CIRCUIT SWITCHED DIGITAL CAPABILITY

CHANNEL UNITS

D4 CHANNEL BANK

DIGITAL TRANSMISSION SYSTEMS

CONTENTS PAGE

1. GENERAL

1.01 This section describes the D4 channel units which are used in carrier trunks and lines for Circuit Switched Digital Capability (CSDC). Table A lists the units and the respective reference drawings. Channel units with CSDC capability for subscriber loop carrier are covered in the descriptive practices for that equipment (363 division).

1.02 Whenever this section is reissued, the reasons for reissue will be listed in this paragraph.

1.03 Included in this description are application information for the units, block diagrams, and the accompanying functional descriptions. Circuitry common to all D4 channel units such as the active filters, pulse amplitude modulators, gates, and channel unit logic functions are described in the general channel unit section (365-170-101).

2. NETWORK OVERVIEW

2.01 Circuit Switched Digital Capability (CSDC) allows alternate data and voice transmission over a network of digital carrier facilities and customer terminating equipment. Originally known as public switched digital capability, this service was developed as a feature option available with the No. 1A ESS* switch. This high grade service is suitable for applications such as audio graphics teleconferencing, high speed facsimile, document distribution, bulk data transmission, and encrypted voice and data. The end-to-end switched connection is originated in the voice mode by dialing in the same manner as message telephone service. When connected, customers switch to data and full 56 kb/s duplex transmission occurs. The voice or data information is sent over the digital facilities on a single channel, data is inserted in the channel, and voice undergoes pulse code modulation (PCM). The information rate over the channels is 64 kb/s arising from the use of 8 bits for PCM encoding and a channel sampling rate of 8000 times per second in the D-channel banks.

2.02 At the CSDC customer's serving office, the electronic switching equipment which contains the program generic to handle CSDC is required to recognize, process, and switch calls to dedicated digital facilities for trunking between offices. Toll and tandem switching within the network

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is also done by the No. 1 ESS switch or is done on the 64 kb/s level signal by the No. 4 ESS switch which uses common channel interoffice signaling (CCIS). Figure 1 shows a direct connection of the customer to the CSDC office and the use of a remote exchange for the CSDC connection. Customers served directly by a CSDC office are connected to the No. 1A ESS switch by a 2-wire loop and a metallic facility terminal (MFT) unit or by subscriber loop carrier. Customers outside the serving area of a CSDC office are connected through their normal exchange office to the CSDC office by a remote exchange trunk using digital carrier facilities.

2.03 Routine tests and trouble isolation tests for CSDC are initiated by the maintenance circuits associated with the electronic switching equipment. These circuits direct the switch-to-switch straightaway tests over the facilities and loopback tests with the network channel terminating equipment and CSDC channel units.

2.04 In the process of making a CSDC call, several different signals are sent over the network. To initiate a call, the caller or automatic calling equipment (ACE) for a computer goes off-hook which applies a loop closure to the customer loop. On detection of loop current, the ESS switch serving end office connects the line to a dialing receiver to detect dialed digits. Only TOUCH TONE* calling can be used; dial pulsing cannot be used. After dial tone is received, the customer or ACE will transmit the access code, information digits, and terminating number. The called customer is alerted by interrupted 20 Hz ringing which is applied to the customer loop from the serving office in response to received signaling. The connection is established in the voice mode, but once established the call may be switched between the voice and data modes at the customer's discretion. To send data, one end switches to the digital mode which signals the other end. After the other end changes to the digital mode, an acknowledgement will be sent enabling data transmission. In the voice mode, the analog voice signals are sent over the customer's loop and PCM is sent over the digital network. In the data mode, customer data is time compressed and is sent on the loop at 144 kb/s; this data is sent over the digital network as 64 kb/s unipolar data.

2.05 The customer boundary for the CSDC network is at the network channel terminating equipment (NCTE). One side of this unit connects to the customer premise equipment and the other side connects to the 2-wire loop going to the serving end office. The NCTE provides time compression multiplexing (TCM), initiates balancing and equalization procedures for the adaptive hybrids in the CSDC channel units, and signals a change in mode in either direction. Time compression multiplexing accelerates the 56 kb data to nearly 3 times its speed and introduces delays in transmission to create a time difference for transmissions in each direction so that both directions can be sent over the same 2-wire loop. This loop may be dedicated to CSDC use only or may be shared between CSDC and message telephone service.

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3. D4 COMMON EQUIPMENT CONSIDERATIONS

3.01 For assignment flexibility in the CSDC network, D4 channel banks must either have the shop wiring to support all applications or be updated. Banks stamped ED-3C650-31, Group WA have been in production since October 1981 and provide the wiring required for CSDC flexibility. This wiring includes an alarm path for the office interface unit #4 (OIU-4) plug-in to activate the office alarm when timing slips are encountered (see para. 3.02) and wiring to the bank signaling buses for the CSDC dataport. The alarm path (SD-3C304-02, option G) for the OIU-4 and the wiring for the CSDC dataport (SD-3C304-02, option H) must be added to ED-3C650-31 banks with printed wiring backplanes which were manufactured before October 1981. Extensive wiring changes are required on the banks with hard-wired backplanes just to achieve general dataport compatibility; then the CSDC wiring options must be added. These extensive changes include moving power leads; so whenever possible it is advisable to choose carrier routes using later vintage D4 banks.

3.02 The J9872AY OIU-4 is a D4 common equipment plug-in that provides looped and external bank timing options and has a timing slip detector for the external timing option. This unit continuously compares the external clock frequency with the received T-line frequency for timing slips. If timing slips exceed a rate of one every 5 minutes, an LED on the faceplate lights and if the rate should exceed 16 in any 5-minute period an office alarm sounds. The OIU-4 is required for CSDC whenever external timing is used to provide slip detection. Although the OIU-2 can be used whenever looped timing is re-

quired, the OIU-4 is preferred since it increases the bank's assignment flexibility.

3.03 When CSDC dataports are connected back-to-back at an intermediate office, both D4 banks must be timed from a single source. If the digital office timing supply (DOTS) is available in the office, each bank can be wired to it; otherwise, one of the banks must be synchronized to the other. This synchronization is done by wiring one of the composite clock outputs from the OIU in one bank to the external clock input to the OIU in the other bank. The OIU-4 must be used in whichever of these banks that is terminating towards the customer to monitor the system for timing slips.

4. CHANNEL UNIT APPLICATIONS

Remote Exchange Units

4.01 Customers not served directly by a CSDC office are connected to a CSDC office by a digital carrier facility. The remote exchange units are used at the ends of the carrier channels to produce remote exchange lines for the customer to be served from the remote CSDC office (Fig. 2). The remote exchange subscriber (TRXS) end unit is used at the customer's normal exchange office and produces the interface between the customer's loop and the digital carrier channel. The remote exchange office (RXO) end unit is used at the CSDC office and forms the interface between the digital carrier channel and the 2-wire access lines wired to the ESS switch. Both units contain the circuitry for transmission of voice, data, and control signals in both directions with the accompanying signaling and supervision. In addition, the TRXS unit utilizes TCM for signals sent and received over the customer loop.

Dataport Unit

4.02 The CSDC dataport channel unit (designated PSDP) serves as the interface between the carrier channel and the office DSØ signal connections. These connections may be to the Digital Data System (DDS) which is an all digital network of data transmission equipment and long haul facilities, but the connections are not limited to DDS. For DDS, the dataport is used at the end of a carrier trunk connecting a CSDC office or a remote exchange office to a DDS office. Figure 3 shows the dataport in trunks between CSDC and DDS offices. In non-DDS applications, the CSDC dataport unit is used with another CSDC dataport unit at an intermediate office to connect carrier channels in tandem for a longer remote exchange trunk (Fig. 2). The DSØ sides of the dataports are interconnected in this application. Unlike other D4 dataport units, the CSDC dataport has specialized features for voice/data transmission and for end-to-end compatibility with TRXS, RXO, alternate voice/data units for No. 1A ESS switch and SLC† -96 carrier system terminal as well as another CSDC dataport. A signaling option on the unit conditions it for the application.

Maintenance Loopback Unit

4.03 Routine tests and trouble isolation tests for CSDC are initiated by the maintenance circuits in the electronic switching equipment. The maintenance loopback unit is used at the No. 4 ESS switch office to allow loopback testing from a distant office in the CSDC network. This loopback unit is installed in a carrier channel which is included in a loopback testline accessed by the 4 ESS switch (Fig. 4). The testline is accessed by a dial-up procedure through the maintenance circuit of the distant switcher. Trunks originating from a No. 4 ESS switch will be tested with the associated Remote Test System (RTS-5A), and trunks going from the No. 1A ESS switch to the No. 4 ESS switch will be tested from the No. 1A ESS switch.

5. FUNCTIONAL DESCRIPTION

A. RXO Channel Unit

5.01 ***Voice Transmission:*** The voice circuitry consists of the line interface, transmit and receive attenuators, active bandpass filters, and gate circuitry for pulse amplitude modulation (PAM). See Fig. 5. Transformer coupling connects the 2-wire access line to the electronic line feed in the interface which produces the 2- to 4-wire conversions (electronic hybrid) in the unit and presents the proper impedance on the 2-wire side. The attenuators are set when the unit is put in service to produce the required vf levels to and from the access line. The gate circuitry produces PAM samples for connection to the D4 common equipment and detects PAM samples from that equipment while the bandpass filters limit the bandwidth before modulation in the transmit direction and reconstruct the vf waveforms in the re-

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ceive direction. The receive gate is disabled when the unit is in the data mode or during a carrier failure.

5.02 ***Signaling:*** In the transmit direction, the unit accepts the signaling and supervision conditions from the switch and represents these conditions by logic states sent over the carrier by the A and B signaling bits when the unit is in the voice mode. In addition to the A and B signaling bits sent every sixth and twelfth frame, bit 8 is also monitored in the other frames for status information. On-hook, off-hook, and 20 Hz ringing conditions are sent in this manner. The polarity of the battery for a closed loop controls the transmission mode, voice or data. In the receive direction, the mode select circuitry detects the received signaling and operates relays in the loop interface to produce the signaling and supervision conditions. Open and closed loop conditions are received in this way.

5.03 ***Data Transmission:*** The data circuitry consists of the line interface, an adaptive hybrid and equalizer, a data converter, and a digital signal conditioner (Fig. 5). Transformer coupling connects the 2-wire access line to the electronic line feed in the line interface and establishes the 2-wire impedance and the transmission level range in the unit. The adaptive hybrid automatically conditions the 2-wire access line for 56 kb/s full-duplex data, and the equalizer automatically adjusts for cable losses. Bipolar data from the 2-wire access line is converted to 64 kb/s unipolar, dual-rail data by the transmit data converter; and dual-rail data is converted to bipolar in the adaptive hybrid and equalizer. The digital conditioner inserts the transmit data bytes into the 8-bit PCM words under control of external timing connected to the bank, and the conditioner converts data from the received PCM signal to a 56 kb/s dual rail signal. A digital control circuit in the conditioner circuitry coverts 64 kb/s unipolar data to 56 kb/s data and monitors the received data for loopback and control codes, enables or inhibits data transmission, and inserts transmit control codes.

5.04 ***Mode Select Control Circuitry:*** Most of the channel unit control functions are accomplished by the mode select circuitry. It places the channel unit in the data or voice mode by processing the mode requests from both customers. It initiates loop conditioning in the data mode and sends the power-down and power-up signals to the appropriate circuits in the unit. The mode select sets the electronic line feed for voice and data modes to match the 2-wire impedance and transmission levels. It also contains the logic to set the transmit signaling states, and decodes and responds to the received signaling. In the data mode, the mode select oversees the operation of the adaptive hybrid and causes the control circuit in the DSØ/DS1 data conditioner to send control codes or become transparent for customer data transmission.

5.05 ***Loopback Testing:*** When directed by the maintenance circuit in the CSDC office, the RXO unit will connect a digital signal loopback and send a maintenance signaling pattern of A and B signaling bits toward the customer end of the access line. This loopback allows the maintenance circuit to perform routine tests or isolate trouble. Service requests will be denied while the unit is looped.

B. TRXS Channel Unit

5.06 ***Voice Transmission:*** The voice circuitry is the same as the RXO except that the TRXS does not use transformer coupling at the line interface. See Fig. 6 and refer to the description in paragraph 5.01, but substitute 2-wire customer loop for the 2-wire access line referred to in the RXO description.

5.07 ***Signaling:*** In the transmit direction, the unit monitors the loop current states from the customer equipment and represents these signaling and supervision conditions by logic states sent over the carrier by the A and B signaling bits. In addition to the A and B signaling bits sent every sixth and twelfth frame, bit 8 is also monitored in the other frames for status information. On-hook (loop open) and off-hook (loop closed) conditions are sent in this manner. In the receive direction, the mode select circuitry operates relays in the loop interface to produce the signaling and supervision conditions corresponding to the signaling received over the carrier. Open and closed loop conditions and 20 Hz ringing are received in this way. The TRXS detects a request for voice or data mode selection by recognizing an interruption of loop current; then it changes mode and signals the change back to the customer and to the far end. The polarity of the battery applied to the loop signals the customer equipment and control signals sent over the channel signal the far end. The follow-

ing table shows the battery polarity applied to the loop for the two modes.

MODE	POLARITY	
	TIP	RING
VOICE	Grd	-48V
DATA	-48V	Grd

5.08 ***Data Transmission:*** The data circuitry consists of the line interface, TCM analog and digital circuits, and the digital signal conditioner (Fig. 6). The electronic line feed provides the 2- to 4-wire conversions (electronic hybrid) in the unit and establishes the interface impedance and the transmission level range. The TCM analog circuit recovers clock and connects the analog data from the customer to the TCM digital circuit for conversion to dual rail digital data. In the opposite direction, these circuits convert received dual rail digital data to analog and perform time compression multiplexing on the data. The DSØ/DS1 signal conditioner processes the data for insertion into the outgoing PCM bitstream and in the opposite direction produces 64 kb/s dual-rail data from the received PCM. Timing for data insertion and extraction is obtained from the incoming bitstream using loop timing of the bank. A digital control circuit in the conditioner circuitry monitors the received data for control codes, enables or inhibits its data transmission, and can transmit control codes.

5.09 ***Mode Select Control Circuitry:*** This circuitry is the same as that in the RXO but it is programmed to respond to TRXS signaling conditions. See Fig. 6 and refer to the description in paragraph 5.04.

5.10 ***Loopback Testing:*** When the maintenance signaling pattern of A and B bits is received from the office end of the access line, the TRXS unit will initiate going to the data mode and it will connect the digital signal loopback. Service requests will be denied while the unit is looped.

C. Dataport Channel Unit

5.11 The CSDC dataport serves as the interface between the 64 kb/s DSØ office data signals and the 64 kb/s channel in the digital bitstream. As seen in Fig. 7, the 4-wire office circuit connects to the bipolar/unipolar converters in the unit. These converters make the conversions between bipolar, nonreturn-to-zero data on the office side and the unipolar signal used in the channel bank. Buffers in the DSØ/DS1 signal processors read the unipolar data into the channel bitstream in one direction and recover the data signal from the receive PCM bitstream in the other direction. The data is read into and out of the bitstreams by the clocking action of timing signals connected to the circuits. Control and signaling circuit blocks in the unit are covered in the following paragraphs.

5.12 Zero code suppression and signal loopback capabilities are also provided in the dataport. Subrate data error correction can also be derived in the dataport, but this feature will not be offered unless a subrate data application develops. When in the voice transmission mode, the zero code suppression circuit inserts a 1 in bit position 7 of the encoded voice signal whenever zeros are received in bits 2-8 of the received PCM signal. Insertion of a 1 in this bit position prevents the DDS equipment from inserting 1s in positions 4 and 5 which would be more offensive to CSDC voice transmission. Signal loopback can be established on either the DSØ or DS1 side of the dataport buffers in response to a control signal sent by the maintenance circuit connected at the No. 1 ESS switch. Which loopback is established depends on which side receives the control signal; when received on the DS1 side, the DSØ side will loop and vice-versa. While looped, the unit sends out-of-service codes over the facility away from the maintenance circuit. When more than one dataport is present in the CSDC facility connections, any one can be addressed and looped by a countdown technique. Each dataport along the way detects and removes one burst signal and then if the loopback code is detected next in the string of control pulses, it will loop; otherwise it becomes transparent to further pulses.

5.13 The CSDC dataport contains circuitry not found in other D4 dataports to allow it to be used for alternative data/voice transmission. This circuitry translates the A and B signaling received from the carrier into a pattern of bits in the DSØ signal, and in the other direction translates the pattern in the DSØ signal into A and B signaling for the carrier. The translations are accomplished by the DSØ signaling detector and DS1 signaling addition circuit in one direction and by the DS1 signaling detector and DSØ signaling addition circuit in the reverse direc-

tion (Fig. 7). In this way, the A and B signaling which normally is lost in the DDS is preserved and is translated into a form that will pass through the DDS equipment including the DSØ cross-connect bay. For back-to-back dataports, the pattern in the DSØ signal will be translated back to A and B signaling for application to the tandem carrier link. A data/voice detector in the unit determines when the unit is in the voice mode (signaling required) and when it is in the data mode (transparent to pass control codes).

5.14 Two options in the dataport must be set for the dataport applications. The BANK option is set to condition the dataport for the type of bank it is used in (D4 or SLC) and the SIGNALING option conditions the unit for the signaling requirements. The TRUNK SIGNALING option setting is used for trunking to a voice/data channel unit in a digital carrier trunk (DCT). The LOOP SIGNALING setting is used in remote exchange or SLC configurations. The other setting is for CCIS (SIGNALING-NONE) in which no signaling is sent and the dataport is transparent to both encoded data and voice.

D. Application Restrictions

5.15 ***Dataport Units:*** The dataport incorporates low current drain circuitry which allows filling all 48 channel slots of the D4 bank without overloading the power converter. However, the number of dataports must be limited to prevent a yellow alarm in the receiving bank. When a dataport is not receiving customer data, it transmits, to the T1 line, data words containing logic zeros in all bit positions except bits 4 and 5. The alarm control unit in the receiving D4 bank responds with a yellow alarm if too many channel slots in the transmitting bank have bit 2 equal to zero. To prevent alarms under idle conditions, the recommended maximum number of dataports is 18 per digroup if they are installed with no empty channel slots between dataports on any shelf. If dataports are installed in alternate channel slots with empty slots between them, the recommended maximum number of dataports is five per shelf.

5.16 ***Remote Exchange Units:*** The number of RX units that can be used in a D4 channel bank (48 channels) is limited to 11 because of their current drain. Any mix of RXO and TRXS can be used in the bank since they have equivalent current drains. Other types of channel units can be assigned to the remaining 37 slots using the same guidelines that normally apply to the particular units.

E. Maintenance Loopback Unit

5.17 This unit consists of DSØ/DS1 buffers in the transmit and receive paths and a circuit to loop data back toward the DS1 side (Fig. 8). The buffers read data out of and into the PCM channel by the clocking action of timing derived by the D4 common equipment. The loopback circuit accepts DSØ data from the receive buffer, inverts customer data bits 1-7, and connects the data to the transmit buffer. This bit inversion is done to prevent incorrect test results due to hybrid reflections along the route, but inversion is only done if bit 8=1 which identifies the first seven bits as customer data. When bit 8=0, a DDS control word is indicated and the bits are not inverted.

6. EQUIPMENT FEATURES AND OPTIONS

6.01 ***Physical Design:*** The CSDC units contain integrated circuits and have the characteristic D4 design features. A daughter board is used on the RX units along with the main circuit board for the required circuitry. Attenuators on the RX units are the rocker switch type (62B type, 6.3 db attenuation) which are described in Section 365-170-101. No attenuators are required on the other units. Figure 9 shows the front view of the units. Notice that the dataport is designated PSDP (public switched dataport) which is in accordance with the original name for the service; ie, Public Switch Digital Capability.

6.02 ***Test Access:*** Except for the maintenance loopback unit, each of the CSDC channel units have card jacks on the faceplate for testing at the unit. When a test cord with a card plug (such as is used with the D3/D4 portable test set) is inserted, the normal through connections are broken and either direction can be accessed. The VOICE TST jack on the RX units provides splitting access to the −8.5 transmit and +4 receive transmission level points in the 4-wire voice circuit and provides splitting access to the tip and ring leads on the 2-wire side. The DATA TST jack on the RX units provides splitting access to the transmit and receive 64 kb/s unipolar data points. On the dataport, the TST jack provides splitting access to the tip and ring leads for testing the bipolar data signal. These data access points on

the RX and dataport units are intended for tests with transmit and receive digital data test sets (such as the KS-20909 transmit and KS-20908 receive test sets). ***However, in order to perform data tests the units must be placed in the data mode.*** The mode of the channel units can be controlled by manupulating the signaling conditions on the tip and ring leads to simulate open/closed loops and battery reversal. Access to the tip and ring is obtained at the VOICE jack on the units.

6.03 ***Options:*** Only the dataport unit has circuit options selected by option switches. These options are listed with the functions in Table B. The SIGNALING option is selected by a socket plug and the BANK option is selected by a slide switch which can be operated by the tip of a screwdriver. Both of these options can be seen from the front, but the SIGNALING option selection is made inside the unit. The other socket plug option (S,O) inside the unit is only used for factory testing.

TABLE A

CHANNEL UNIT LISTING

CHANNEL UNIT	SD/CD
J98726PA Remote Exchange Office End (RXO)	7C302-01
J98726PB Remote Exchange Subscriber End with TCM (TRXS)	7C301-01
J98726DG CSDC Dataport (PSDP)	7C307-01
J98726DF Maintenance Loopback Unit	3C461-01

TABLE B

DATAPORT OPTION SWITCHES

OPTION	FUNCTION
BANK- D4, SLC Slide Switch	Conditions unit for use in particular bank
SIGNALING - TRUNK, LOOP, NONE Socket Plug Switch	Conditions unit for signaling required for application
S, O Socket Plug Switch (J2)	Enables testing at factory; S position used for normal operation

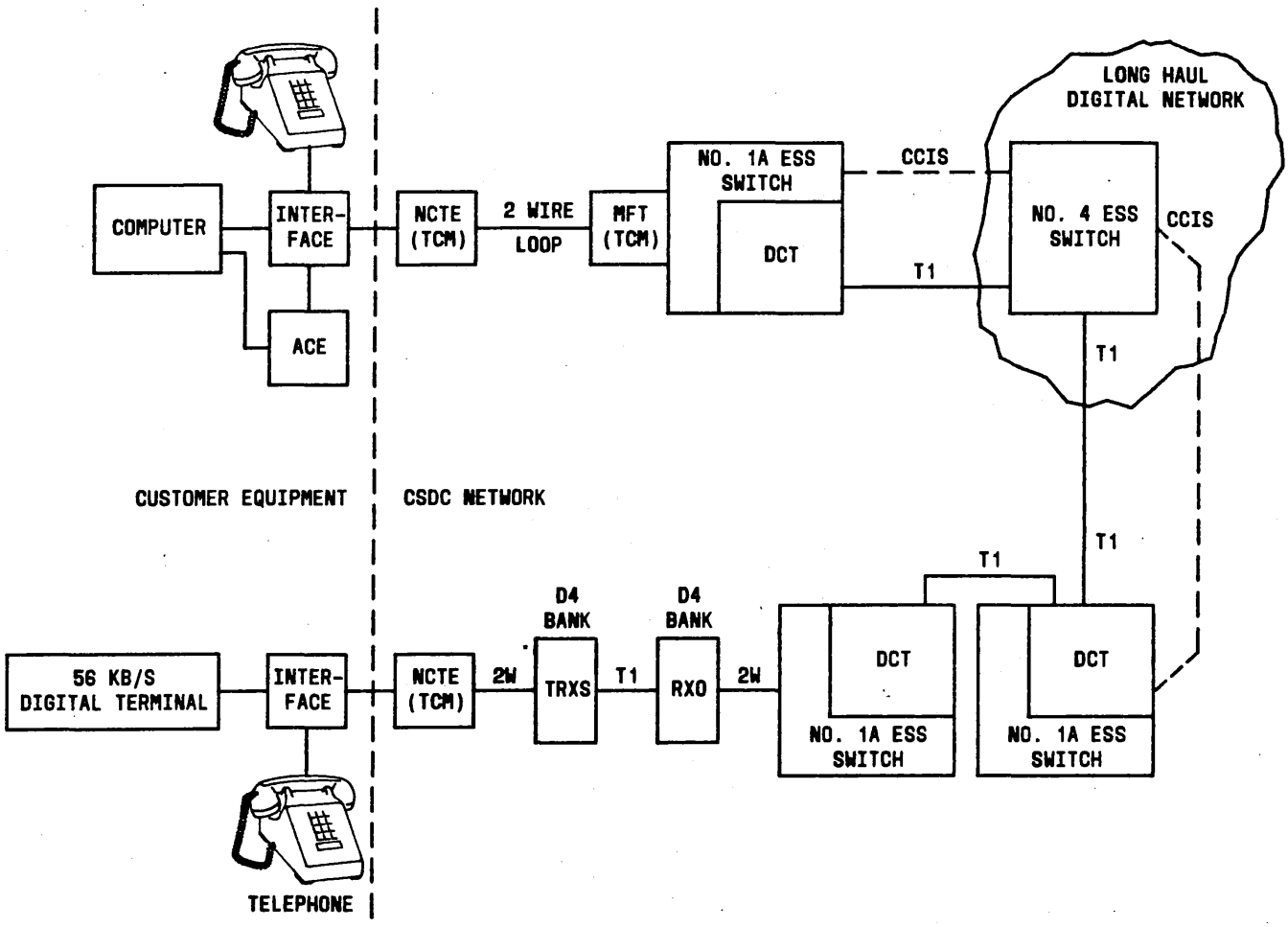

Fig. 1—Connections Over CSDC Network

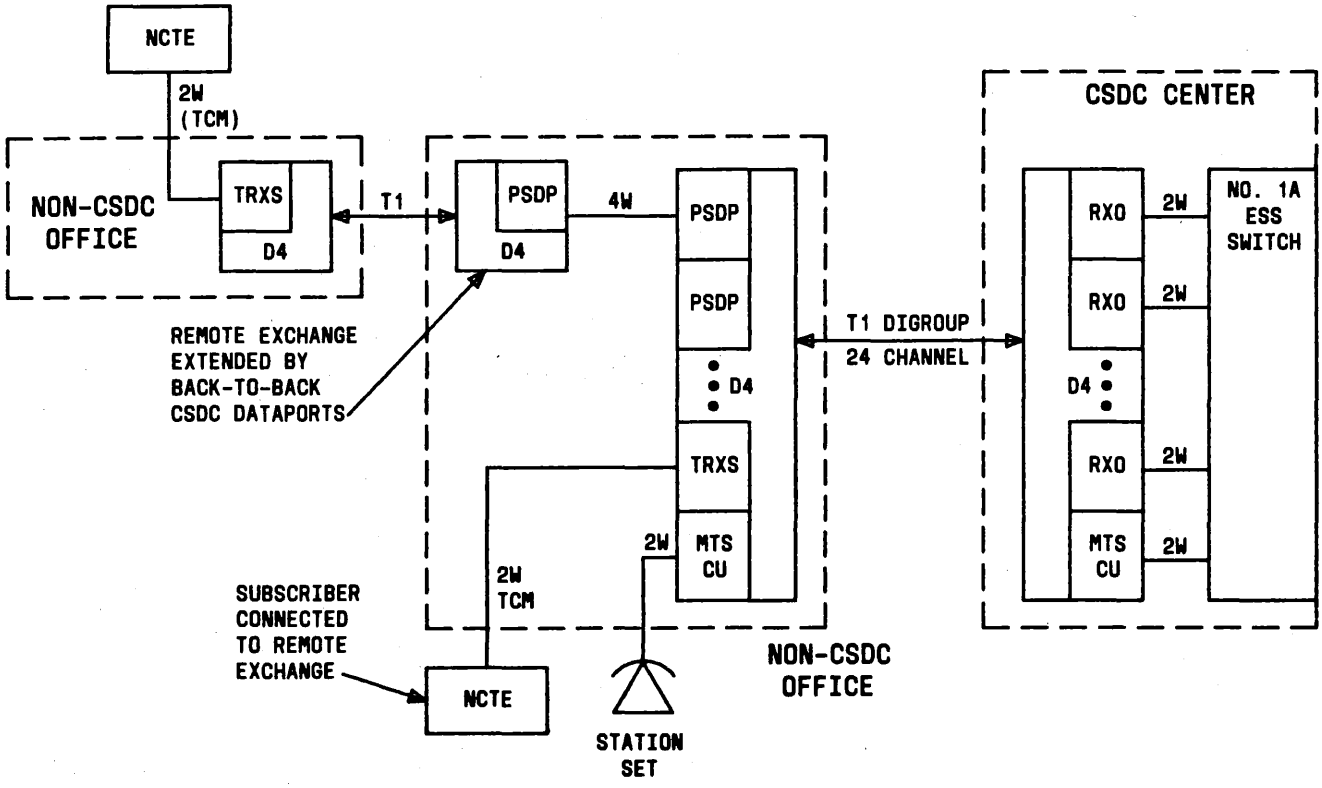

Fig. 2—Remote Exchange Trunks

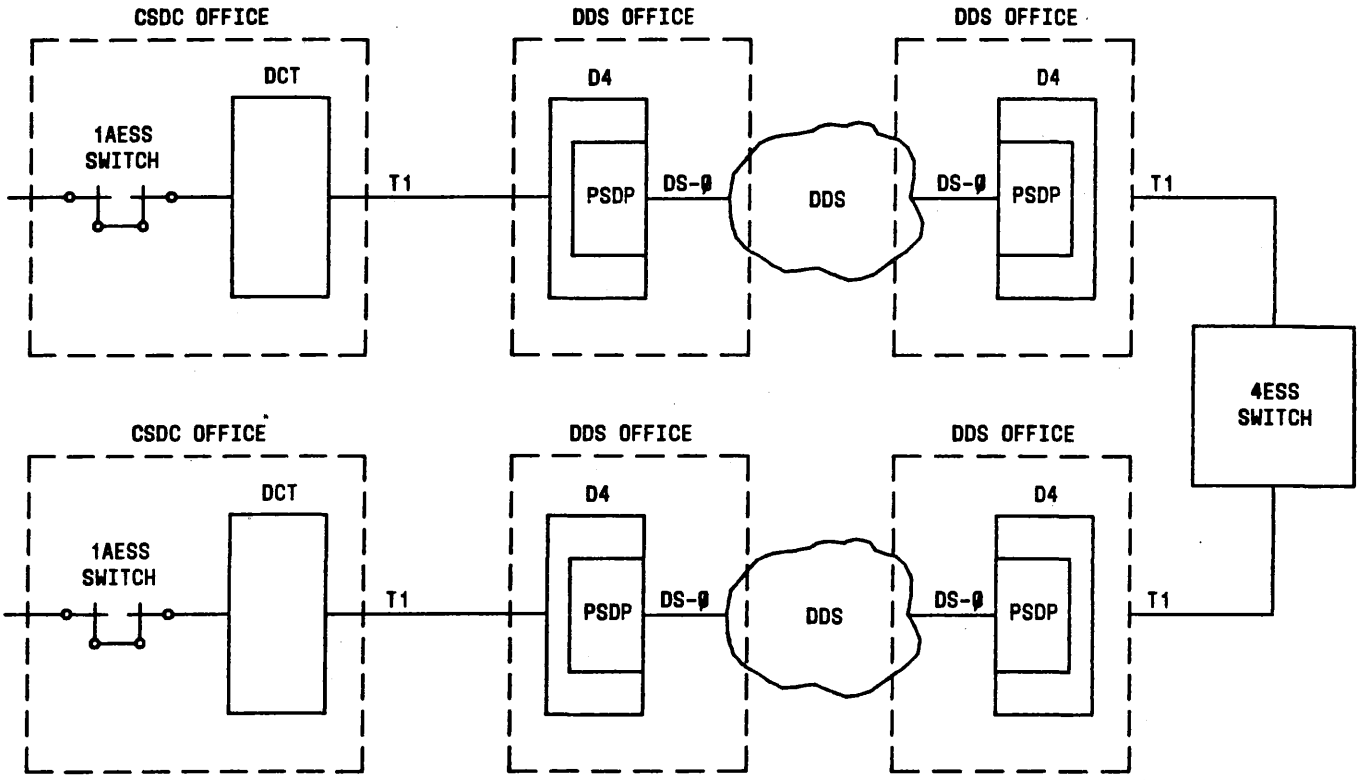

Fig. 3—Dataport Connections to DDS

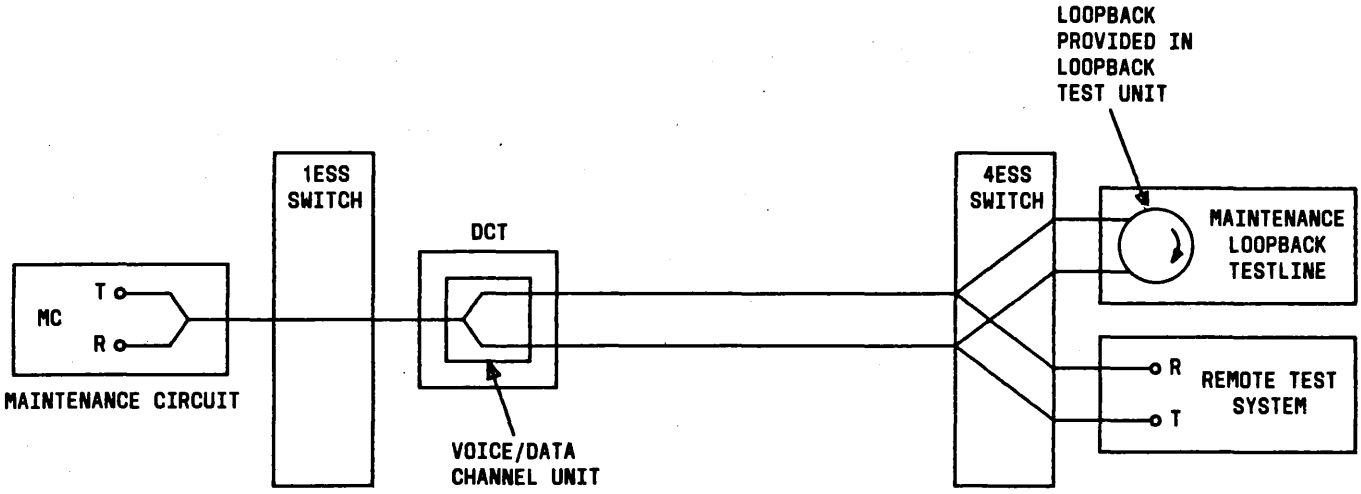

Fig. 4—Maintenance Loopback Unit Application

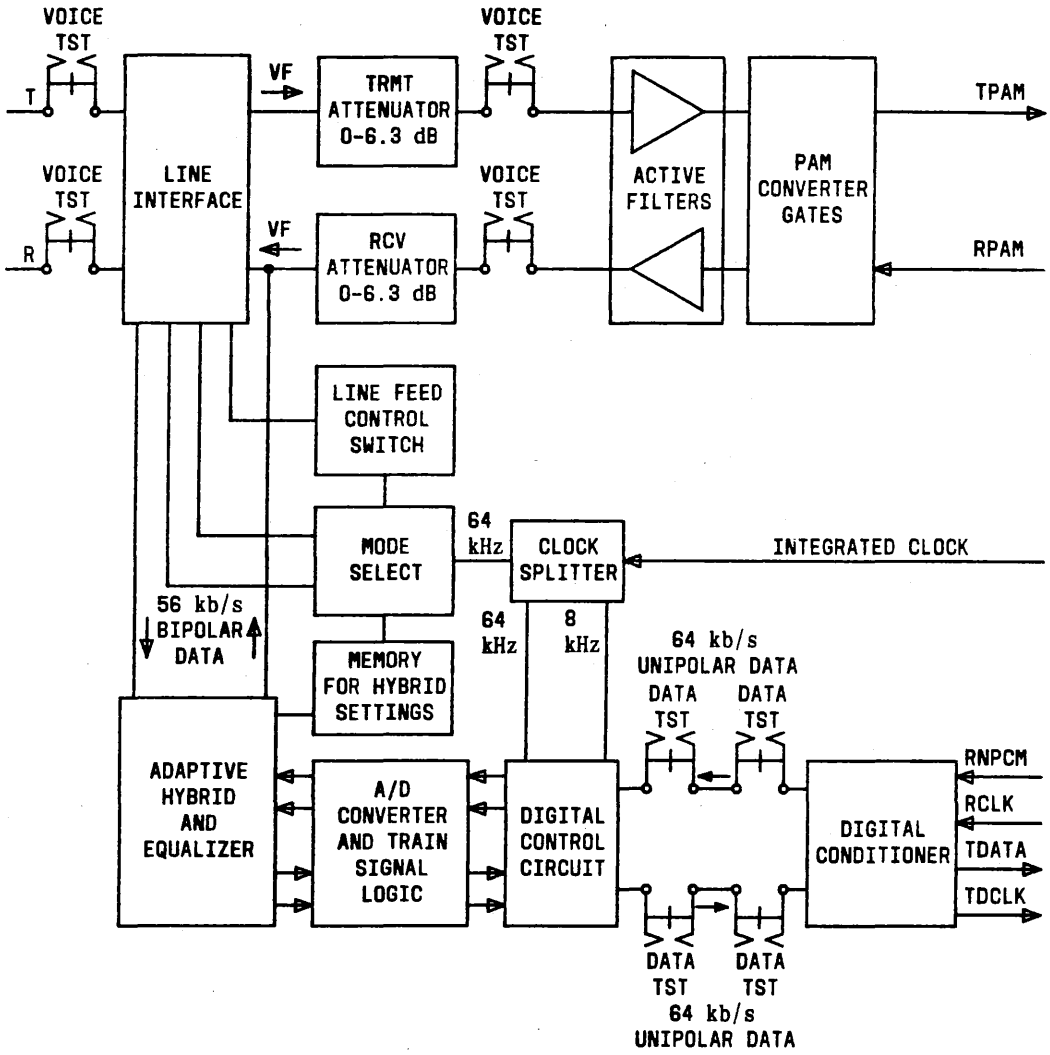

Fig. 5—RXO Block Diagram

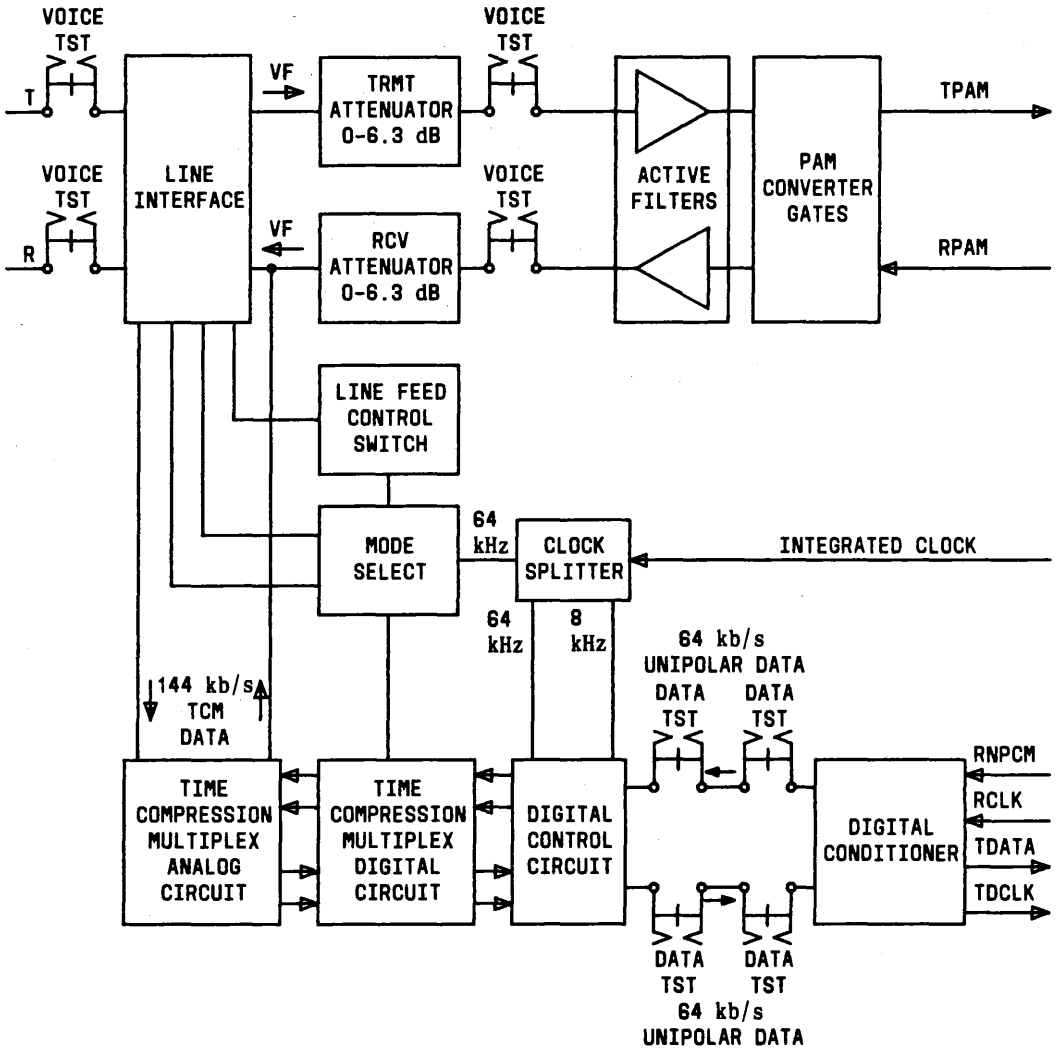

Fig. 6—TRXS Block Diagram

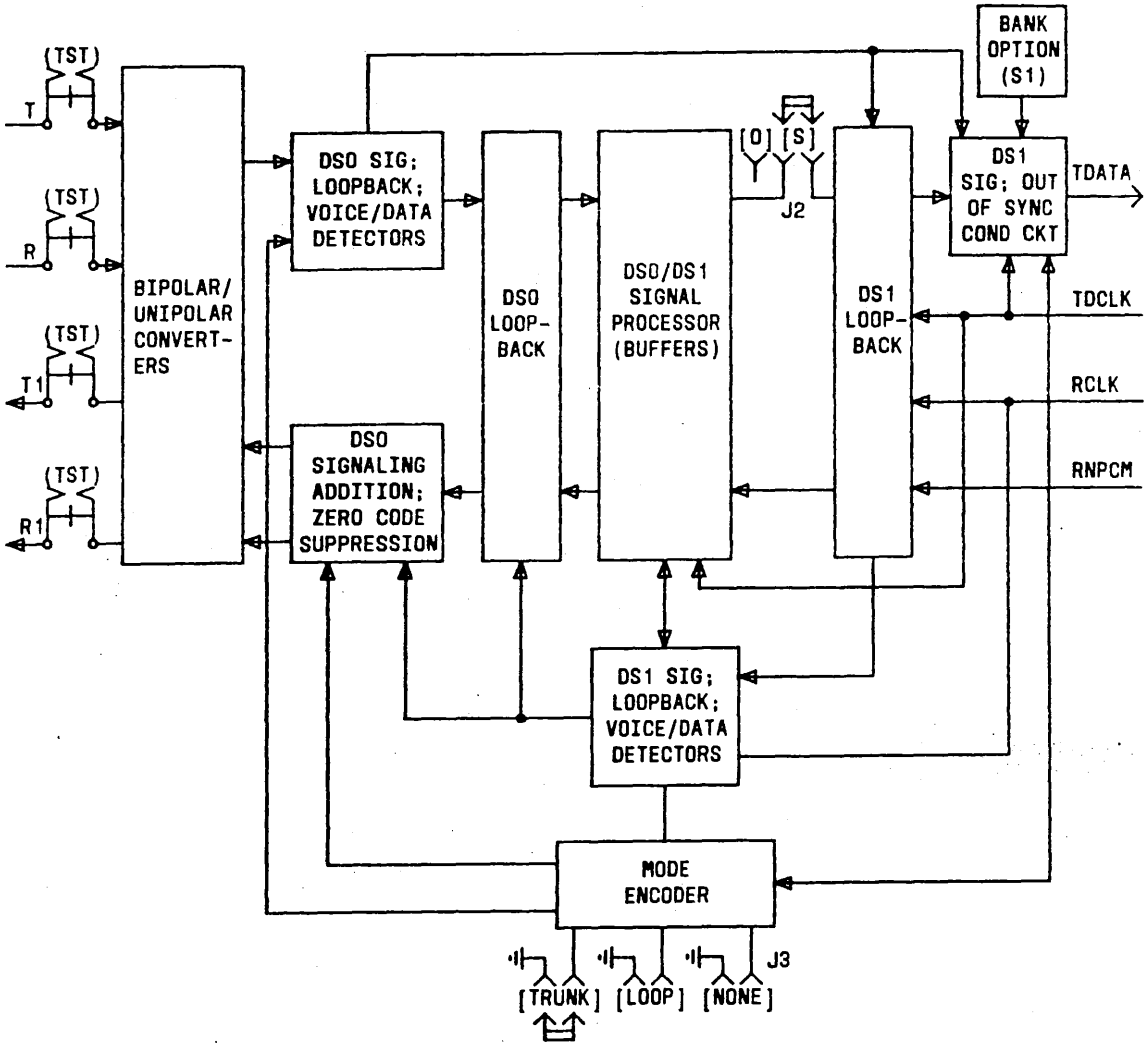

Fig. 7—Dataport Block Diagram

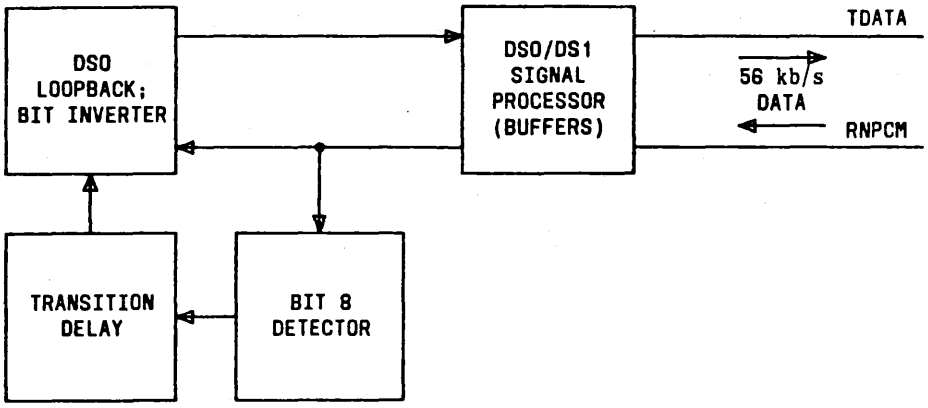

Fig. 8—Maintenance Loopback Unit Block Diagram

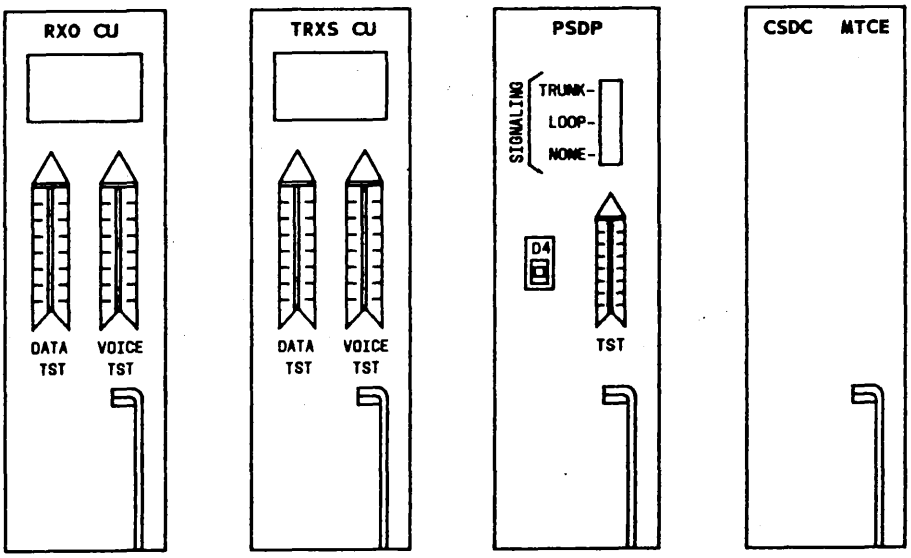

Fig. 9—CSDC Channel Unit