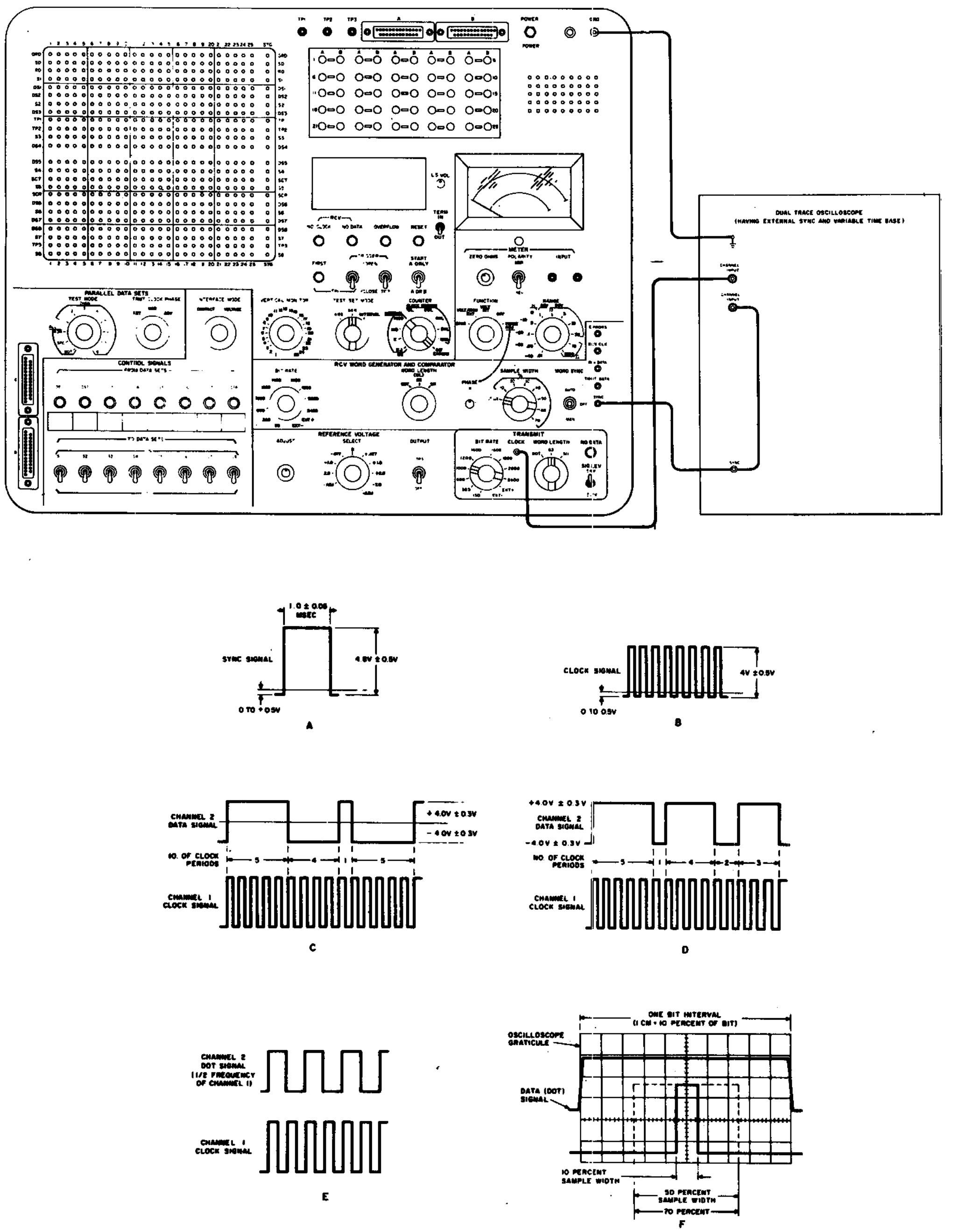


Fig. 27—Data and Sample Circuits—Test Connections

ABRIDGED

J94027A, C, E, P/AR METER GENERATORS AND J94027B P/AR METER RECEIVER DESCRIPTION, OPERATION, AND MAINTENANCE

CONTENTS **PAGE**

1. GENERAL INFORMATION

1.01 This section covers the description, operation, and maintenance of the J94027A, C, and E P/AR meter generators; the J94027B P/AR meter receiver; and the J94027B, List 2 calibration network. These sets are designed to provide a rating of some of the more important characteristics which affect the capability of a transmission facility to handle voiceband data signals. This rating is a measure of the amplitude and envelope delay distortion in the system under test.

1.02 This section is reissued to include the currently available P/AR meter generators and a calibration network. The added P/AR meter generators are coded J94027C (27C), a rack-mounted set, and J94027E (27E), an ac-operated portable set. The newer generators perform the same function as the J94027A (27A) P/AR meter generator with the following advantages:

(a) They transmit pulses with a more precisely controlled repetition rate.

(b) Adjacent pulses are bilateral (of opposite polarity) to eliminate the turnover effect possible with the unilateral pulse of the 27A set.

(c) They have no internal or external adjustments.

The calibration network is coded J94027B, List 2 and is used when calibrating the 27B P/AR receiver with either a 27C or a 27E P/AR meter generator.

A. Purpose

1.03 It should be noted that the 27C and 27E P/AR transmitters are satisfactory for use on local facilities and short-haul carrier systems. However, errors of up to six P/AR points may be encountered on long-haul systems that employ single sideband transmission. A new P/AR generator is being designed to overcome this problem and will supercede the 27C and 27E sets.

1.04 The P/AR (peak-to-average ratio) meter 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.

1.05 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.

1.06 While the primary purpose of the P/AR meter 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.

1.07 Measurements are made using a procedure similar to 1000-Hz loss measurements.

1.08 The P/AR meter is sensitive to a variety of transmission impairments. Primarily these are:

(a) Envelope delay distortion (EDD)

(b) Bandwidth reduction

(c) High background noise.

Secondary impairments include:

(d) Gain-slope distortion

(e) Gain and phase ripples (echoes)

(f) Resonances (tendency to sing)

(g) Nonlinearities (compression, clipping, etc).

When several of these impairments are present, the P/AR meter provides a combined measure of all of the distortions.

1.09 The two main unavoidable impairments of a normal carrier channel are bandwidth restriction (due to the channel filters) and EDD introduced at the band edges. Therefore, any test over a carrier facility is not expected to provide a reading of 100 percent on the P/AR meter.

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 27A generator with its unilateral pulse is used as the generator, the clipping will cause different peak-to-average ratios depending on the polarity of the applied signal with respect to tip and ring. When the 27C or 27E generator 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.

> ***Note:*** See Fig. 11d and 12j for the difference in the two signals. The 27C and E generators produce successive pulses 180 degrees out of phase with each other, which are combined in a filter circuit to provide a bipolar waveform. The 27A generator produces a train of pulses which are identical.

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 test signal are compressed by the nonlinearity, the peak-to-average ratio will be reduced.

1.12 High background noise reduces the P/AR rating because it increases the full-wave average value of the received signal more than its peak value.

1.13 A comparison of the characteristics of the 27A, 27C, and 27E P/AR meter generators is shown in Table A.

B. 27A Generator Unit Description

1.14 The 27A generator unit of the P/AR equipment is shown in Fig. 1. A block diagram of the 27A generator is shown in Fig. 2.

1.15 There are two pushbutton controls on the generator. One is used in calibrating the sensitivity of the P/AR meter receiver by changing the pulse repetition rate; the other is used with a lamp indicator to check the battery which powers the generator. Holding and blocking are provided and cannot be switched out.

1.16 When a 310-type plug is inserted into either the 600- or 900-ohm jack on the generator, the set is automatically turned on. Once turned on, the generator transmits pulses of a fixed amplitude, wave shape, and repetition rate.

1.17 The power supply shown in Fig. 2 supplies a regulated voltage to the P/AR meter generator circuits while the battery decays from

TABLE A

CHARACTERISTIC	GENERATORS			RECEIVER
	27A	27C	27E	27B
Impedance (Balanced)	600 Ohms or 900 Ohms	600 Ohms or 900 Ohms	600 Ohms or 900 Ohms	600 Ohms or 900 Ohms
Number of Outputs	One	Two	One	One (Input)
Pulse Repetition Freq	250 pps	253 pps	253 pps	
Pulse Polarity	Unilateral	Bilateral (Bipolar)	Bilateral (Bipolar)	
Peak Power Output	−7 dBm	−7 dBm	−7 dBm	
True RMS Power Output	−17.5 dBm	−18 dBm	−18 dBm	
Average Power Output	−22.2 dBm	−23.2 dBm	−23.2 dBm	
Adjustments, Number (Internal Circuit)	5	None	None	5
Input Attenuator Range				0 to 33 dB, coarse 0 to 3 dB, fine
Power Supply	24V Battery	(External) −48 ±4 Vdc	(ac Line) 105 to 125 Vdc	24V Battery
Set Type	Portable	Relay-Rack Mounted (23 in.)	Portable	Portable
Operating Temperature	0° to 50°C	0° to 50°C	0° to 50°C	0° to 50°C
Overall Dimensions (Approximate, in inches)	6-1/2 Long 3-1/2 Wide 4-1/2 High	23 Wide 4 High 6 Deep	8-1/2 Long 7-1/4 Wide 5-3/4 High	11 Wide 7 High 7-1/4 Deep
Weight	4 Pounds	4.5 Pounds	6 Pounds	10 Pounds

24 volts to 16 volts. The BAT CHK pushbutton and its associated lamp on the face of the generator are part of the battery check circuit of Fig. 2. When the battery decays to less than 16 volts, the lamp no longer lights.

1.18 The pulse generator circuit in Fig. 2 contains a solid-state relaxation oscillator with controls for adjusting the repetition rate and the width of the output pulses. The CAL CHK pushbutton on the generator changes the normal repetition rate of 250 pps to 375 pps.

1.19 The limiter puts square corners on the rounded pulses from the pulse generator. In addition, it provides the proper driving point impedance for the shaping filter.

1.20 The shaping filter performs the preliminary frequency weighting necessary for the final P/AR measurement. (Most of the frequency weighting is in the receiver.) It is also designed to give the generator output pulses bipolar (both a positive and negative going signal) characteristics.

1.21 The output circuit on the transmitter provides 600- and 900-ohm output impedance as well as dc holding and blocking.

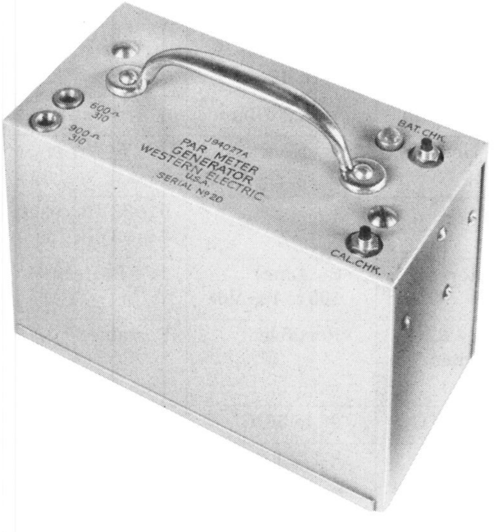


Fig. 1—J94027A P/AR Meter Generator

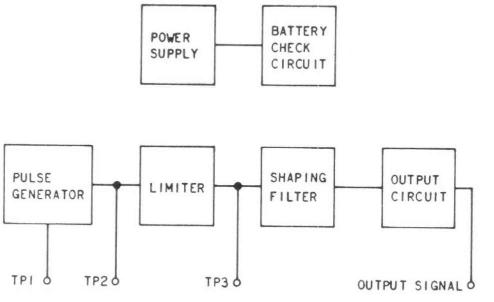


Fig. 2—27A P/AR Meter Generator—Block Diagram

C. 27C Generator Unit Description

1.22 The 27C generator unit of the P/AR equipment is shown in Fig. 3. A block diagram of the 27C generator is shown in Fig. 4.

1.23 There are no front panel controls; all connections to the generator are made internally to terminals mounted on the circuit board. The circuit board is made accessible by removal of the cover which is secured by four lock screws. The generator has two balanced outputs with each output having either a 600- or a 900-ohm impedance. These outputs are independent of each other and can be used simultaneously. Impedance selection is made on installation by setting the internal switches S1 and S2 in the appropriate position.

Note: The output jacks will be designated with the appropriate impedance.

1.24 The set is powered from an external -48 ± 4 volt dc supply capable of delivering 250 mA of current. A 1/2-ampere fuse (F1), which fuses the line voltage, is provided to protect the set against damage caused by component failure or accidental shorts. The second fuse holder furnished contains a spare fuse.

1.25 The crystal oscillator, a highly accurate frequency source, provides two 126.5-Hz square-wave outputs 180 degrees out of phase with each other. The two square-wave outputs from the crystal oscillator are differentiated and summed in the summing differentiator circuit. Thus, the input to the pulse generator is a train of negative spikes at a 253-pps rate.

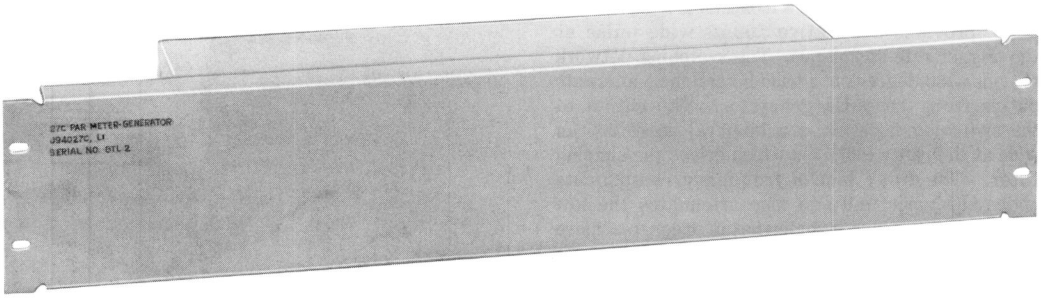


Fig. 3—J94027C P/AR Meter Generator

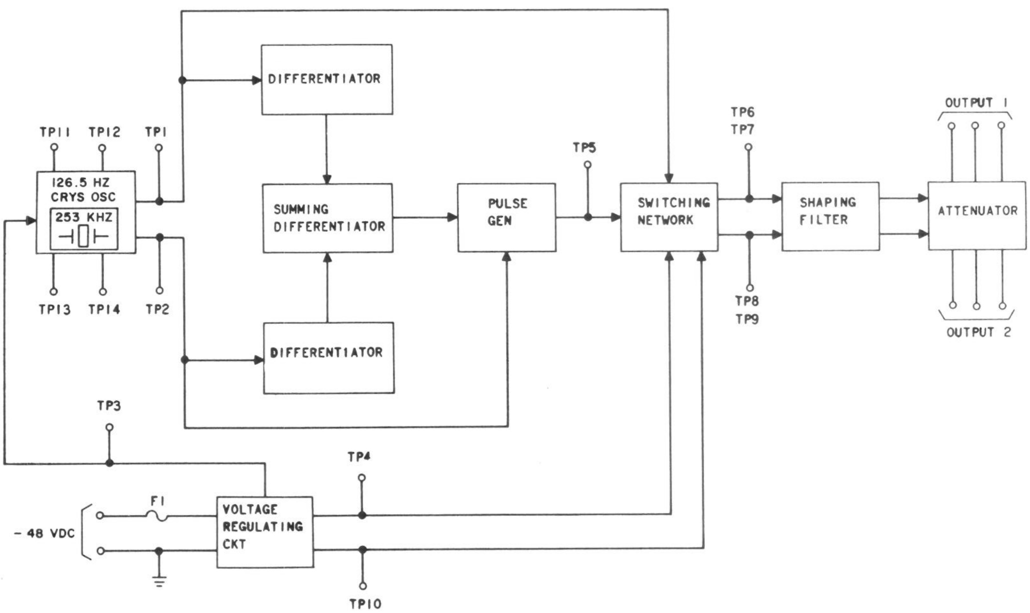


Fig. 4—27C P/AR Meter Generator—Block Diagram

1.26 The pulse generator, a monostable multivibrator, provides a negative 200-μs wide pulse at the trigger rate of 253 pps. The switching network provides 180 degrees of phase inversion to alternate pulses from the pulse generator. The output of the switching network is a bilateral pulse 200 μs wide at the rate of 253 pps which drives the shaping filter. The filter blocks frequency components above the voiceband and also attenuates the low frequency components somewhat in order to achieve the desired output pulse shape. The fixed attenuator ensures the correct output level at either the 600- or 900-ohm outputs. The voltage regulating circuits provide regulation and filtering of the external −48 volt dc supply used to power the set.

Fig. 5—J94027E P/AR Meter Generator

D. 27E Generator Unit Description

1.27 The 27E generator unit is shown in Fig. 5. A block diagram of the 27E generator is shown in Fig. 6.

1.28 The generator operates from a 105- to 125-volt, 50- to 60-Hz ac source. The total power consumption is approximately 5.5 watts. A pushbutton switch turns the set ON and OFF; a pilot lamp which is part of the switch indicates when the set is ON. A 1/2-ampere fuse (F1) fuses the line voltage.

1.29 The generator has a single output with either a 600- or a 900-ohm input impedance. The

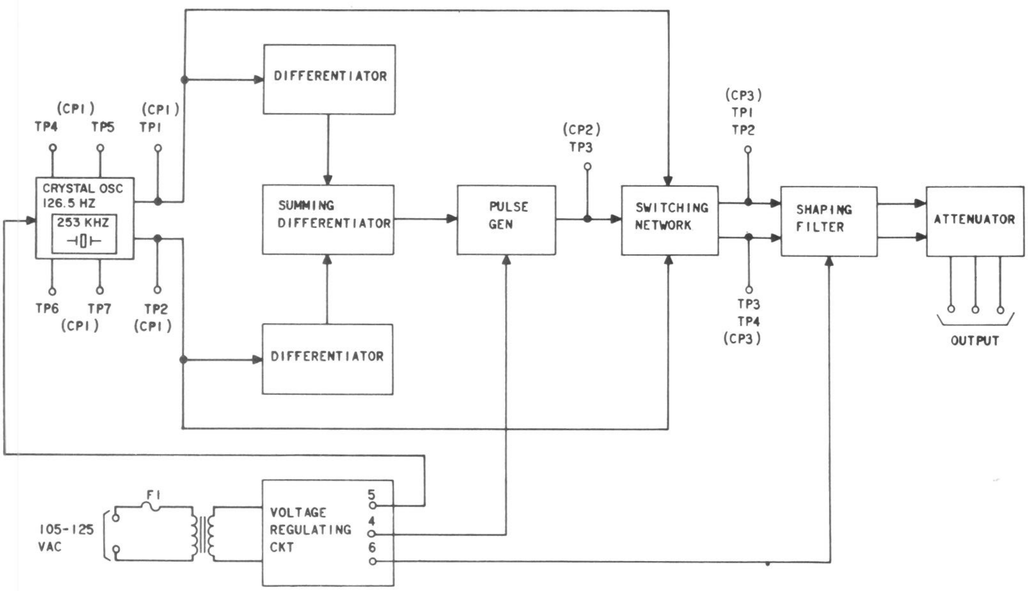


Fig. 6—27E P/AR Meter Generator—Block Diagram

selection of the appropriate impedance is made with front panel switch S2. The output is taken from either the 310-type jack or binding posts labeled T (tip), R (ring), and S (sleeve). A chassis ground is available at the binding post labeled GND.

1.30 The crystal oscillator, a highly accurate frequency source, provides two 126.5-Hz square-wave outputs 180 degrees out of phase with each other. The two square-wave outputs from the crystal oscillator are differentiated and summed in the summing differentiator circuit. Thus, the input to the pulse generator is a train of negative spikes at a 253-pps rate.

1.31 The pulse generator, a monostable multivibrator, provides a negative 200-μs wide pulse at the trigger rate of 253 pps. The switching network provides 180 degrees of phase inverson to alternate pulses from the pulse generator. The output of the switching network is a bilateral pulse 200 μs wide at the rate of 253 pps which drives the shaping filter. The filter blocks frequency components above the voiceband and also attenuates the low-frequency components somewhat in order to achieve the desired output pulse shape. The fixed attenuator ensures the correct output level for either the 600- or the 900-ohm output, selection of which is made by a front panel switch. The voltage regulating circuit rectifies the ac power input to a −48 volt regulated direct current, which is used to power the set.

E. 27B Receiver Unit Description

1.32 The 27B receiver unit of the P/AR equipment is shown in Fig. 7. A block diagram of the 27B receiver is shown in Fig. 8.

Fig. 7—J94027B P/AR Meter Receiver

1.33 The receiver has four controls in addition to an ON-OFF switch. Adjustment of the detector input signal to a reference level is provided by coarse and fine controls. A toggle switch is used to set the input impedance to either 600 or 900 ohms. A pushbutton is provided for checking the battery.

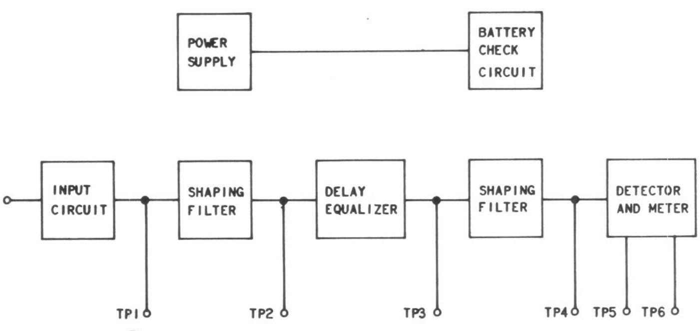


Fig. 8—27B P/AR Meter Receiver—Block Diagram

1.34 There are two meters on the front panel of the 27B P/AR meter receiver. The smaller of these is used alternately for the battery check and for measuring the average value of the input signal. The large meter gives the value of P/AR for the facility, circuit, or equipment under test.

1.35 There are two sets of 5-way binding posts on the set. One is used for the input and the other is used as an output to an oscilloscope. An oscilloscope is not necessary, but it sometimes may be of value in diagnosing the transmission impairment causing a low P/AR reading.

1.36 One of the functions of the receiver is to apply frequency weighting and delay equalization to the pulse from the generator. Following this, the receiver detects the peak and full-wave average values of the pulse and displays a measure of their ratio on the meter.

1.37 The power supply shown in Fig. 8 contains two 24-volt batteries. The BAT CHK pushbutton and the small meter on the face of the P/AR meter receiver are a part of the battery check circuit. When the small meter indicates less than BAT MIN with the BAT CHK button depressed, the batteries must be replaced.

1.38 The input circuit of Fig. 8 provides a balanced 600- or 900-ohm input impedance with dc holding and blocking for the receiver. The COARSE and FINE RECEIVED LEVEL ADJ controls are also included in the input circuit.

1.39 Figure 8 shows two shaping filters. These filters, and those in the transmitter, provide the frequency weighting necessary for a meaningful P/AR measurement.

1.40 The delay equalization circuit compensates for the delay distortion of the shaping filters. The equalization has been adjusted so that the delay-versus-frequency characteristic between the pulse generator and the detector is almost flat when the P/AR meter generator is connected directly to the P/AR meter receiver.

1.41 Finally, the detector circuit shown in Fig. 8 contains two full-wave average detectors and one peak detector. One of the average detectors is connected to the small meter on the face of the P/AR meter receiver. This meter and the level controls mentioned in 1.38 are used to adjust the average value of the measured pulse to a constant. The second average detector and the peak detector are used in deriving the P/AR reading which appears on the large meter.

1.42 The P/AR receiver will operate satisfactorily over a range of approximately 7-dB gain to 25-dB loss from a nominal (−17.5 dBm true rms) transmitted signal.

F. 27B, List 2 Calibration Network Description

1.43 The front view of the 27B, List 2 calibration network is shown in Fig. 9; the rear view is shown in Fig. 10.

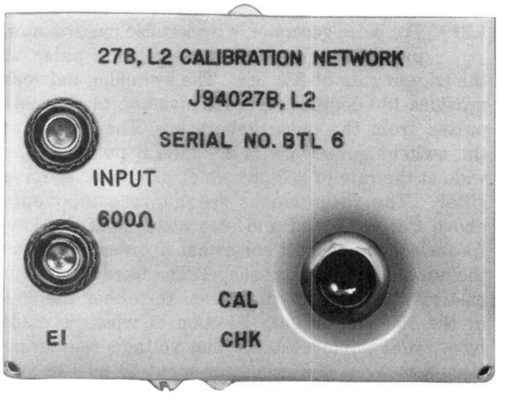


Fig. 9—J94027B, L2 Calibration Network—Front View

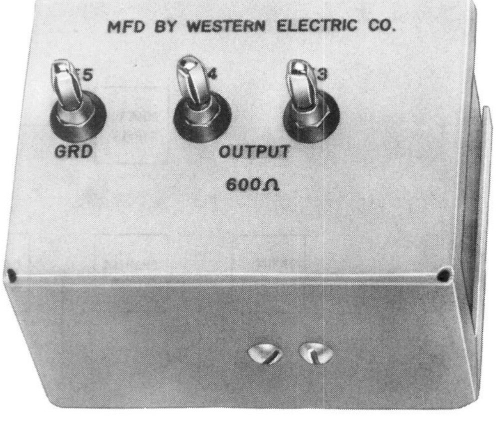


Fig. 10—J94027B, L2 Calibration Network—Back View

1.44 The calibration network is used when calibrating the 27B P/AR receiver with either a 27C or a 27E P/AR meter generator. The network consists of resistors and capacitors and requires no power. The input and output impedance of the network is 600 ohms. The network input is equipped with a pair of binding posts; the output is equipped with banana plugs which allow the network to fit directly into the 27B P/AR receiver input. The calibration check is made with the generator and receiver impedance switch in the 600-ohm position. A pushbutton CAL CHK switch mounted on the calibration network is depressed to make the calibration check.

2. OPERATING INSTRUCTIONS

A. 27A Generator With a 27B Receiver—Calibration Check

2.01 To ensure measurement accuracy, the 27A set should be calibrated weekly or when the batteries are changed. Calibration of the set compensates for battery decay and other aging effects. The procedure is as follows.

STEP	PROCEDURE
1	Turn the receiver ON and connect it to the generator. (Inserting the 310-type plug into the output jack turns the generator on.)
2	Check the battery in the generator by depressing the switch marked BAT CHK and observing the indicator lamp. If there is any illumination from the lamp, the battery is acceptable.
3	Check the battery in the receiver by depressing the switch marked BAT CHK. The RECEIVED LEVEL meter should read above the BAT MIN mark on the meter for proper operation.
4	Turn the INPUT IMPEDANCE switch on the receiver to correspond to the chosen generator output impedance.
5	Adjust the COARSE and FINE RECEIVED LEVEL ADJ controls on the receiver to make the RECEIVED LEVEL meter read at REF LEVEL.
6	The P/AR meter should now read 100. If it does not, adjust the mechanical zero adjuster on the meter to make it read 100.
	Note: Step 6 should be made with the meter panel face up and then repeated with the meter panel in a vertical position.
7	Reverse the leads between the generator and receiver. If the meter does not read 100, refer to Part 3.
8	Depress the CAL CHK switch on the generator and follow the instructions of Step 5; the P/AR meter should read 33 ± 2. If this condition is not met, refer to Part 3.

B. 27C or 27E Generator With a 27B Receiver—Calibration Check

2.02 To ensure measurement accuracy, the 27B set should be calibrated monthly or when the battery is changed in the 27B. A J94027B, List 2 calibration network is required to make a calibration check. The procedure is as follows.

STEP	PROCEDURE
1	Turn the generator and receiver ON.
2	Plug the output of the J94027B, List 2 calibration network into the receiver INPUT and connect the generator OUTPUT to the network INPUT.
3	Check the battery in the receiver by depressing the BAT CHK switch. The RECEIVED LEVEL meter should read above the BAT MIN mark on the meter for proper operation.
4	Set the IMPEDANCE switch on the 27E generator and the 27B receiver to the 600-ohm position. If a 27C generator is used, connect from the 600-ohm output jack to the 27B receiver if possible. If only a 900-ohm output is provided, see note to Step 7.
5	Adjust the COARSE and FINE RECEIVED LEVEL ADJ controls on the receiver to make the RECEIVED LEVEL meter read at REF LEVEL.
6	The P/AR meter should now read 100. If it does not, adjust the mechanical zero adjuster on the meter to make it read 100.
	Note: Step 6 should be made with the meter panel face up and then repeated with the meter panel in a vertical position.
7	Depress the switch on the calibration network and repeat Step 5. The P/AR meter should read 59 ±2. If this condition is not met, refer to Part 3. Remove the calibration network.
	Note: If the 900-ohm output is used with the 27C generator, the reading should be 56 ±2 with the 27B receiver on 900 ohms.

C. Measurement Procedure (Compandored Trunks)

2.03 The measurement procedure for compandored trunks or facilities is as follows.

STEP	PROCEDURE
1	Connect the generator to the trunk to be tested; use the 600- or 900-ohm output, as necessary. The generator should be connected to the trunk at a zero or higher transmission level point. If the trunk is tested with TP2, it will be necessary to transmit the P/AR signal through an auxiliary attenuator, eg, a 5A attenuator.

STEP	PROCEDURE
2	Connect the 27B receiver to the other end of the trunk to be tested. Operate the IMPEDANCE switch to the required impedance.
3	Adjust COARSE and FINE RECEIVED LEVEL ADJ controls on the receiver to make the RECEIVED LEVEL meter read at the REF LEVEL line.
4	Read the P/AR rating of the trunks. *Note:* The above procedure may be followed when making measurements on noncompandored trunks.

2.04 When using a 27A generator, the P/AR reading should be obtained for both polarities of transmitted test signal on compandored trunks. (When using the 27C or 27E generators, only one polarity is necessary.) The connections between the 27A generator and the trunk must be transposed. (See also 1.10.) The two readings are averaged to obtain the rating.

Note: This transposition is made only at the transmitting end of the trunk.

D. Measurement Procedure (Other Type Facilities)

2.05 Procedures and requirements for other type facilities and tests (ie, loops, end-to-end, DATA-PHONE®) are covered in appropriate sections.

NOTES

J94003C NOISE MEASURING SET (3C)

CONTENTS PAGE

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 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.

1.03 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.

1.04 The input impedance (terminating) is 735 ohms which is the geometric mean between 600 and 900 ohms, as described in Part 4.

1.05 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.

1.06 The use of the 3C NM set 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 TIF coupling units for measurements of KV·T and I·T product from which the telephone interference factor is determined.

1.07 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 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 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. Two 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 by 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

Fig. 1—J94003C Noise Measuring Set

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 as shown in Fig. 10.

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. This arrangement is shown in Fig. 11.

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 N_G position is used to measure noise voltages between a circuit and ground, such as those resulting from longitudinal induction.

(f) The N_M 600/900 position is used as a termination when a metallic measurement at either 600 or 900 is specified.

(g) The N_G HOLD position has the same function as the N_G position and in addition, connects a holding network with a dc resistance of 700 ohms across the input circuit.

(h) The N_M 600/900 HOLD position has the same function as the N_M 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.

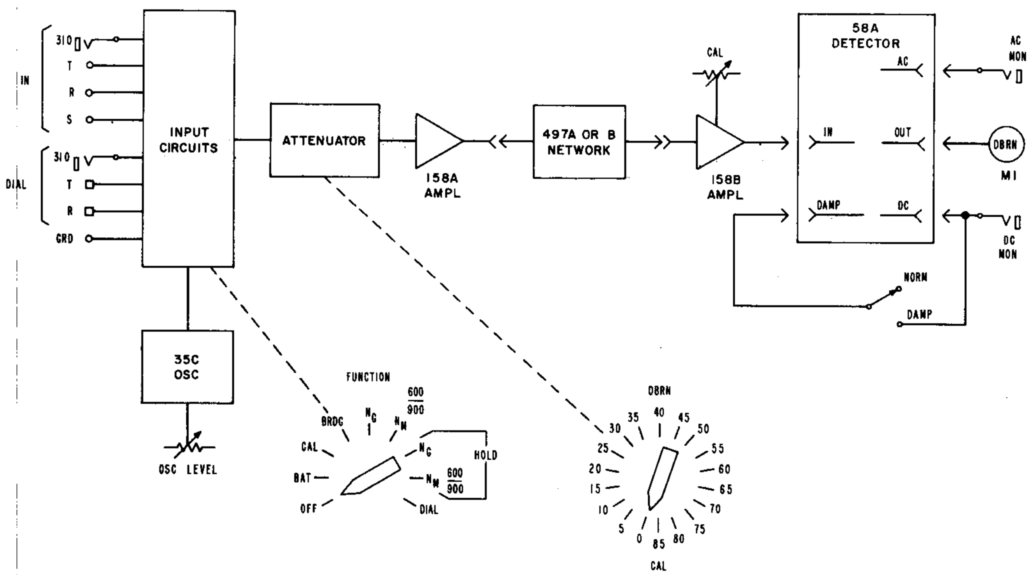


Fig. 2—J94003C Noise Measuring Set, Block Diagram

(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.

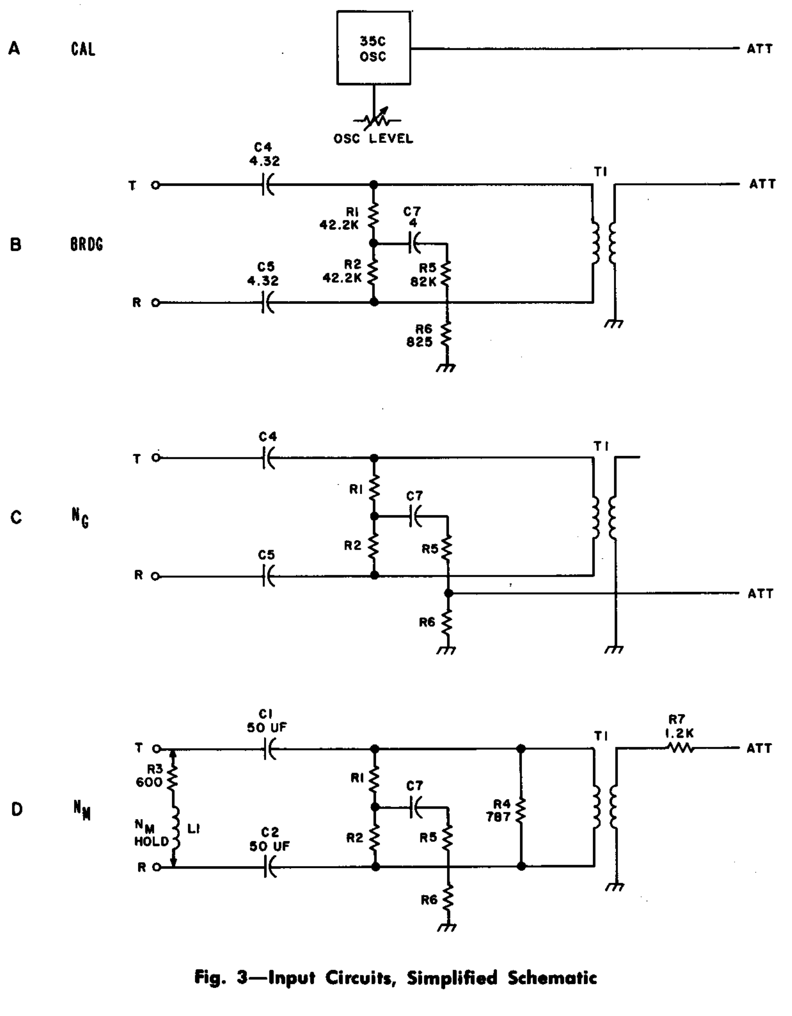


Fig. 3—Input Circuits, Simplified Schematic

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.

158B Amplifier

2.20 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

2.21 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.

2.22 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, ♦including manufacturing tolerances,♦ 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. 3-kHz Flat Weighting

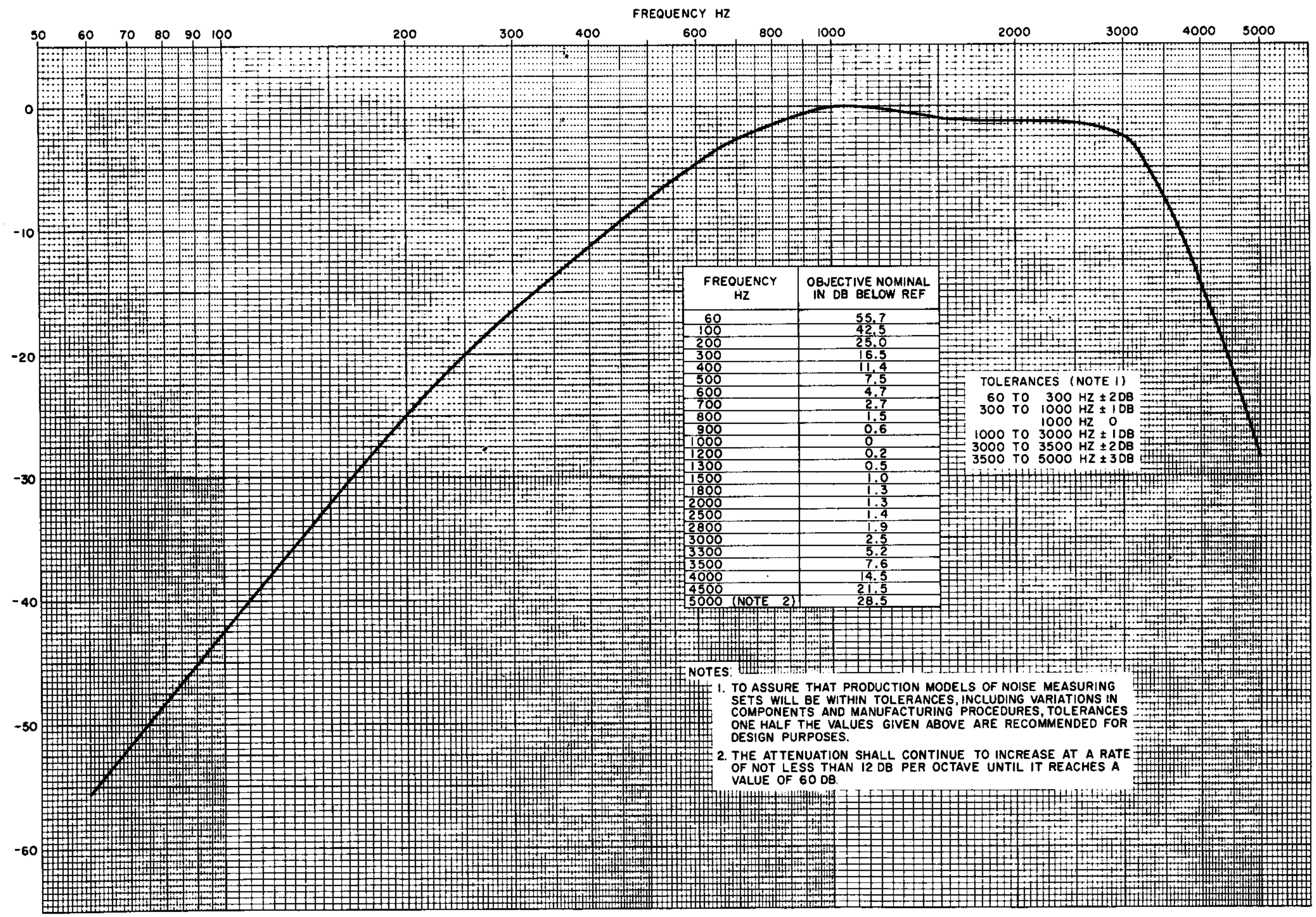
3.02 The 3-kHz flat weighting frequency characteristic, including manufacturing tolerances, is shown in Fig. 5. The 3-kHz flat ♦(3KC FLAT)♦ network, associated with this characteristic, is included in the package of the 497A network and is used when it is desired to weight all frequencies in the band 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).

C. Program Weighting

3.03 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. 6. 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.

D. 15-kHz Flat Weighting

3.04 The typical 15-kHz flat weighting frequency characteristic, including manufacturing tolerances, is given in Fig. 7, 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 shaping. The 15-kHz flat weighting is used to measure noise in program circuits having a bandwidth of 15 kHz.



FREQUENCY HZ	OBJECTIVE NOMINAL IN DB BELOW REF
60	55.7
100	42.5
200	25.0
300	16.5
400	11.4
500	7.5
600	4.7
700	2.7
800	1.5
900	0.6
1000	0
1200	0.2
1300	0.5
1500	1.0
1800	1.3
2000	1.3
2500	1.4
2800	1.9
3000	2.5
3300	5.2
3500	7.6
4000	14.5
4500	21.5
5000 (NOTE 2)	28.5

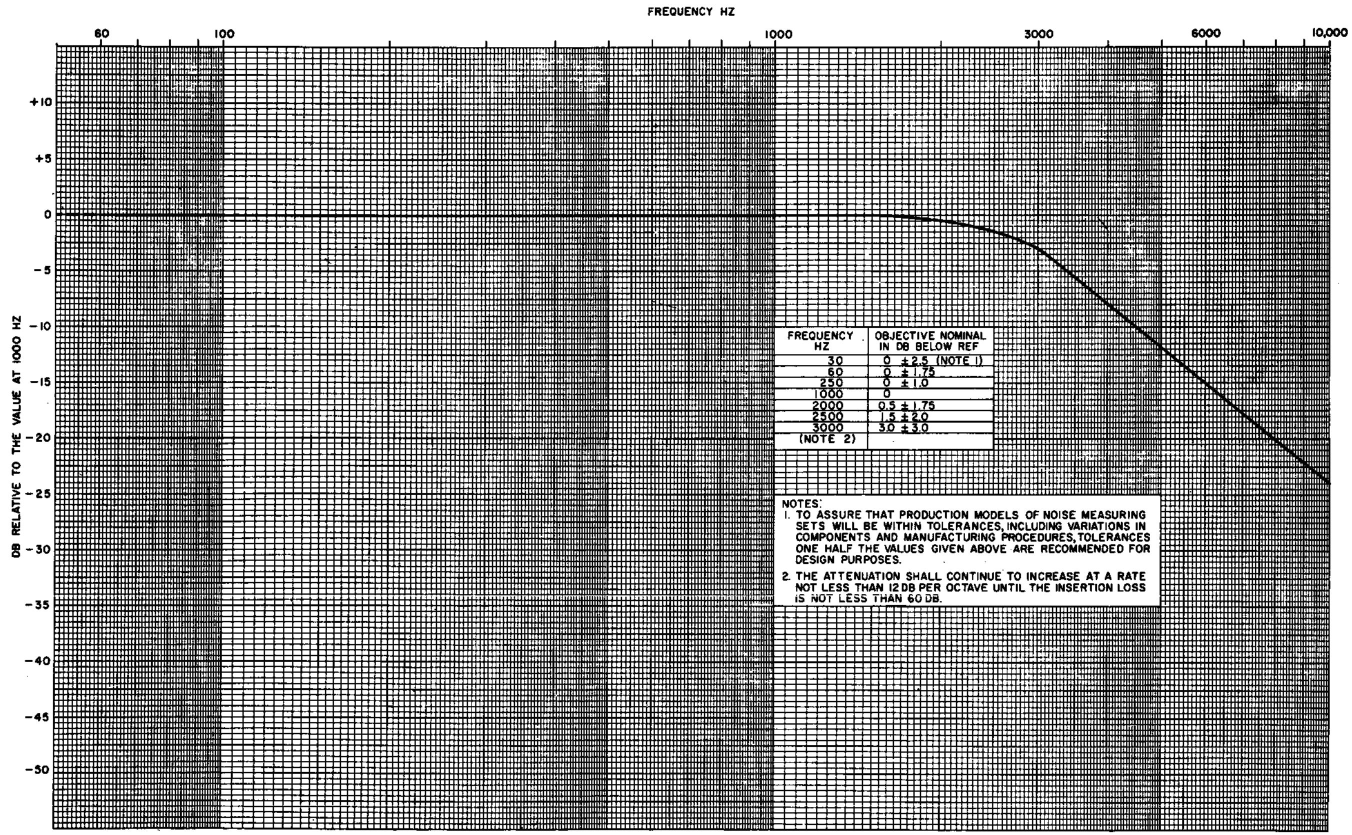
TOLERANCES (NOTE 1)

60 TO 300 HZ ± 2 DB
300 TO 1000 HZ ± 1 DB
1000 HZ 0
1000 TO 3000 HZ ± 1 DB
3000 TO 3500 HZ ± 2 DB
3500 TO 5000 HZ ± 3 DB

NOTES:

1. TO ASSURE THAT PRODUCTION MODELS OF NOISE MEASURING SETS WILL BE WITHIN TOLERANCES, INCLUDING VARIATIONS IN COMPONENTS AND MANUFACTURING PROCEDURES, TOLERANCES ONE HALF THE VALUES GIVEN ABOVE ARE RECOMMENDED FOR DESIGN PURPOSES.
2. THE ATTENUATION SHALL CONTINUE TO INCREASE AT A RATE OF NOT LESS THAN 12 DB PER OCTAVE UNTIL IT REACHES A VALUE OF 60 DB.

Fig. 4—C-Message Characteristic Curve

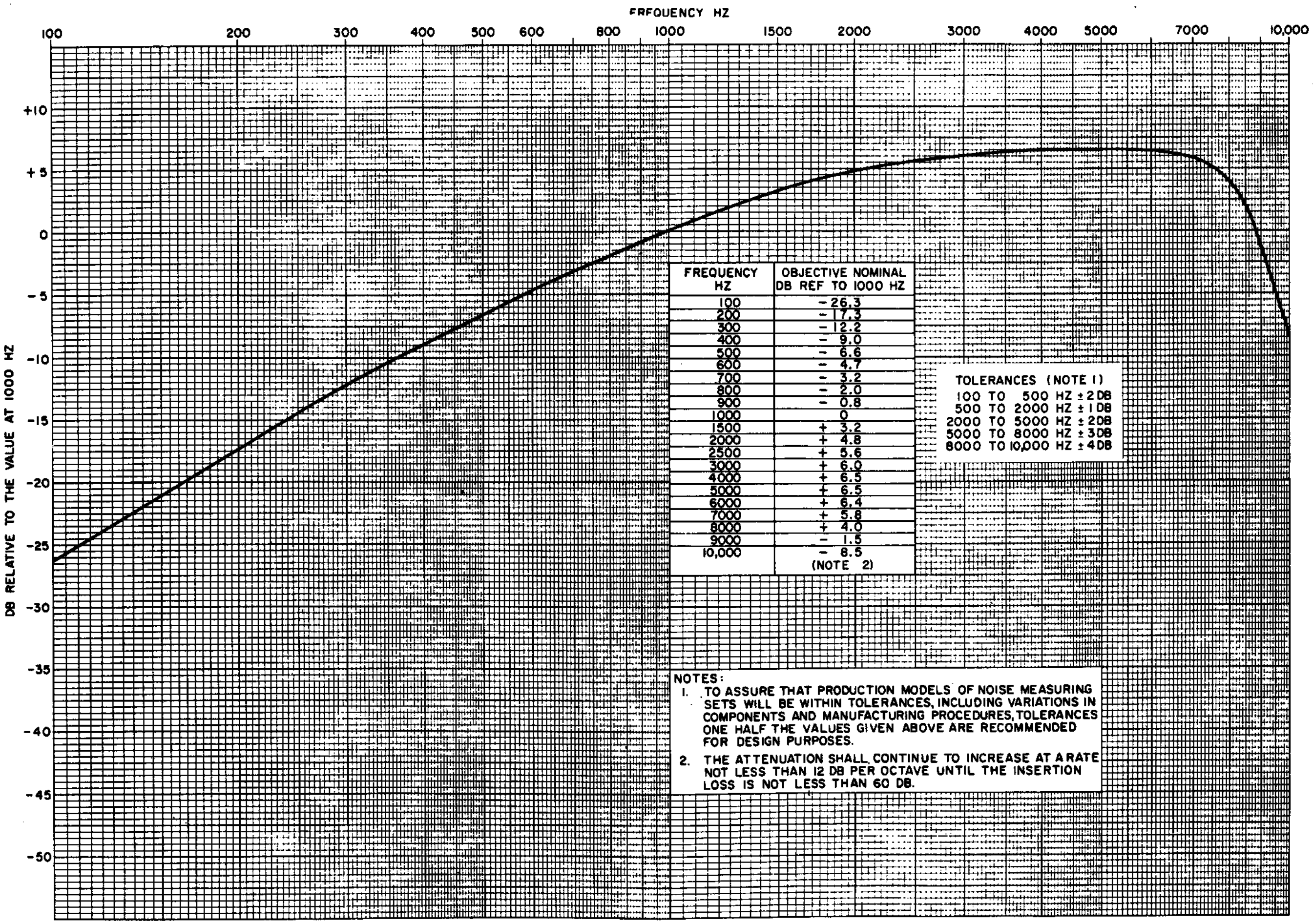


FREQUENCY HZ	OBJECTIVE NOMINAL IN DB BELOW REF
30	0 ±2.5 (NOTE 1)
60	0 ±1.75
250	0 ±1.0
1000	0
2000	0.5 ±1.75
2500	1.5 ±2.0
3000	3.0 ±3.0
(NOTE 2)	

NOTES:

1. TO ASSURE THAT PRODUCTION MODELS OF NOISE MEASURING SETS WILL BE WITHIN TOLERANCES, INCLUDING VARIATIONS IN COMPONENTS AND MANUFACTURING PROCEDURES, TOLERANCES ONE HALF THE VALUES GIVEN ABOVE ARE RECOMMENDED FOR DESIGN PURPOSES.
2. THE ATTENUATION SHALL CONTINUE TO INCREASE AT A RATE NOT LESS THAN 12 DB PER OCTAVE UNTIL THE INSERTION LOSS IS NOT LESS THAN 60 DB.

Fig. 5—3-KHz Flat Weighting Characteristic Curve



FREQUENCY HZ	OBJECTIVE NOMINAL DB REF TO 1000 HZ
100	−26.3
200	−17.3
300	−12.2
400	− 9.0
500	− 6.6
600	− 4.7
700	− 3.2
800	− 2.0
900	− 0.8
1000	0
1500	+ 3.2
2000	+ 4.8
2500	+ 5.6
3000	+ 6.0
4000	+ 6.5
5000	+ 6.5
6000	+ 6.4
7000	+ 5.8
8000	+ 4.0
9000	− 1.5
10,000	− 8.5 (NOTE 2)

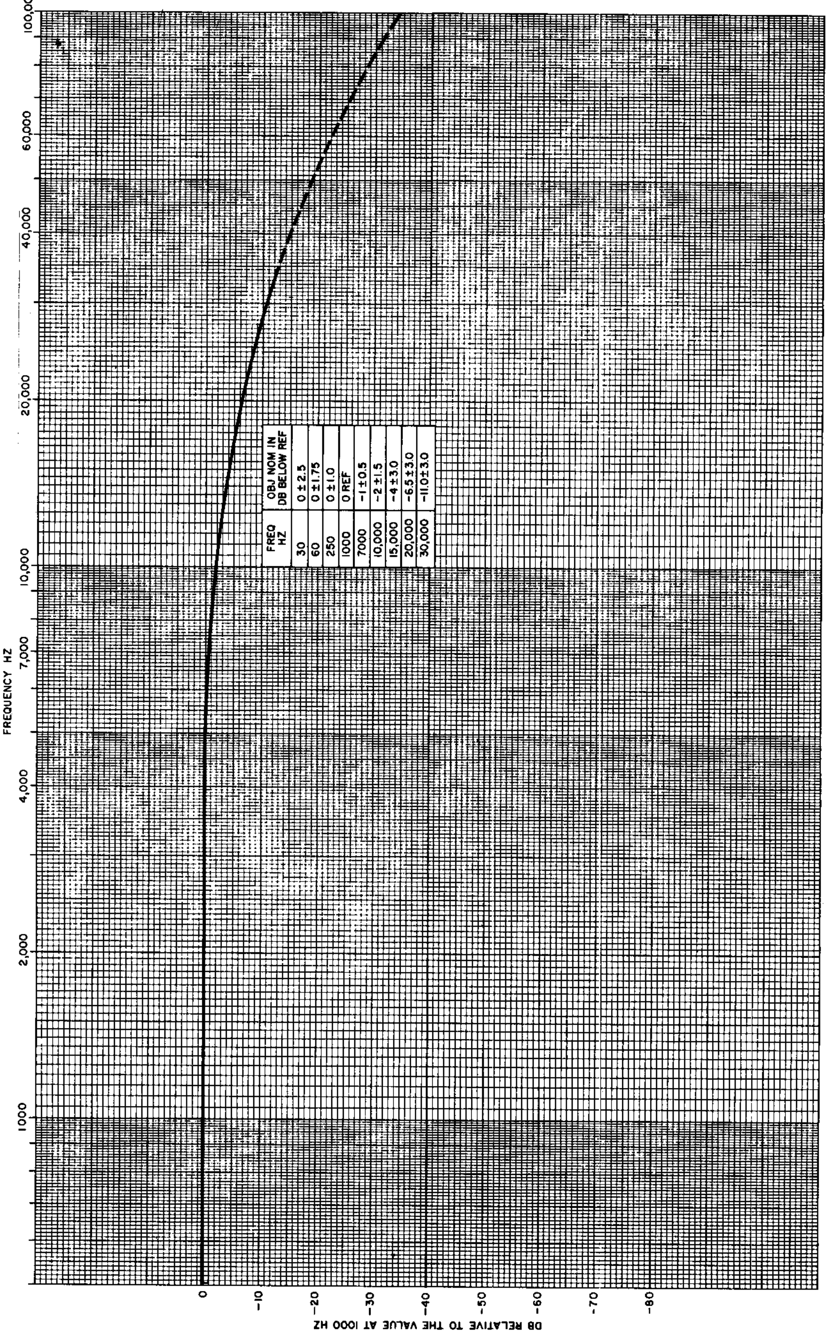
TOLERANCES (NOTE 1)

100 TO 500 HZ ± 2 DB
500 TO 2000 HZ ± 1 DB
2000 TO 5000 HZ ± 2 DB
5000 TO 8000 HZ ± 3 DB
8000 TO 10,000 HZ ± 4 DB

NOTES:

1. TO ASSURE THAT PRODUCTION MODELS OF NOISE MEASURING SETS WILL BE WITHIN TOLERANCES, INCLUDING VARIATIONS IN COMPONENTS AND MANUFACTURING PROCEDURES, TOLERANCES ONE HALF THE VALUES GIVEN ABOVE ARE RECOMMENDED FOR DESIGN PURPOSES.
2. THE ATTENUATION SHALL CONTINUE TO INCREASE AT A RATE NOT LESS THAN 12 DB PER OCTAVE UNTIL THE INSERTION LOSS IS NOT LESS THAN 60 DB.

Fig. 6—Program Weighting Characteristic Curve



FREQ HZ	OBJ NOM IN DB BELOW REF
30	0 ± 2.5
60	0 ± 1.75
250	0 ± 1.0
1000	0 REF
7000	−1 ± 0.5
10,000	−2 ± 1.5
15,000	−4 ± 3.0
20,000	−6.5 ± 3.0
30,000	−11.0 ± 3.0

Fig. 7—15-KHz Weighting Characteristic Curve

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.

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

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 8 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 (e.g., 30 dBrnc, 40 dBrn 3 kHz, 15 dBrn PROG, or 10 dBrn 15 kHz).

D. Measurements on Circuits Equipped With E-Type Signaling Units

4.09 The path to ground of the input circuit of the 3C NM set includes a 4-uf capacitor, C7, as shown on Fig. 3D, to prevent false keying of certain types of E-type signaling units.

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 oscillator or calibrated milliwatt outlet having an output impedance of 600 or 900 ohms and an output level of 0 dBm to supply a calibration signal. When an oscillator is used, measure its output with a 22A milliwatt reference meter to be sure it is 1 milliwatt (0 dBm).

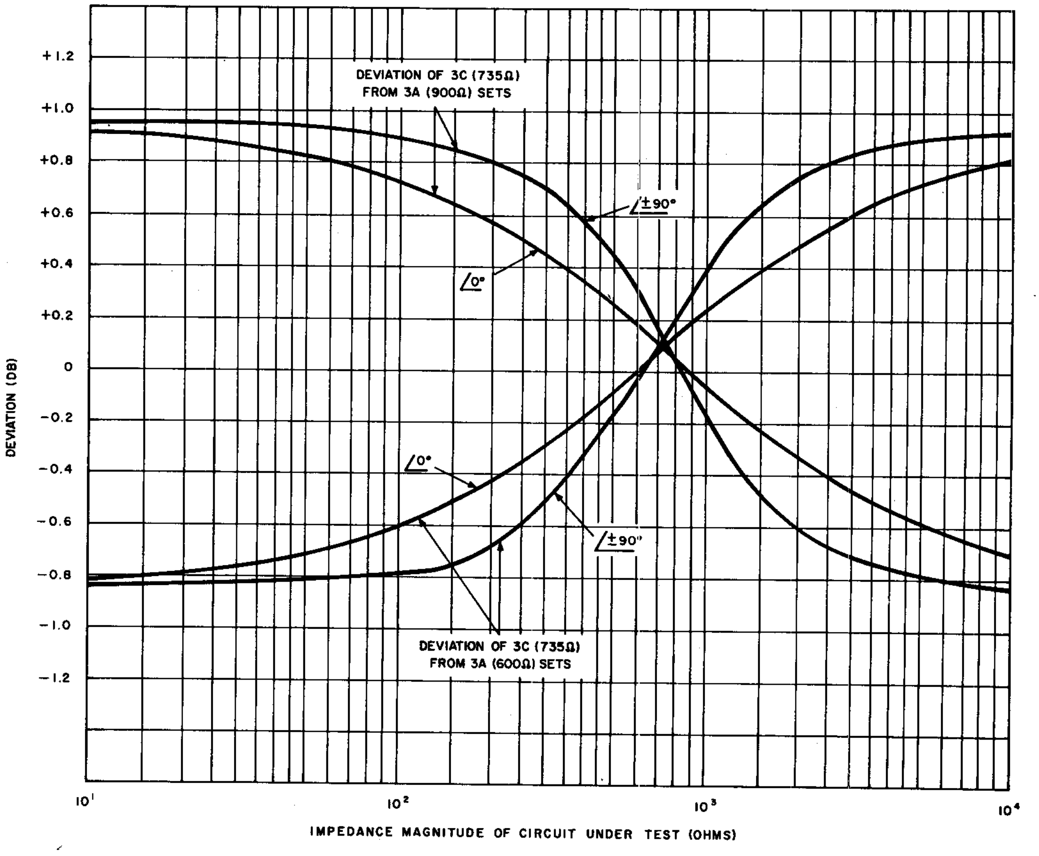


Fig. 8—Measurement Comparison Between 3C and 3A Noise Measuring Sets

(c) Insert any of the weighting networks.

(d) Adjust the DBRN dial to 85.

(e) Turn the FUNCTION switch to N_M 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. 9) 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 5.01(a).] The meter pointer adjustment is on the meter case.

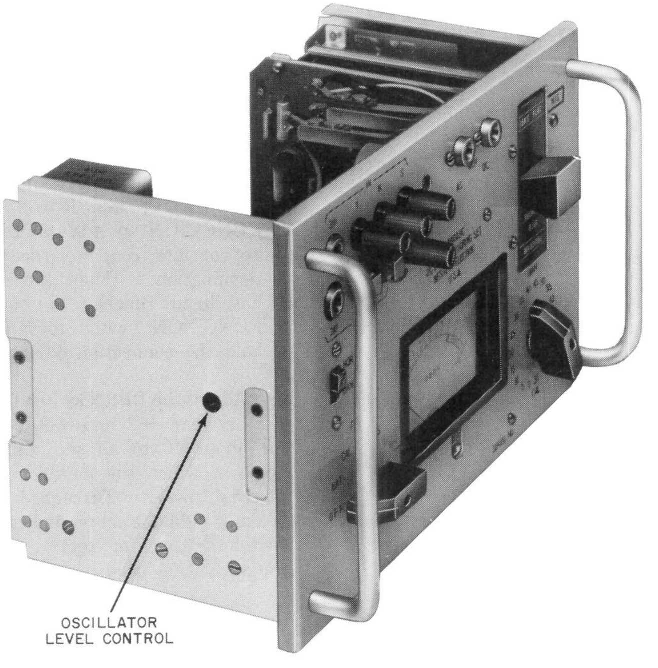


Fig. 9—Location of Oscillator Level Control

(b) Insert the proper weighting network, with the appropriate orientation.

(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 6.01). If the external J87281A power supply is being used, check the ac voltage or rectifier in accordance with Section 167-256-301.

(e) Turn the FUNCTION switch to CAL. Adjust the CAL control for a meter indication on the red line of the scale.

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. 10. 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. 11).

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.

(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 N_M 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.

(i) Rapidly fluctuating noise (i.e., 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 adjunct 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 (N_G) 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

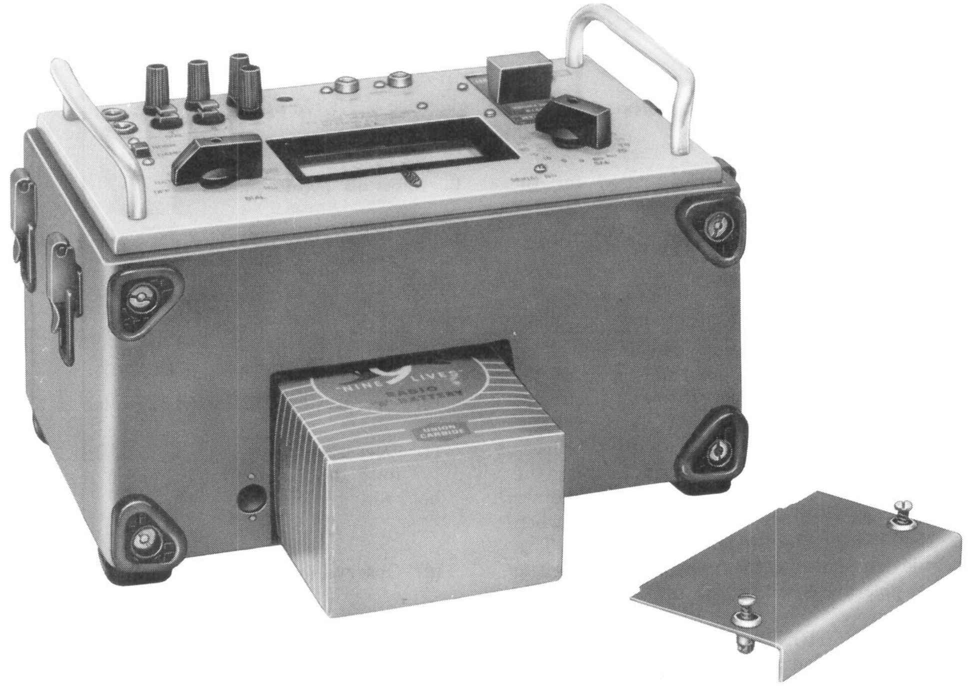


Fig. 10—J94003C Noise Measuring Set, Showing Access to Battery

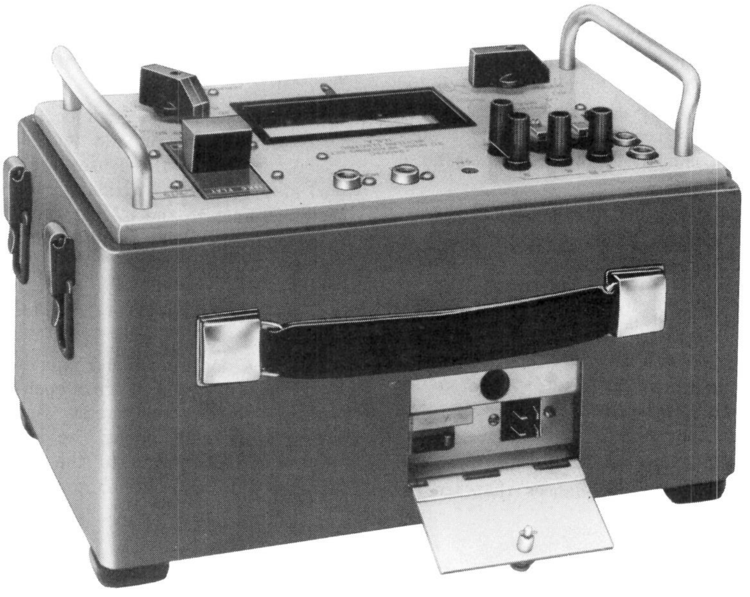


Fig. 11—J94003C Noise Measuring Set, Showing Access to Power Connector

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, with tolerances indicated, are shown on Fig. 5 and 7. 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 N_M 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 9.06.)

9.06 Part of the indication on the measuring set may be contributed by 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 12 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. 12 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. 12). 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. 13) 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. 12.

9.11 To calibrate the recorder, use the equipment setup shown in Fig. 13. (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 N_M 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.

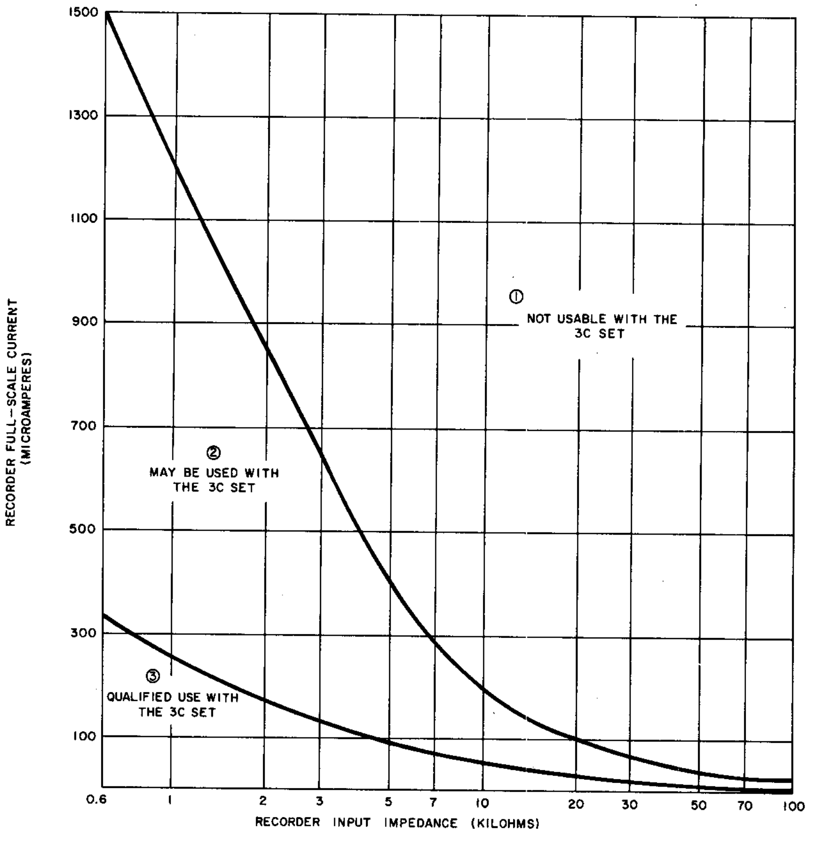


Fig. 12—Use of Recorder With 3C Noise Measuring Set

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 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 N_M 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.

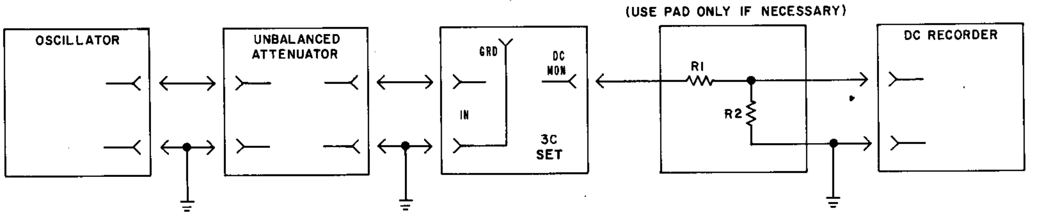


Fig. 13—Calibration Circuit for DC Recorders

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.

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.

NOTES

PART IV

DATEC

DATA TECHNICAL (DATEC) SUPPORT

CONTENTS PAGE

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 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: TO CO. HQ: TO AT&T HQ:

Date ________ Date ________ Date ________ ☐ Installation/Pre-service

Time ________ Time ________ Time ________ ☐ 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.

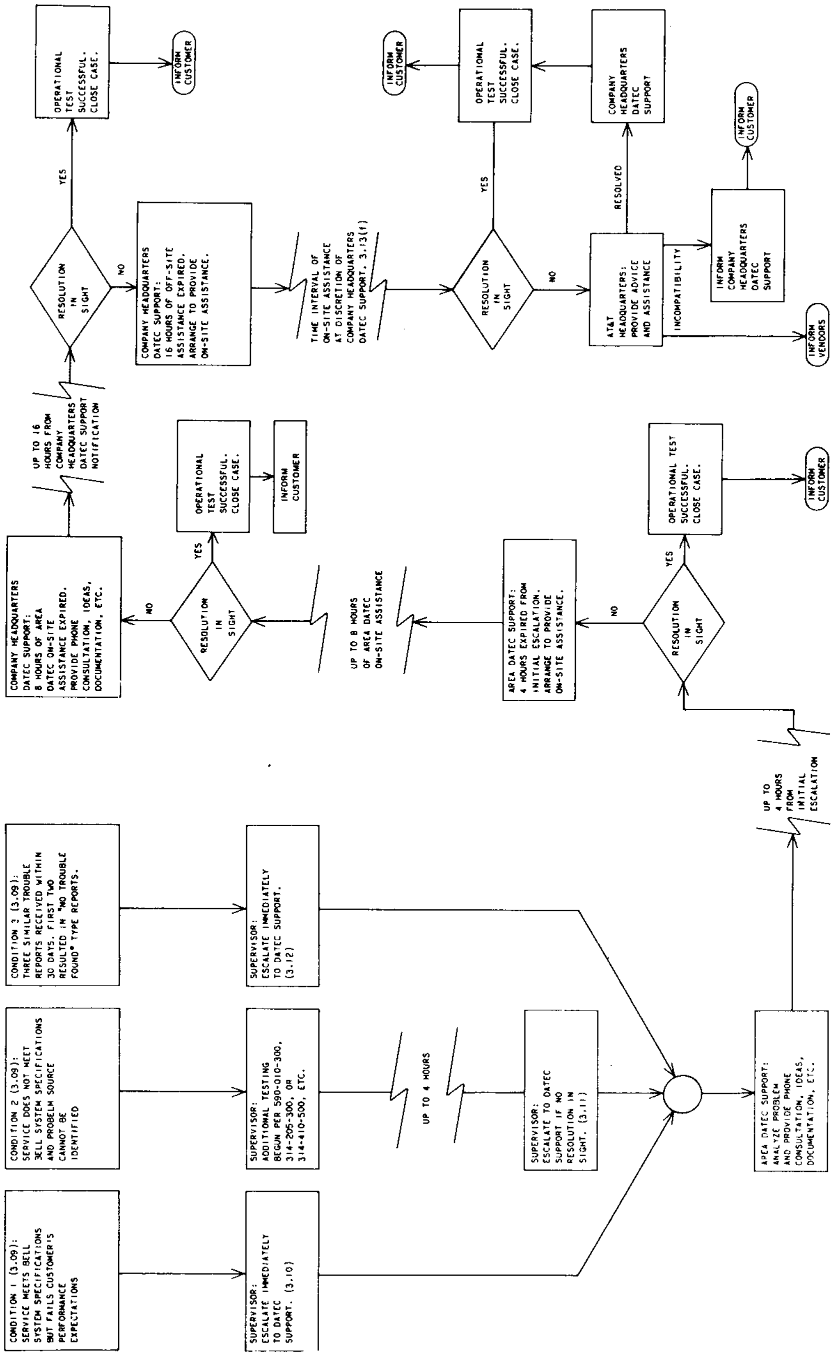


Fig. 3—Flowchart of Data Service Problem Technical Escalation

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).

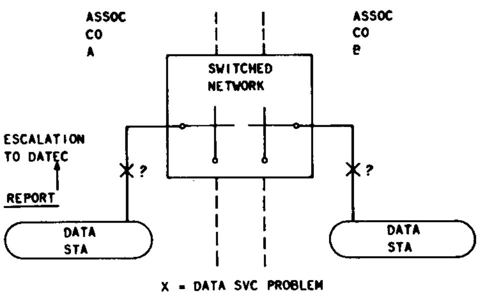


Fig. 4—Associated Company Case 1

(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).

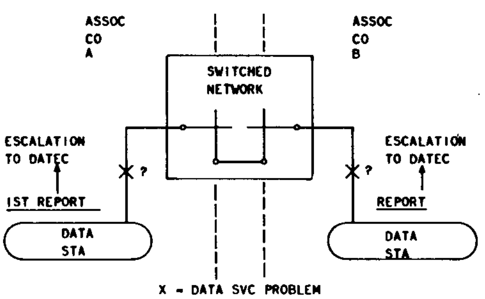


Fig. 5—Associated Company Case 2

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).

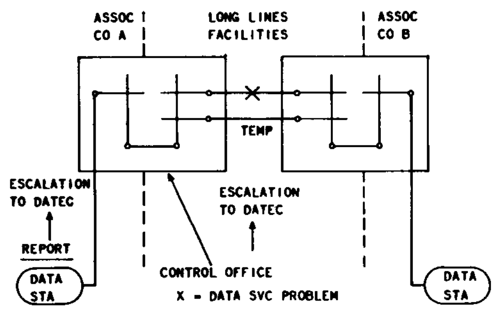


Fig. 6—Long Lines Case 1

(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).

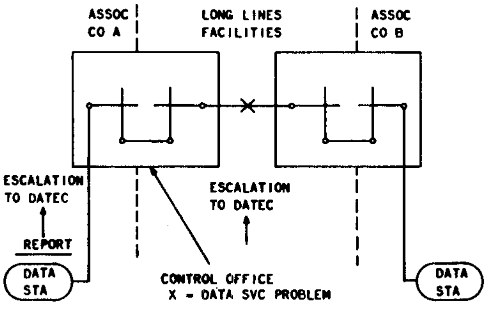


Fig. 7—Long Lines Case 2

(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).

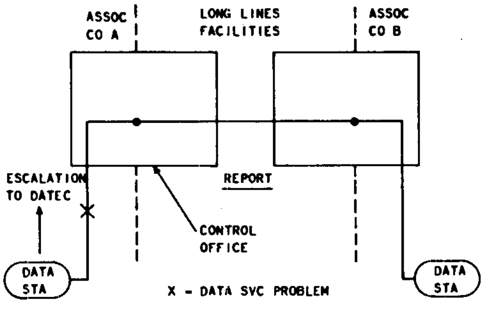


Fig. 8—Long Lines Case 3

(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).

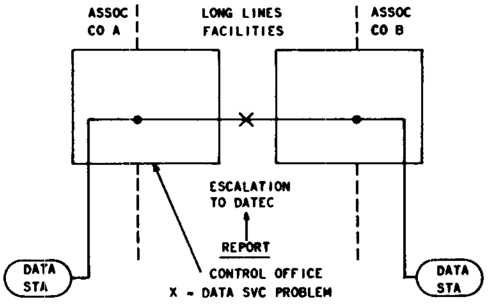


Fig. 9—Long Lines Case 4

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).

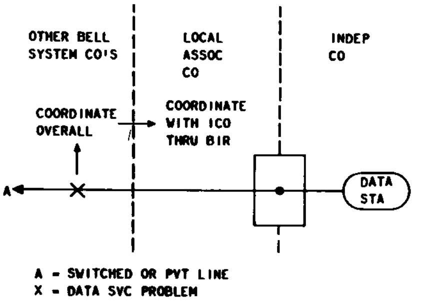


Fig. 10—Bell—ICO Case 1

(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).

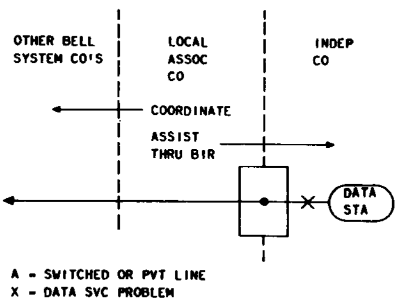


Fig. 11—Bell—ICO Case 2

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