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Bell System

TECHNICAL REFERENCE

DATA SET 208B INTERFACE SPECIFICATION

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Bell System Data Communications

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Interface Specification

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ENGINEERING MANAGER - DATA SYSTEMS

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TECHNICAL SPECIFICATION SUMMARY

Data Rate:	4800 bps
Modulation:	Phase Shift Keyed (PSK)
Operation:	Synchronous, Binary, Serial
Line Requirements:	2-Wire Switched Network
Operating Modes:	Simplex or Half-duplex
Interface Signals:	Per EIA RS-232-C for all Clock, Data, and Control Leads

Interface Control Functions:

Request-to-Send — Clear-to-Send delay: 48.5 ± 0.5 or 150 ± 20 milliseconds (controlled by "50" button on front panel)

Received Line Signal Detector Operation:

Turn ON	47 ± 3 milliseconds after a signal of the proper level appears at the receiver input
Turn OFF	8 ± 3 milliseconds after the line signal drops below threshold of receiver

Interface Connector and Cable:

Business machine must provide a 25-pin Cinch or Cannon Type DB-19604-432 (male) Connector Plug with Cinch Type DB-51226-1 Hood (or equivalents). Interface cable provided by customer is recommended to be no more than 50 feet long in conformance with EIA Standard RS-232-C.

AC Power:

117-volt ± 10% ac, 60 Hz ± 5% Consumes about 26 watts

Power cord provided by Telephone Company. Power outlet should be a conventional 3-wire type not under switch control.

Environmental Requirements:

Ambient temperature range 40° — 120°F
Relative humidity: From 20 to 95%

TECHNICAL SPECIFICATION SUMMARY (Cont'd)

Dimensions: 16 inches wide, 4-1/4 inches high, and 11-1/2 inches deep.

Weight: Approximately 20 pounds

1. GENERAL

1.1 Data Set 208B Type

Data Set 208B is a 2-wire data set designed for transmission and reception of synchronous 4800 bps serial, binary data on a switched telecommunications network. The data set uses phase-shift keyed (PSK) modulation and features a fast start-up (less than 50 milliseconds) automatic adaptive equalizer which permits fast turnaround on 2-wire circuits.

Data Set 208B provides one-way (simplex) or two-way nonsimultaneous (half-duplex) transmission for switched network service. The data set places no restriction on the coding of customer data as the transmitter contains a scrambler circuit to randomize the line signal. The data set does not provide local copy of transmitted data. The adaptive equalizer is designed to automatically retrain on customer data signals when error performance is degraded due to perturbations on the channel. Transmitter timing is provided by the data set (or from the data terminal equipment as an option), and receiver timing is provided by the data set. The data set also provides a customer accessible option switch to select the Request-to-Send — Clear-to-Send interval of approximately 150 or 50 milliseconds.

Among other standard features available are comprehensive data set self-test and remote test capabilities (controlled via test switches on the data set). These test features permit easy isolation of data transmission troubles by either the customer's attendant or the Telephone Company Test Center. The data set has seven status lamps on the front panel to aid in trouble diagnosis and provide interface monitoring capability.

A standard six-button telephone set is normally used with the data set, as shown in Figure 1. In addition, the 208B can be optioned for unattended automatic answer of incoming calls. The data set may be arranged to work with an 801-Type Data Auxiliary Set for automatic call origination. All optional features which must be specified by the customer when ordering this data service are presented in Section 2.

1.2 Physical Description

The data set housing, shown in Figures 1 and 2, measures 16 inches wide, 4-1/4 inches high, and 11-1/2 inches deep. The data set will operate over a temperature range from 40° to 120°F and with a relative humidity from 20 to 95 percent. The data set weighs approximately 20 pounds.

1.3 Power Requirements

Power is supplied through a 3-wire shielded power cord attached via a twist lock connector on the back of the data set. The cord should be connected to a conventional 117 volt ± 10 percent, 60 Hz ± 5 percent, nonswitched three-prong ac outlet. The data set consumes approximately 26 watts of ac power.

1.4 Grounding

The Protective Ground circuit on the interface of Data Set 208B is established through the ground wire of the power cord. This also provides grounding of the data set housing and chassis to the local building power ground. It is recommended that the data terminal equipment be tied to the same building power ground as the data set to avoid differences in ground potentials which may affect data performance or damage electronic circuitry. The Signal Ground circuit on the interface is the common reference potential for all the other circuits on the interface. The Protective and Signal Ground circuits are tied together by means of a strap in the data set as provided from the factory. This is intended to provide additional margin to longitudinal power line noise. The strap may, however, be disconnected at the request of the customer with due consideration given to possible noise conditions, ground potential differences, safety conditions, local electrical codes, and data terminal manufacturer recommendations.

1.5 Location and Mounting of the Data Set

The data set should be located in the vicinity of the data terminal equipment on a nearby desk, table, stand, or for multiple arrangements in Bell System provided data set cabinets or equipment racks. The room or cabinets in which it is

located should preferably provide some ventilation to prevent heat build-up which may occur with stagnant air. The customer-provided interface cable from the data terminal should not exceed 50 feet in length in accordance with recommendations in EIA Standard RS-232-C. This recommendation is intended to minimize cross-talk coupling among the unbalanced interface circuits and reduce the chance of noise pickup from outside sources. The data set will be installed in a location to permit compliance with this recommendation.

1.6 Interface Compatibility with Data Terminal Equipment

The interface signals exchanged between the data set and the data terminal equipment conform electrically to those specified in EIA Standards RS-232-C and RS-334. The complete listing of interface circuits on Data Set 208B is presented in Figure 3. Section 3 provides descriptive information on the function and operation of each of the interface circuits.

1.7 Test Switches, Self-Testing Features, and Option Switch

Data set 208B has five push-button test switches and one push-button option switch accessible on the right side of the front cover. The test buttons permit comprehensive local and remote testing of the data set and facilities. The option button ("50") permits the customer to select either an approximately 150 or 50 millisecond Request-to-Send – Clear-to-Send interval. All of the buttons, shown in Figure 1, are a push-to-operate and push-to-release type with the exception of the LP button which is nonlocking. The six buttons are identified as follows with their respective functions:

1. LP (Lamp Test): This is a nonlocking button which when held depressed will light all of the status lamps except on the ON lamp (which is lit whenever the data set is powered) to check that they are working. Depressing this button does not affect data set operation.
2. AL (Analog Loopback): The AL button is used to connect the transmitter output through an internal attenuator to the receiver input. This permits the testing of the local data set with either self-contained test circuitry activated by the ST button or with external test equipment or the data terminal equipment through the data set interface. Use of the AL switch will prevent the data set from transferring to the DATA mode from the TALK mode on attended calls and will inhibit automatic answer. Even though the TALK mode is not inhibited, (i.e., calls may be received on the telephone), any attempt to transfer to the DATA mode when the AL button is depressed will result in the call being disconnected.
3. ST (Self-Test): The ST button is used to condition the data set to operate with a built-in test word generator and word comparator to check for errors. This switch internally turns the Request-to-Send and Data Terminal Ready signals ON. The ER lamp will blink on to indicate the occurrence of errors.
4. RO (Receive Only): The RO button is used when self-testing two data sets and the 2-wire switched network facilities between them. This button conditions the local data set as a receiver. When depressed the switch turns the Request-to-Send signal within the data set to OFF regardless of the state of Request-to-Send at customer interface or any of the other test switches.
5. RT (Remote Test): This button is used to condition the data set for switched network testing from a Telephone Company Test Center.
6. 50 (50 millisecond Request-to-Send – Clear-to-Send interval): When depressed, this button conditions the data set for approximately a 50 millisecond Request-to-Send – Clear-to-Send interval. When the button is in the out position, the data set is conditioned for approximately a 150 millisecond interval.

The five test switches permit the following types of tests to be made [see Figures 7(a), 7(b), and 7(c)]:

Self-Tests

1. Analog loopback self-test (data set alone).
2. End-to-end self-test with remote data set (two data sets plus 2-wire switched facilities).

Test with Data Terminal through Data Set Interface

3. Analog loopback test (data terminal equipment and local data set; requires full-duplex data terminal operation).

Remote Test

4. Two-wire switched network remote test from Telephone Company Test Center.

Either of the first two self-tests can be made by the customer's attendant prior to calling Telephone Company repair service without any auxiliary test equipment. Test 3 permits testing through the data set interface by the data terminal or with external test equipment. Procedures for all of these tests are covered in Section 5 of this document.

1.8 Status Lamp Indications

Seven LED status lamps are provided on the front of the data set. They indicate a power on condition, the status of five interface control circuits, and the mode of the automatic equalizer in DATA mode or error indication when making a self-test. The following is the list of lamp indications giving abbreviated mnemonics and corresponding function:

ON — Power Indication
TR — Data Terminal Ready (Terminal Ready)
MR — Data Set Ready (Modem Ready)
RS — Request-to-Send
CS — Clear-to-Send
CO — Received Line Signal Detector (Carrier On)
ER — Equalizer Retrain in normal mode or Error Indication in self-test mode

The LP (Lamp Test) button when depressed will turn on all the lamps, except the power indicator (which is lit whenever the data set is powered), to check that they are working. Otherwise, the lamps operate as follows:

The TR, MR, CS, and CO lamps light in accordance with the ON condition of the respective interface circuits CD, CC, CB, and CF (see Section 3.2 for description of the operation of these circuits). The RS lamp lights whenever the CA circuit is ON and the data set is in the DATA mode (i.e., Data Set Ready (CC) circuit is ON). In the TEST mode, the RS lamp lights when the data set is to operate as a transmitter. Depending upon the particular test being performed, the RS lamp may be controlled by internal test circuitry or through the customer interface (CA circuit).

The ER lamp indicates the mode of the adaptive equalizer when the data set is in the DATA mode. It is normally on when the CO lamp is off. When the CO lamp is on and the ER lamp is flashing, the automatic adaptive equalizer is retraining. After retraining ER will go off. If ER continuously flashes when the CO lamp is on, marginal performance is indicated (i.e., channel impairments are excessive or the data set is faulty). If this condition should arise, it is recommended that another call be made to obtain a better channel connection. The ER lamp is also used when the data set is in either of the two self-test modes (analog loopback or end-to-end). The ER lamp will flash whenever an error is detected in the Received Data signal in these tests.

Section 5 outlines several tests which can be made. Verification of proper data set operation is by means of these lamp indications.

1.9 Automatic Retraining of Adaptive Equalizer

The start-up procedure of the Data Set 208B receiver involves a training interval of approximately 50 milliseconds duration during which a special sequence of signals from the associated transmitter is sent to the receiver. Once the receiver has been properly trained and data transmission is in progress, the receiver may require retraining due to interfering phenomena on the switched connection. The 208B receiver's adaptive equalizer will retrain itself automatically using customer data signals while data transfer is in progress when the error

rate approaches one error in 100 bits. This feature eliminates the need for restarting transmission (turning Request-to-Send OFF and back ON) from the associated transmitter. When the adaptive equalizer is retraining, the ER lamp will go on. During this time, data signals on the Received Data circuit may not be valid. The local data terminal equipment does not receive an indication on any interface lead when retraining occurs. Retraining intervals will vary according to the source of channel perturbations. One such perturbation on long distance calls may be caused by protective channel switching on microwave radio channels due to radio fading.

1.10 Fast Turnaround Operation

When in the DATA mode, Data Set 208B is designed to operate with disabled echo suppressors, if any should be involved on the connection. This method of operation is required to achieve fast turnaround operation (approximately 50 milliseconds) on long distance circuits.

2. OPTIONAL CUSTOMER FEATURES

Data Set 208B is provided with several optional features which must be specified by the customer when the data service is ordered to ensure compatibility with the data terminal equipment and system operation. A description of each of these optional features and a customer actuated feature (see Section 2.2) is provided in this section. They are summarized in Figure 4.

2.1 Transmitter Timing Provided by Data Terminal

The data set transmitter normally provides a transmit clock signal on circuit 15 (DB) to allow the data terminal to properly time the signals on the Transmitted Data lead at the 4800 bps rate. As an option, the data terminal may instead provide an EIA compatible transmit clock signal to the data set on interface circuit 24 (DA). This signal must conform to the distortion and frequency accuracy of EIA Standard RS-334 which requires peak individual distortion of no more than 0.5 percent and frequency accuracy within $\pm$.01 percent of the bit rate. With this option the internal transmitter timing of the data set will be phase locked to the external clock signal provided by the data terminal.

2.2 Request-to-Send — Clear-to-Send Timing Option

As mentioned previously Data Set 208B is provided with a customer accessible option button which selects one of two Request-to-Send (CA) — Clear-to-Send (CB) intervals, either approximately 50 or 150 milliseconds. In this CA-CB interval, the transmitter sends a start-up sequence to allow the receiving data set's adaptive equalizer to automatically adjust itself and to allow the receiver's timing to properly synchronize with the incoming signals. With either choice, the Request-to-Send lead is used to turn the transmitter on and off for half-duplex switched carrier operation and echo suppressors are kept disabled while in the DATA mode (see Section 1.10). Transmission between two 208B's on a connection, with one optioned for 50 and the other for 150 milliseconds, is possible should the customer choose to operate this way.

The 150 millisecond CA-CB option is compatible with the operation of existing switched network data systems and the capability of the switched network using half-duplex transmission on calls of any circuit length and transmission of any block length. The advantage with the 50 millisecond interval is the increase in data throughput which can be achieved compared to operation with the 150 millisecond option.

Due to the nature of the 2-wire switched network, signal reflections (echoes) occur at points in the network where impedance irregularities exist such as at 2- to 4-wire hybrid circuits. It is estimated that in 99 percent of all connections the round-trip propagation delay will not exceed 50 milliseconds. In the few instances when these echoes occur on long connections (generally 2000 miles or longer) with round-trip propagation delays greater than 50 milliseconds, and the echoes are strong enough to be detected by the 208B receiver, they may appear to the data set which transmitted them as a legitimate message from the far end. While the data set is in the transmit mode, the receiver ignores the echoes. After the data set goes into the receive mode (i.e., after

CA is turned off), the data set receiver monitors the channel for the beginning of a transmission. If the start-up sequence of the echo is received at this time, the data set treats the signal as a valid message from the distant end. This situation can occur when the interval of the customer's data message plus the start-up sequence is less than the round-trip delay of the channel. Since round-trip delays in excess of 50 milliseconds rarely occur, with a start-up (request-to-send — clear-to-send) interval of approximately 50 milliseconds, echoes will rarely be interpreted as valid data, even with short transmissions such as with an ACK or NAK message. Echoes of data messages longer than a few characters (say 50 bits or 7 characters) are even less likely to be erroneously interpreted as valid transmissions. In most cases, by the time the data set is placed in the receive mode the beginning of the echo start-up sequence has already been returned and the receiver will not interpret the remaining echo as a valid start-up sequence. Consequently, it is anticipated that the vast majority of applications will be compatible with the 50-millisecond CA-CB option.

In view of the possibility of echoes, the 150 millisecond CA-CB interval should be used on long calls (over 2000 miles) if suspected echo messages are received (as indicated by data terminal time-outs or lack of proper data transfer) by those data terminals which are transmitting messages of less than 50 bits. Calls between two stations which are within 1000 miles of one another usually will not encounter this problem. The possibility does exist on some calls of 1000 miles or less for a connection to be set up over an extended alternate route due to traffic congestion on the direct route. This alternate routing could also result in a connection of 2000 miles or longer. The customer operations personnel should decide on the basis of the calling distance between data set locations whether it is worth risking the small chance of spurious echo messages with the 50 millisecond CA-CB interval for receiving data terminals sending only short response messages. If actual experience indicates no message control problems with the 50 millisecond option, the customer can use it to realize better data throughput in his system.

2.3 Automatic Calling Unit

For applications with unattended automatic originating data terminals, call originations may be performed by an optional Data Auxiliary Set 801-Type Automatic Calling Unit. These units are described in two Technical References. The 801A-Type with dial pulse signaling is described in an AT&T publication with order number PUB41601. The 801C-Type using TOUCH-TONE® signaling is order number PUB41602. Refer to these documents for additional descriptive and operational information. In both cases the Automatic Calling Unit must be equipped with end-of-answer tone detection for operation with a 208B.

2.4 Automatic Answer Option

Data Set 208B can be optioned for automatic or manual (attended) answering of calls. When the automatic answer option is selected, calls are answered unattended by the data terminal which must turn ON the Data Terminal Ready circuit in response to a ringing indication on the Ring Indicator circuit, or the data terminal must hold Data Terminal Ready ON continuously when it is idle but ready to receive calls. Without automatic answer, calls must be handled by an attendant.

2.5 Data Set Ready Circuit Option for Analog Loopback Testing by Data Terminals

The current EIA Standard RS-232-C, which defines operation of the data terminal/data set interface, requires the data set to place the Data Set Ready (CC) circuit in the OFF condition when the data set is in the TEST mode or other non-DATA mode. When this occurs the data terminal by hardware or software design ignores any signals on all of the other interface circuits except Ring Indicator. In the case that the 208B is placed in the analog loopback test mode, the CC circuit will normally turn OFF (see Sections 3.2.6 and 5.2). Since the analog loopback test is intended to permit the data terminal to verify transmission through the local data set, the normal operation of CC may defeat this test feature.

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If the data terminal equipment manufacturer provides the hardware and software capability in the terminal to perform an analog loopback test with the local data set and recommends such a test be used to isolate transmission problems with the local data set, the data terminal may require the CC circuit to be held ON during this test. An option is provided in the 208B to permit this condition of the Data Set Ready (CC) circuit. Although this option is in violation with the current RS-232-C Standard, the analog loopback test is among several fault isolation tests defined in a recently published document by EIA on fault isolation between data sets and data terminals* (see Section 3.3.2, Local Test Line, in that document).

Without specific knowledge of the test capability and requirements of the data terminal, the CC circuit option should be set OFF (CC will be OFF in the analog loopback test mode). This does not prohibit the use of external test equipment to make an analog loopback test through the data set interface.

3. INTERFACE DESCRIPTION

The interface is the point of connection between the data set and the data terminal. Each data set is equipped with a 25-pin (female) connector. The user must supply the plug and necessary cable to connect his equipment to the data set. For the male connector, a plug such as the DB-19604-432 Plug manufactured by Cannon** or Cinch+ is required. This type plug provides a reliable, low resistance contact. In addition, a DB-51226-1 Hood manufactured by Cinch (or equivalent) is recommended to protect the connections, anchor the cable to the plug, provide a finger grip for easy insertion or removal, and provide a positive screw-in locking arrangement to prevent the connector from being pulled out inadvertently.

3.1 Electrical Considerations

Data Set 208B is equipped to follow the recommendations of Electronic Industries Association Standard RS-232-C with regard to interface circuit function and operation (except as noted in Section 2.5 on an optional basis on the CC circuit). The data set also provides two additional interface divided clock circuits (see Sections 3.2.11 and 3.2.13) which are not described by that standard. In addition, pin 25 (which is unassigned in the standard) is reserved for data set testing. The peak individual distortion of the signal element (bit) timing circuits and the isochronous distortion of the data circuits are in conformance with EIA Standard RS-334.

3.1.1 Signal States

For the Transmitted and Received Data circuits, the signal is considered in the MARK condition when the voltage on the circuit is more negative than minus three volts with respect to Signal Ground, and in the SPACE condition when the voltage on the circuit is more positive than plus three volts with respect to Signal Ground.

For all control circuits, the control function is considered ON when the voltage on the circuit is more positive than plus three volts with respect to Signal Ground, and is considered OFF when the voltage on the circuit is more negative than minus three volts with respect to Signal Ground. When no signal voltage is applied to the Request-to-Send or Data Terminal Ready circuits, the data set will hold these circuits in the OFF condition.

TABLE 1

Summary of EIA Data and Control Circuit Interface Terminology

Voltage	Negative	Positive
Binary State	ONE	ZERO
Signal Condition	MARK	SPACE
Control Function	OFF	ON

3.1.2 Impedance of Terminator

The terminating impedance of the receiving end of the interface circuits has a dc resistance of not less than 3000 ohms nor more than 7000 ohms over the range of voltages for which the

* "Fault Isolation Methods for Data Communications Systems," Industrial Electronics Bulletin No. 11, November 1972. Available from Electronic Industries Association, 2001 Eye Street, N.W., Washington, D.C. 20006; Price $1.40 each.

** ITT-Cannon Electric, Division of IT&T Corp., 3208 Humboldt St., Los Angeles, California 90031.

+ Cinch Manufacturing Co., 1026 S. Homan Avenue, Chicago, Illinois 60624.

signal is defined. When the interface plug is disconnected, the interface voltage on terminator circuits is less than ±2 volts.

3.1.3 Rise and Fall Times

The operation of the circuitry that receives signals from an interface circuit is dependent only on the signal voltage and conforms to RS-232-C with regard to the rise time and fall time. For control interface circuits, the time required for the signal to pass through the transition region (−3 volts to +3 volts) during a change in state does not exceed one millisecond. For the Received Data, Receive Signal Element Timing and Transmitter Signal Element Timing circuits, the rise time and the fall time does not exceed 8 microseconds through the six-volt range (−3 volts to +3 volts) in which the signal condition is not defined. The Transmitted Data and Transmitter Signal Element Timing External signals from the data terminal equipment should also meet this limit.

3.1.4 Open Circuit Voltages

The open circuit driver voltage with respect to Signal Ground on any interface circuit does not exceed ±25 volts. The terminator on an interface circuit is designed to withstand any input signal within the ±25 volt limit. The driver design is such that when the terminating impedance is in the proper range (3000 ohms to 7000 ohms) and the terminator open circuit voltage is zero, the potential at the point of interface is not less than ±5 volts or more than ±15 volts.

3.2 Purpose and Use of Interface Circuits

The data set interface connector is provided with 15 interface circuits for connection to the customer's data terminal equipment and three additional circuits for connection to Telephone Company test equipment. Figure 3 shows the pin assignments that are applicable for data set operation. Note that seven of the pins are not used for any function. These are pins 11, 12, 13, 14, 19, 21, and 23. A description of the operation of each circuit and the signals appearing on them follows. Circuit names and their mnemonics are in accordance with EIA Standard RS-232-C except as noted. Circuit numbers correspond to pin assignments on the 25-pin receptacle. Designation of circuit direction is provided to identify whether the data set is the source of or the sink for the interface signals.

3.2.1 Protective Ground (AA) — Circuit 1

This conductor is electrically bonded to the equipment frame. It is further connected to external grounds through the third wire of the power cord.

3.2.2 Transmitted Data (BA) — Circuit 2

Direction: TO Data Set

Signals on this circuit are generated by the data terminal equipment and are sent to the data set for transmission to remote data terminal equipment. A positive polarity signal is a binary "0" or SPACE, and a negative polarity signal is a binary "1" or MARK. The data set samples signals on this circuit on the negative transition (ON to OFF) of the Transmitter Signal Element Timing (DB) signal or the clock signal provided by the data terminal (circuit DA) on externally timed data sets.

The data terminal should not transmit signals on this circuit unless an ON condition is present on the Clear-to-Send (CB) interface circuit from the data set. Except for Analog Loopback testing with the data terminal, the Data Set Ready (CC) circuit should also be ON before data is presented to the BA circuit (see Section 2.5).

3.2.3 Received Data (BB) — Circuit 3

Direction: FROM Data Set

Signals on this circuit are generated by the receiving data set in response to data signals received from a remote transmitting data set. The data terminal equipment should sample the Received Data signal on the negative transition (ON to OFF) of the Receiver Signal Element Timing (DD) signal. A positive polarity represents a binary "0" or SPACE, and a negative polarity is a binary "1" or MARK.

This circuit is always held in the MARK ("1") condition when the Received Line Signal Detector circuit (CF) is OFF. Because the CF circuit is held OFF when Request-to-Send is ON

(transmit mode), the data set does not provide local copy of transmitted data signals on the Received Data circuit. Test data is applied to BB during all test modes.

3.2.4 Request-to-Send (CA) — Circuit 4

Direction: TO Data Set

An ON condition on this circuit is an indication to the local data set transmitter of the intent of the data terminal equipment to transmit data. After turning this circuit ON, the data terminal should wait for an ON condition on the Clear-to-Send (CB) circuit before starting transmission. To minimize the variation from the nominal CA-CB delay, the positive going transition of CA should be coincident with a positive transition of the Divided Clock Transmitter (DCT) circuit. When the CA circuit is turned OFF at the end of a message, the data set transmitter remains on about another 2 milliseconds to clear the last few bits from the transmitter. Then the transmitter will turn off. When the CA circuit is turned ON the data set's receiver is disabled and the Received Line Signal Detector (CF) circuit is clamped to OFF. Thus, there is no local copy of transmitted data signals on the Received Data circuit.

3.2.5 Clear-to-Send (CB) — Circuit 5

Direction: FROM Data Set

Signals on this circuit are generated by the data set to indicate whether or not the data set is ready to transmit data. Circuit CB is turned ON in response to an ON condition of the Request-to-Send (CA) circuit from the data terminal equipment, delayed approximately by 50 or 150 milliseconds (48.5 $\pm$ 0.5 or 150 $\pm$ 20 milliseconds), depending on the customer option selected by the front panel button. This interval allows the adaptive equalizer in the remote data set to train itself and allows the receiver to get into synchronization. The ON condition of Clear-to-Send means that signals presented on the Transmitted Data (BA) circuit will be transmitted to the communications channel. The OFF condition on this circuit is an indication to the data terminal equipment that it should not transfer data on the BA circuit. CB will turn OFF when CA is turned OFF. The OFF condition of CB will be maintained as long as CA is OFF.

3.2.6 Data Set Ready (CC) — Circuit 6

Direction: FROM Data Set

Signals on this circuit indicate the mode of the data set. This circuit is used to respond to signals on the Data Terminal Ready (CD) lead when the data terminal requests to go into the DATA mode or requests the call to be terminated. The ON condition of CC indicates that the data set is in the DATA mode and is capable of transmitting and receiving data signals. The ON condition is required in conjunction with the Request-to-Send and Clear-to-Send circuits when transmitting data. The OFF condition indicates that the data set is in the TEST mode or in the TALK, call setup, or on-hook modes. The ON condition of this circuit alone should not be used to interpret that a communication channel has been established to a remote data station or used to determine the status of any remote terminal equipment.

An option, described in Section 2.5, permits Data Set Ready to be held ON when the AL test button is depressed for testing with the data terminal equipment. This ON condition option violates current procedures of EIA Standard RS-232-C. When this option is selected, the data set will not be connected to the telephone line during an analog loopback test although it will appear to the terminal to be in the DATA mode.

3.2.7 Signal Ground (AB) — Circuit 7

This circuit establishes the common ground reference potential for all interface circuits except Protective Ground (AA). This circuit is normally connected to the Protective Ground circuit to minimize the introduction of longitudinal power line noise into electronic circuitry through the power transformer. Depending on local procedures and conditions, this connection to Protective Ground can be removed by the Telephone Company installer.

3.2.8 Received Line Signal Detector (CF) — Circuit 8

Direction: FROM Data Set

The ON condition of this circuit indicates the presence of data carrier signal above the receiver threshold for at least 47 $\pm$ 3 milliseconds. It will not normally turn ON due to

transmission circuit noise or other interference.

This circuit will go OFF if the line signal drops below the receiver threshold for more than about 8 milliseconds due to the end of transmission or to a transmission line interruption. The OFF condition causes the Received Data (BB) circuit to be clamped to the MARK condition. When the Request-to-Send circuit is turned ON, this circuit is turned OFF and the receiver is disabled.

3.2.9 Circuits 9 and 10

These circuits are used for the purpose of data set testing by Telephone Company personnel. The data terminal must not be connected to them.

3.2.10 Transmitter Signal Element Timing (DB) — Circuit 15

Direction: FROM Data Set

For data sets which are timed by their own internal clock, square wave signals on this circuit at the nominal 4800 Hz rate are used to provide the data terminal equipment with signal element timing information for the Transmitted Data (BA) circuit. Signals on circuit BA should be presented such that the negative going (ON to OFF) transition of this circuit indicates the nominal center of each bit. A timing signal will be present on this circuit at all times when power is on in the data set. When initiating data transfer the first signal element of the Transmitted Data signal should be presented by the data terminal equipment on the first positive (OFF to ON) transition of DB which is coincident with the ON condition of the Clear-to-Send (CB) signal. The Clear-to-Send circuit will turn ON coincident with a positive transition of circuit DB.

Circuit DB will provide a timing signal which is phase locked to the signal on circuit 24 (Transmitter Signal Element Timing External) for data sets timed by the data terminal equipment.

3.2.11 Divided Clock Transmitter (DCT, non-EIA) — Circuit 16

Direction: FROM Data Set

A square wave signal at one-third the nominal bit rate (1600 Hz) appears on this circuit whenever power is supplied to the data set. Positive transitions on this circuit are coincident with positive transitions of the Transmitter Signal Element Timing (DB) signal and negative transitions are coincident with negative transitions of DB. This circuit indicates the rate at which phase changes are made in the transmitted line signal. Three customer bits are used to determine a phase change by the modulator, and the grouping of bits is according to the transitions on this circuit so that over one cycle of DCT three customer bits are encoded into one phase shift.

3.2.12 Receiver Signal Element Timing (DD) — Circuit 17

Direction: FROM Data Set

The square wave signal on this circuit at the nominal 4800 Hz rate is used to provide the data terminal equipment with receiver signal element timing information. The transition from ON to OFF nominally indicates the center of each signal element on the Received Data (BB) circuit. This signal is provided at all times when the data set is powered whether or not the data set is connected to a line or is receiving any data signals on the line.

3.2.13 Divided Clock Receiver (DCR, non-EIA) — Circuit 18

Direction: FROM Data Set

A square wave signal on this circuit provides the receiver timing information at one-third the nominal bit rate (1600 Hz). Positive and negative transitions on this circuit coincide with positive and negative transitions of Receiver Signal Element Timing (DD), respectively. By referring to the transitions on this circuit, the data terminal equipment can define the three bit grouping of the decoded phase shifts of the received line signal. This means that in one cycle of DCR three customer bits that were originally encoded into a phase shift by the transmitter are decoded into three bits with the same sequential relationship that existed at the transmitter. This signal is provided at all times when the data set is powered whether or not the data set is connected to a line or is receiving any data signals on the line.

3.2.14 Data Terminal Ready (CD) — Circuit 20

Direction: TO Data Set

This circuit is intended to control switching of the data set to the telephone line. The data terminal must apply an ON condition on this circuit to indicate to the data set that it is ready to go into the DATA mode. The data set will respond by turning ON Data Set Ready (CC) after the connection to the line is established and the data set handshaking sequence is completed. Circuit CD should be kept ON throughout a call. An OFF condition should be maintained by the data terminal for non-DATA modes. When answering an incoming call with the automatic answer option installed, circuit CD must be ON before the data set will go off-hook and initiate the handshaking procedure (described in Section 4.1). The CD circuit should be used by the data terminal to cause the data set to disconnect from the line at the end of a call by turning OFF at least until Data Set Ready goes OFF (this will take about 10 milliseconds).

3.2.15 Ring Indicator (CE) — Circuit 22

Direction: FROM Data Set

Signals on this circuit indicate that a ringing signal is being received due to an incoming call. An ON condition appears on this circuit when ringing is present. Between bursts of ringing and at all other times when ringing is not occurring, an OFF condition is maintained. Ringing will continue to be indicated on this circuit due to an incoming call until the data terminal turns ON Data Terminal Ready or an attendant answers the call manually. Procedures describing how data terminals should answer a call are presented in Section 4.2.

3.2.16 Transmitter Signal Element Timing, External (DA) — Circuit 24

Direction: TO Data Set

On data sets with the external timing option installed, this circuit is used by the data terminal equipment to provide bit rate timing to the transmitter. The ON to OFF transition of signals on this circuit should nominally indicate the center of each signal element on the Transmitted Data (BA) circuit. The timing signal must have a frequency of 4800 Hz $\pm$.01 percent with peak individual distortion of the negative transitions of no more than 0.5 percent per EIA Standard RS-334. The Transmitter Signal Element Timing (DB) circuit will be phase locked to this signal, and the Divided Clock Transmitter (DCT) circuit is derived from it similarly. When the data terminal provides bit timing, signals should be available on this circuit at all times except when the data set is not in service.

3.2.17 Circuit 25 (non-EIA)

This circuit is used for testing the data set by Telephone Company personnel. The data terminal equipment must not be connected to it.

4. OPERATION WITH DATA TERMINAL EQUIPMENT

4.1 General Call Set-Up Procedures

A call may be initiated manually or by an automatic calling unit. Either manual or unattended automatic answering may be used to receive a call. A sequence diagram of call set-up and termination procedures to automatic and manual calling arrangements is given in Figures 5(a) and 5(b).

In the case of manual originate and answer, the calling attendant picks up the handset on the telephone set, depresses one of the five buttons corresponding to the line on which the data set operates, and dials the number of the distant data set. The attendant at the receiving station answers the call in response to audible ringing by depressing the line button on the telephone set under which the lamp is flashing and then lifting the handset. This will cause ringing to stop and the line button lamp will go out. The data station is then in the TALK mode. After the call is answered and voice contact is made between the two attendants, they should agree when to go into the DATA mode. Before either station goes into the DATA mode, lead 20 (Data Terminal Ready) must be turned ON by both data terminals. Both attendants should enter the DATA mode at about the same time by momentarily depressing the nonlocking DATA button on the telephone set. When the DATA button is depressed, the line button will be released and the lamp under it will light to indicate transfer to the data set. Then the handset should be placed on-hook. The line

lamp will stay on until the call is terminated or the attendants return to the TALK mode. After the DATA button is depressed the data sets will initiate a handshaking sequence consisting of 2 seconds of silence, 2 seconds of answer tone, and 63 milliseconds of silence.* This handshaking sequence occurs every time either attendant transfers from TALK to DATA mode. At the completion of the handshaking sequence the Data Set Ready circuit will go ON indicating to the data terminal that the data set is in the DATA mode. The transmitting data terminal should wait several seconds after Data Set Ready goes ON before turning ON Request-to-Send to assure that the far-end receiver is in the DATA mode.

For calls that are answered automatically but originated manually, the calling attendant should hear a high-pitched answer tone after the call is answered at the far-end. Upon hearing this tone the attendant should momentarily depress the nonlocking DATA button on the telephone set to transfer to DATA Mode and then place the handset on-hook.* Again, both data terminals must apply an ON condition to the Data Terminal Ready circuit (lead 20) to prepare the data sets for data transmission and to hold the connection. If the call is originated by an ACU, the ACU will detect the answer tone and transfer the calling data set to the DATA mode.

4.2 Automatic Answer and Data Mode Transfer

Data Set 208B will respond to central office ringing by turning ON the Ring Indicator circuit during the ringing cycle. When the automatic answer option is installed, the data set will answer the incoming call at the end of the first ringing cycle for which the Data Terminal Ready (CD) circuit is ON. The data set will respond after the call is answered with a handshaking procedure consisting of a 2-second silent interval, 2 seconds of answer tone, and a 63 millisecond silent interval. This is followed by an ON condition of the Data Set Ready (CC) circuit. The data set is then in the DATA mode and can be used for data transmission as a transmitter or receiver under the control of the Request-to-Send (CA) circuit. Circuit CD must be kept ON for the duration of the call to keep the data set off-hook.

It is possible to transfer to the TALK mode at any time by lifting the handset and depressing the line button on the telephone set (lamp under button will be lit) corresponding to the line with which the data set is associated. The lamp under the line button will extinguish. The DATA mode can be reestablished by having the attendants momentarily depress the DATA button on the telephone set at nearly the same time and then hang up the handset. During the TALK mode the Data Set Ready circuit will be OFF, but will turn ON about 4 seconds after the DATA button is depressed.

4.3 Call Termination Procedures

Switched network connections must be terminated by taking positive action at both data stations. A call may be terminated manually by lifting the handset, depressing the line button on the telephone set corresponding to the data line to be terminated, and then replacing the handset on-hook.

A call can be terminated automatically by the data terminal by turning OFF the Data Terminal Ready circuit until the Data Set Ready circuit goes OFF (approximately 10 milliseconds later). The lamp under the line button on the telephone set will extinguish.

4.4 Half-Duplex Data Transmission Procedures on a Switched Network Call

Transmission of data on a switched network call must follow the basic procedures of half-duplex operation. For half-duplex operation, Figure 6 illustrates the sequence of signals on the control and data circuits when turning around the direction of transmission.

* During the handshaking sequence there is a chance that the receiving data set may go into the DATA mode first (CC ON) and receive answer tone from the other data set. This will cause spurious data to appear on the Received Data circuit when CF is ON. The data terminal should ignore this.

5. TESTING OF THE DATA SET

As indicated in Section 1.7, Data Set 208B has built-in comprehensive test capabilities which can readily be used by a customer's attendant to isolate transmission problems to the data set, the transmission facilities, or the data terminal equipment. These test features may be used either prior to calling the Telephone Company Repair Service or when the Telephone Company Test Center requests assistance with certain remote tests. The use of the test buttons and status lamps on the 208B is described in this section.

5.1 Data Set Self-Test Procedures

Tests 1 and 2 described below can be conducted by customer personnel in sequence to isolate a transmission problem to the data set or transmission facilities. Figure 7(a) depicts the testing arrangements for these two tests.

With Test 2, the test is made on a dialed-up connection which the customer must set up. This test does not exercise the data set interface in the way that the data terminal does to turn around the direction of transmission, but it does provide a gross indication of possible transmission impairments on switched network links between the two data stations involved in the test. Because of the statistical nature of data performance on dialed-up calls, Test 2 can only indicate that the given dialed connection is good or bad, but is no guarantee that all calls will be the same. If the indicated number of errors exceeds the acceptance criteria specified below, there is evidence that the particular transmission facilities are causing sufficient errors to cause customer data transfer to be impaired. If Test 2 should indicate complete failure to transmit and receive data, then the data set or transmission facilities, including either subscriber loop, are definitely suspect. For a quick test of the data set itself, Test 1 is quite simple for an attendant to perform.

Initially the status lamps on the suspect data set(s) should be checked by holding the LP button depressed to see that all lamps are working. Once it is confirmed that all lamps are working, the LP button can be released. Before proceeding with the tests, the data terminal equipment associated with the data set(s) under test should be placed in an idle mode so that data transmission is not interrupted by these tests.

TEST 1) Analog Loopback Self-Test

Step 1 — Depress the AL button.

Step 2 — Depress the ST button to place the data set in the self-test mode. Ignore any flashes of the ER lamp while the button is being operated.

Step 3 — At this point the MR and ER lamps should be off and all other lamps except TR should be on. The TR lamp may be on or off depending on the state of the Data Terminal Ready circuit provided by the data terminal equipment (most likely it will be off since the terminal is idle).

Step 4 — If the ER lamp flashes one or more times or remains on or if any of the lamps do not agree with the conditions in Step 3, the data set is defective. The lamps should be observed for at least 30 seconds to be confident that the data set is or is not working.

Step 5 — To return the data set to normal operation, release the ST and AL buttons.

The data set's power supply is equipped with an overvoltage protection circuit which limits the output voltage should it rise excessively. When this occurs, the data set will fail the analog loopback self-test. To reset the power supply, the power cord must be unplugged and replugged into the ac outlet. If the data set still fails analog loopback self-test, the customer should verify that the correct ac voltage is being supplied to the data set and, if such is the case, notify the Telephone Company Repair Service for correction of the problem.

TEST 2) End-to-End Self-Test

If the analog loopback self-test of both data sets suspected of malfunction indicates proper data set operation, then an end-to-end self-test can be made, bearing in mind the previously stated considerations on dial-up calls.

Step 1 — With an attendant at each station, manually establish a call between the two data sets to be tested.

Step 2 — Have the attendants agree on when to start the test and end it and decide which data set will receive data first. The RO button on the

receiving data set will be depressed in Step 3.

Step 3 — Depress the ST button on both data sets and the RO button on the receiving data set.

Step 4 — Transfer both data sets to the DATA mode in the normal way.

Step 5 — After a few seconds have the attendant at the transmitting data set, check that the ON, RS, CS, and ER lamps are on and the MR and CO lamps are off. The attendant at the receiving data set should check that the ON and CO lamps are on and that the MR, RS, CS, and ER lamps are off. The TR lamp on either data set may be on or off depending on the state of the data terminal (most likely TR will be off since the terminal is idle).

Step 6 — At the receiving data set the ER lamp will flash if an error occurs. Satisfactory operation is indicated by an average of three flashes per minute or less. If the number of flashes of ER exceeds an average of three per minute, or if the ER lamp is on continuously, or if the status of any of the lamps on either data set is not correct per Step 5, then the data sets or the particular telephone facilities involved in the call are not providing proper performance. A new call may be established between the same data sets to attempt to utilize different transmission facilities.

Step 7 — If no problems are indicated in Step 6, this same test should be repeated in the opposite direction of transmission by releasing the RO button on one data set and depressing the RO button on the other data set. Then Steps 5 and 6 should be repeated.

Step 8 — To return the data sets to normal operation, release the ST button on each data set and the RO button at the receiving data set to release them from the TEST mode.

If the transmission tests on at least two calls fail to meet the limit of three error indications per minute or the data set lamps are not providing the proper indication in Step 5, then the customer should notify the Telephone Company of the problem. The Telephone Company Test Center may decide to check the telephone facilities and perform a Remote Test of the data set as described in Section 5.3.

5.2 Customer Test Procedures Using the Data Terminal

Besides the self-test capability of the Data Set 208B, it is possible to test the data terminal (or other customer-provided equipment connected to the customer interface) and the data set together in an analog loopback mode similar to TEST 1 above. As mentioned in Section 2.5, if the data terminal manufacturer provides the hardware and software capability for a full-duplex analog loopback test through the data set interface and requires the Data Set Ready (CC) circuit to be ON, the CC circuit ON option in Analog Loopback Test Mode should be specified when the data set is ordered. Then the following test, depicted in Figure 7(b), can be made.

TEST 3) Analog Loopback Test Using the Data Terminal

Step 1 — Depress the AL button.

Step 2 — Condition the data terminal to simultaneously transmit and receive a test signal through the local data set. A delay of about 7 milliseconds occurs between signals on the Transmitted Data circuit and the Received Data circuit because of propagation delays in the data set circuitry. A steady MARK or SPACE signal is sufficient for a test signal since the data set has a built-in scrambler circuit to randomize the data. The data terminal, operating full-duplex, should be able to verify that the test signal is being sent through the local data set and back to the data terminal without an error. If errors should occur, either the data set or data terminal may be in trouble. To isolate the problem, an analog loopback self-test (TEST 1) should be made (if not already done) to check the data set by itself.

Step 3 — To return the data set to normal operation, release the AL button.

5.3 Telephone Company Remote Test Procedures

Besides the two self-tests and the test using the data terminal (or other customer-provided equipment) which can be made by customer personnel, there is a remote test which can be made from the Telephone Company Test Center with the assistance of customer personnel at the data set [see Figure 7(c)]. The Telephone

Company Repair Service should be notified of any problems which have been isolated to the data set or transmission facilities. When the Test Center calls in response to a trouble report, the customer's attendant will be requested to assist with the test features of the data set. They may also ask the customer to make self-tests of the data set.

TEST 4) 2-Wire Switched Network Remote Test

Before initiating this test the data terminal should be placed in an idle mode. When instructed by the Test Center personnel, the RT button should be depressed on the data set.* With the station on-hook, the Test Center will then call the data set which will automatically answer. Following auto answer the Test Center will make a series of programmed transmissions with the local data set. After completing these test transmissions, the data set will disconnect. The Test Center will call the customer location and ask that the data set be removed from the TEST mode by releasing the RT button. Results of the test and any further action by the Telephone Company will be indicated by Test Center personnel.

* If another call is received by the data set under test before the Test Center makes its test call, the local data set will appear inoperative to the calling data set (unless the precise programmed test sequence is received). Assuming the first call is terminated, the Test Center should be able to place a call to the local data set and perform the remote test. If not, the Test Center will call the customer attendant to have the data set placed in the remote test mode again.

6. PERFORMANCE

The performance of Data Set 208B is specified in terms of block error rate because this measure is more meaningful than the conventional bit error rate specification for most users. Many data communications systems send data in a blocked format and consequently block error rate can be related to throughput, an important measure of system performance. A "block error" is defined as a block of data which contains one or more bit errors. A block transmission system generally forms data into blocks of a specific number of bits. This block of data usually contains redundant bits for the purpose of error detection at the receiving terminal. If one or more bit errors is detected in a received block of data, a message requesting retransmission of the entire block is returned to the source. In this sense, the block error rate is the ratio of the number of retransmissions required to the total number of blocks received.

Data Set 208B operating at 4800 bps on the switched network has a long term 1000 bit block error rate objective of 10^{-2} or better on 88 percent of all calls made in the entire network during a normal business day. The 1000 bit block size, selected as part of the specification, is not meant to imply that customer systems should be operated using this size block. Many factors determine the optimum block size for a specific data system. The choice of 1000 bits was made because it is in the range of block sizes normally used in data systems operating at this speed and it is a convenient block size for measurement purposes. For block sizes of 1000 bits or less, block error rates of 10^{-2} or better should be expected. For messages longer than 1000 bits, block error rate increases proportional to block length.

FIGURE 1
FRONT VIEW OF DATA
SET 208B WITH KEY TELEPHONE SET

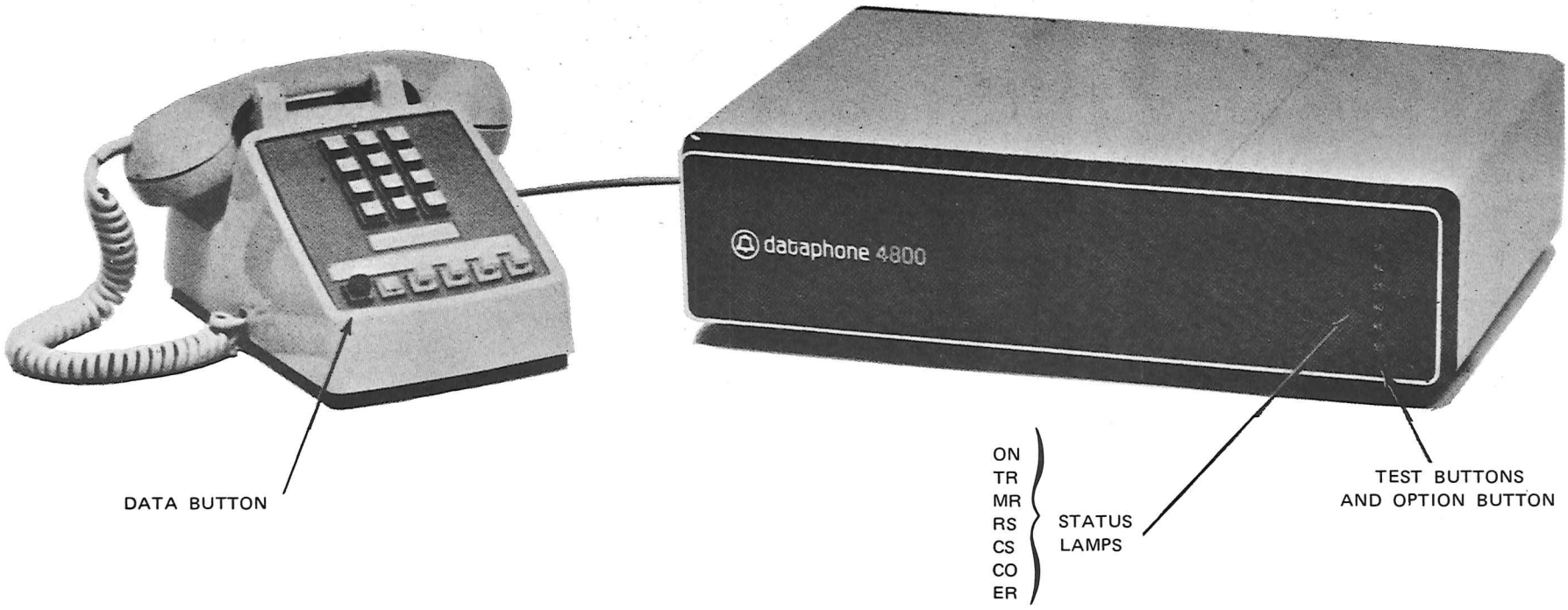


FIGURE 2
REAR VIEW OF DATA SET 208B

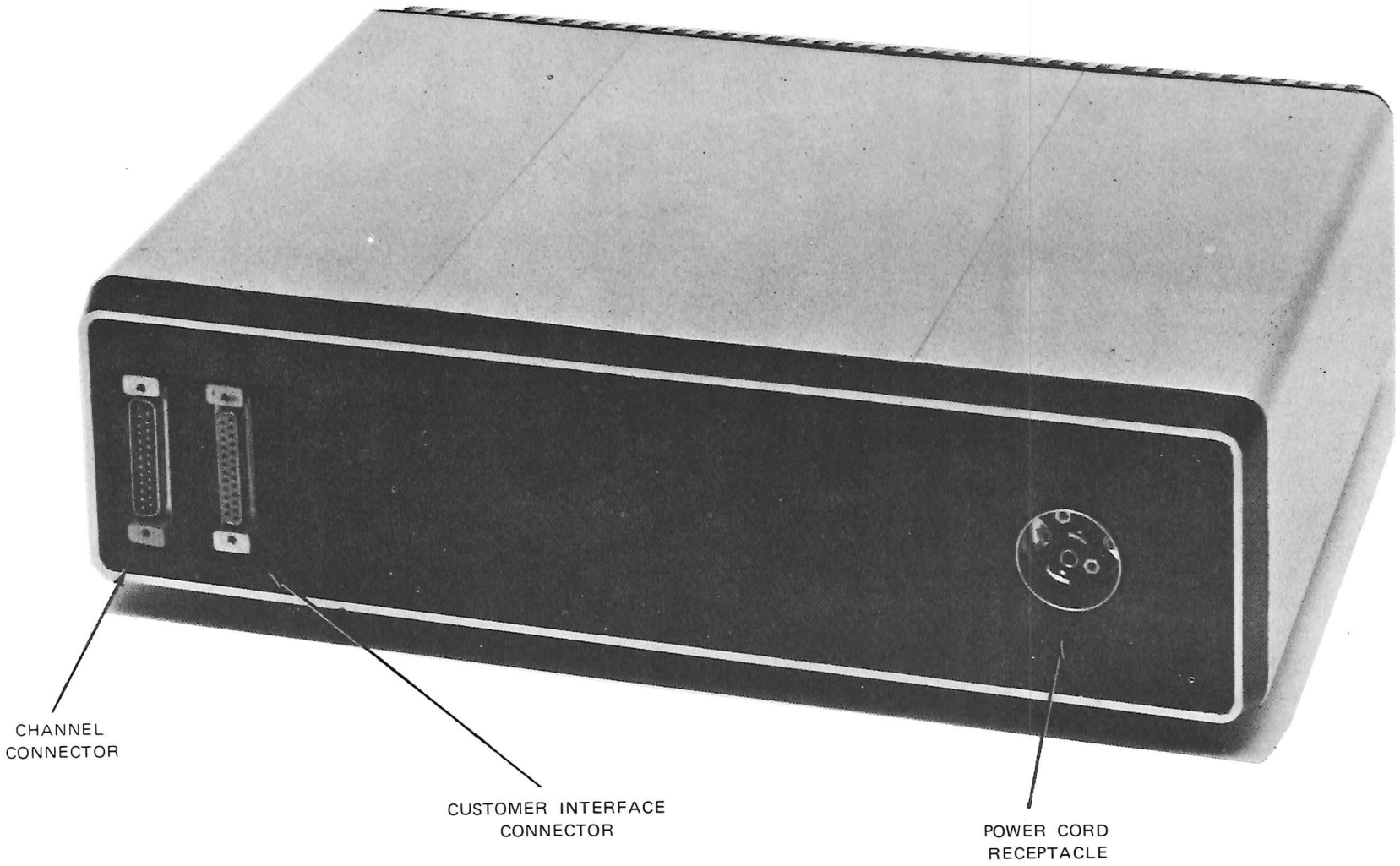


FIGURE 3

Customer Interface Pin Assignments and Circuit Designations

Pin No.	EIA RS-232-C Circuit Designations
1	Protective Ground (AA)
2	Transmitted Data (BA)
3	Received Data (BB)
4	Request-to-Send (CA)
5	Clear-to-Send (CB)
6	Data Set Ready (CC)
7	Signal Ground (AB)
8	Received Line Signal Detector (CF)
9	Reserved for Data Set Testing
10	Reserved for Data Set Testing
11 - 14	Not Used
15	Transmitter Signal Element Timing (DB)
16	Divided Clock Transmitter (DCT, non-EIA)
17	Receiver Signal Element Timing (DD)
18	Divided Clock Receiver (DCR, non-EIA)
19	Not Used
20	Data Terminal Ready (CD)
21	Not Used
22	Ring Indicator (CE)
23	Not Used
24	Transmitter Signal Element Timing, External (DA)
25	Reserved for Data Set Testing (non-EIA)

FIGURE 4

Optional Customer Features of Data Set 208B

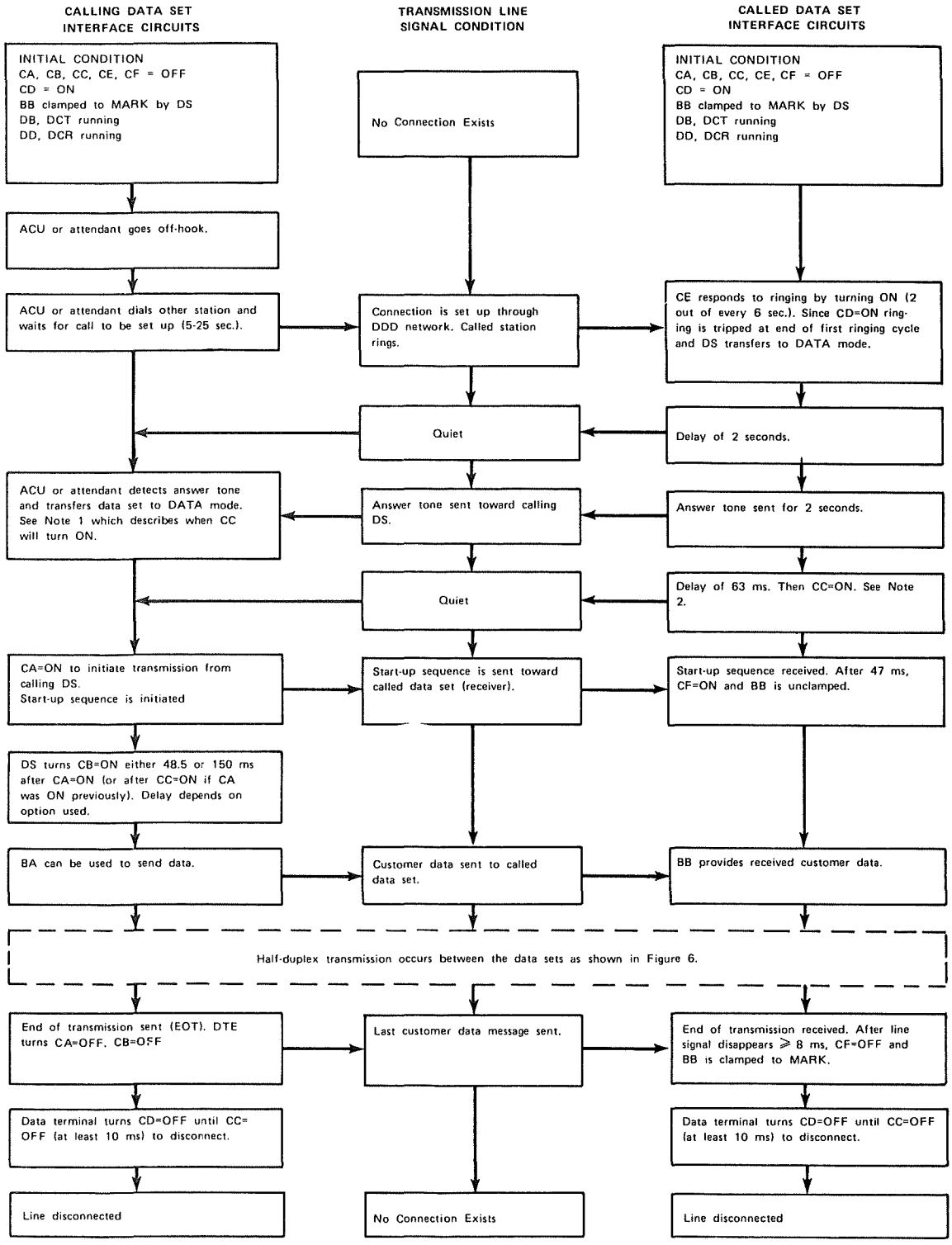
Options Set at Installation	Select One or Other for Each Option
Transmitter Timing Provided by	Data Set (internal)
	Data Terminal (external)
Data Set Ready Lead Option for Analog Loopback Testing by Data Terminal	CC is OFF when the AL button is depressed
	CC is ON when the AL button is depressed
Automatic Answer	Not Provided
	Provided (under control of CD)
Grounding Option	AB connected to AA
	AB not connected to AA
Option Controlled by Customer Accessible "50" Button	**Button Is Used to Select One or Other**
Request-to-Send — Clear-to-Send Delay	With button out: 150 msec
	With button depressed: 50 msec

Additional Features Available with Data Set 208B

RACK MOUNTING AUTOMATIC CALLING UNIT

FIGURE 5(a)

CALL SET UP AND TERMINATION PROCEDURES FOR SWITCHED NETWORK SERVICE USING THE 208B WITH AUTOMATIC OR MANUAL CALLING AND AUTOMATIC ANSWERING*



Notes: 1) With automatic calling unit (ACU), the data set is connected to the line and CC turns ON within 100 milliseconds of the end of the answer tone from the called data set. With manual (attended) calling DATA mode transfer depends on when the attendant depresses the DATA button. Since the calling data set repeats the handshaking sequence (2 seconds quiet, 2 seconds answer tone, and about 63 milliseconds quiet) before turning CC=ON, the transfer will occur approximately 4 seconds after the DATA button is depressed.

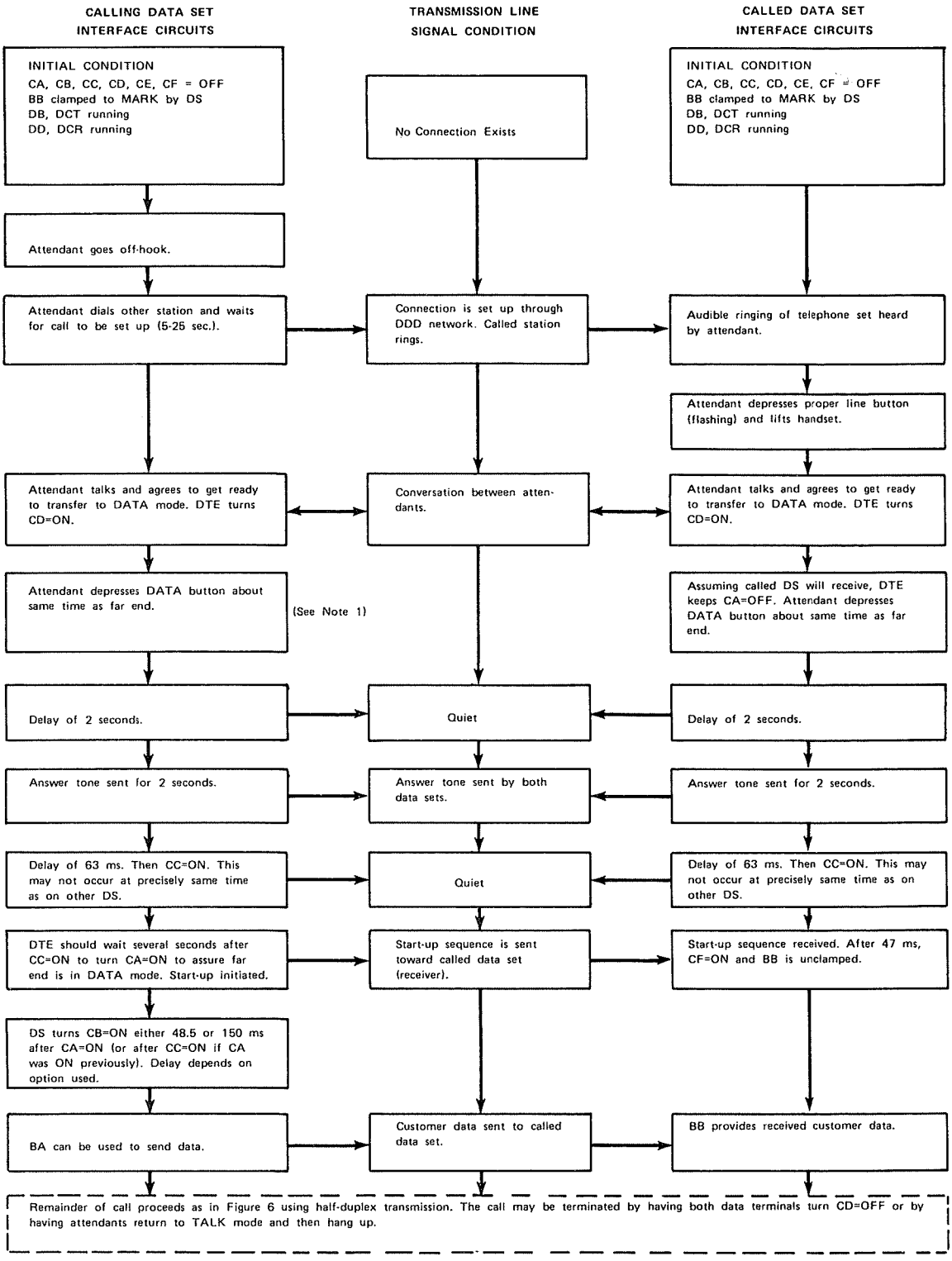
2) If the calling data set uses manual DATA mode transfer, the called data set (receiver since CA=OFF) will probably be placed in the DATA mode (CC=ON) before the other data set has completed the handshaking sequence. This may result in the receiver demodulating the answer tone signal, and spurious data may appear on BB when CF turns ON. This could last for a period up to 2 seconds. The data terminal should ignore this.

Abbreviations: DTE = Data Terminal Equipment
DS = Data Set

* All time specifications are nominal.

FIGURE 5(b)

CALL SET UP AND TERMINATION PROCEDURES FOR SWITCHED NETWORK SERVICE USING THE 208B WITH MANUAL CALLING AND ANSWERING*



Notes: 1) Either data set may act as the transmitter initially according to business machine protocol.

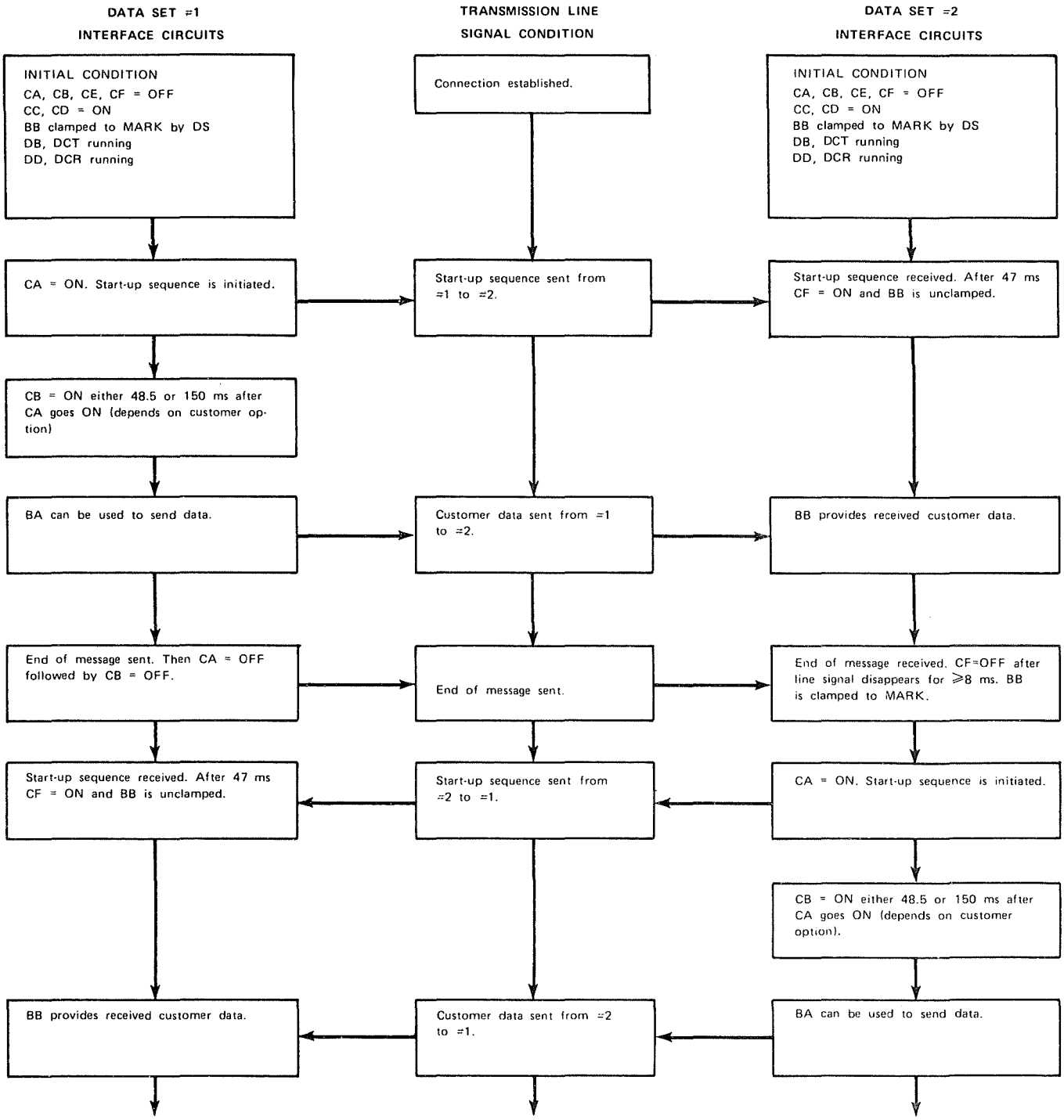
2) During the handshaking sequence between the data sets if the receiving data set turns CC=ON before the transmitting end does, the receiver may demodulate the answer tone from transmitter, and spurious data may appear on BB when CF turns ON. This could last for a period up to 2 seconds. The data terminal should ignore this.

Abbreviations: DTE = Data Terminal Equipment
DS = Data Set

*All time specifications are nominal.

FIGURE 6

HALF-DUPLEX OPERATION OF DATA SET 208B*



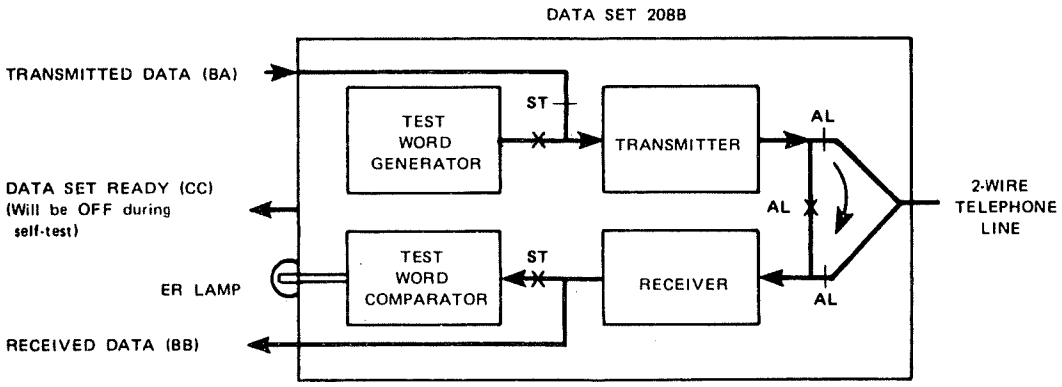
NOTE: When neither data set is transmitting, echo suppressors are kept disabled by the data sets (see Section 1.10).

ABBREVIATION: DS = Data Set

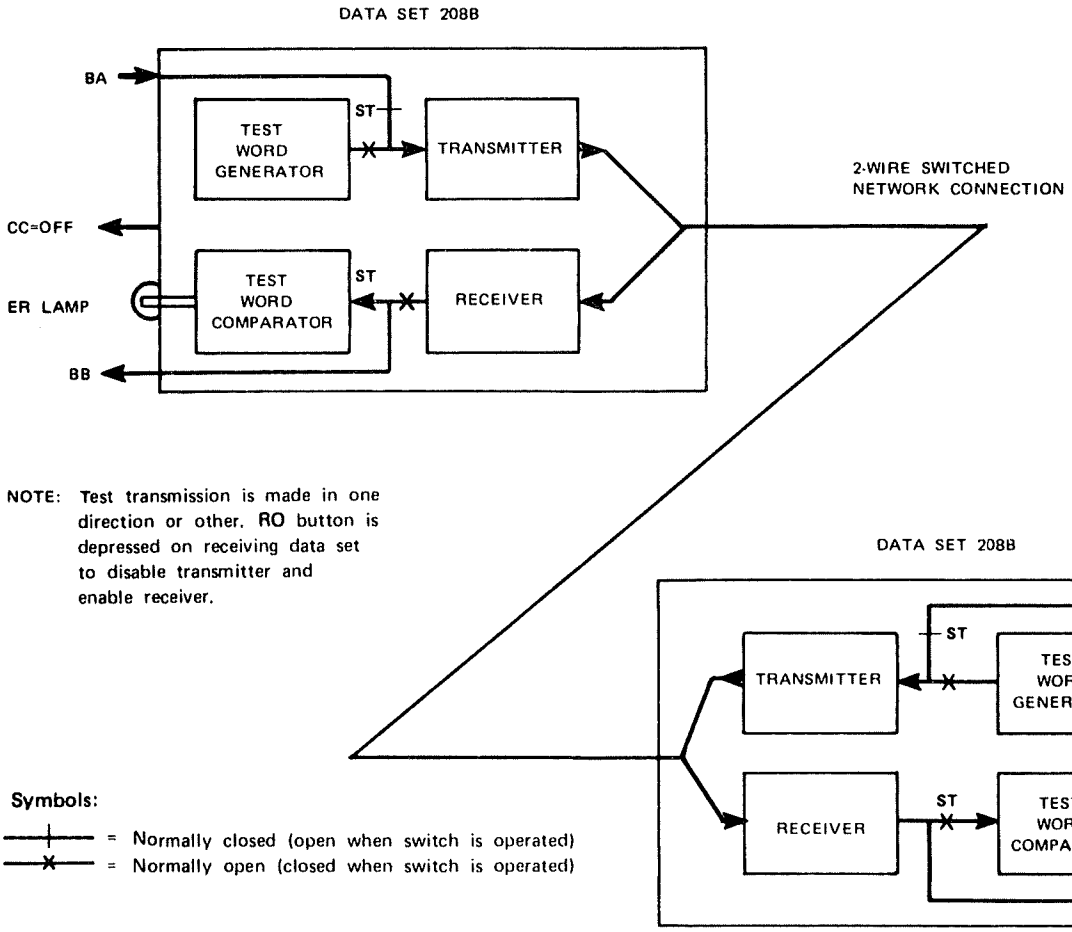
* All time specifications are nominal.

FIGURE 7(a)
DATA SET SELF-TEST ARRANGEMENTS

TEST 1) ANALOG LOOPBACK SELF-TEST



TEST 2) END-TO-END SELF-TEST



NOTE: Test transmission is made in one direction or other. RO button is depressed on receiving data set to disable transmitter and enable receiver.

Symbols:

—|— = Normally closed (open when switch is operated)

—X— = Normally open (closed when switch is operated)

FIGURE 7(b)

ARRANGEMENT FOR TESTING WITH THE DATA TERMINAL

TEST 3) ANALOG LOOPBACK TEST USING THE DATA TERMINAL

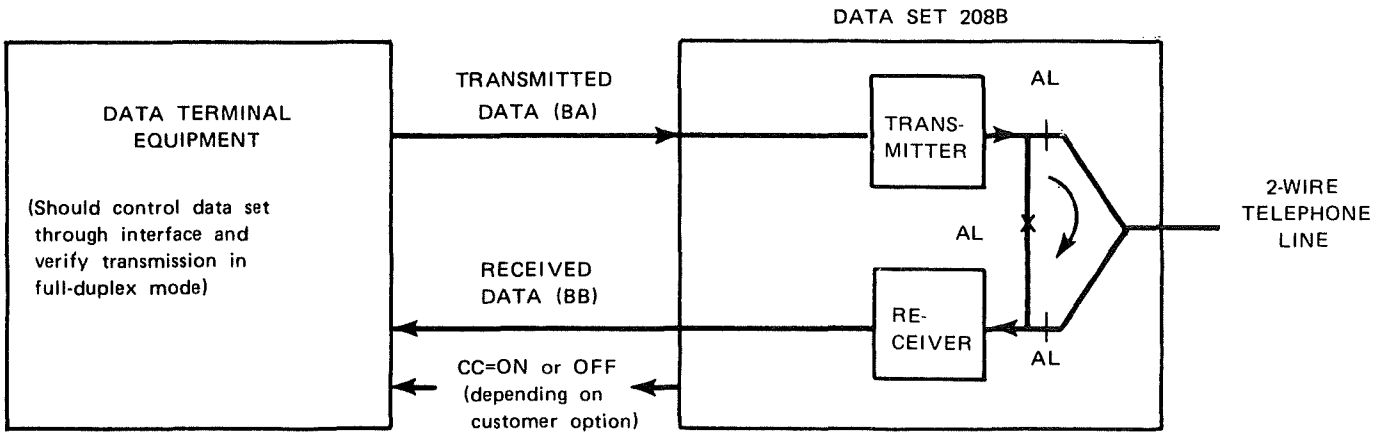


FIGURE 7(c)

TELEPHONE COMPANY REMOTE TEST ARRANGEMENT

TEST 4) 2-WIRE SWITCHED NETWORK REMOTE TEST