Conversion of the DSN Teletype Subsystem to the Eight-Level ASCII National Standard

G. J. Brunder
DSN Data System Section

This article provides a functional description of the new eight-level ASCII Teletype Subsystem and its constituent Teletype Assemblies. An overview of the implementation of the Teletype Subsystem is presented together with a discussion of the distinct capabilities of its equipment.

I. Introduction

In 1978, the NASA Communications Network (NASCOM) requested the Deep Space Network (DSN) to convert their Teletype (TTY) Subsystem from a five-level Baudot format to the eight-level ASCII (American Standard Code for Information Exchange) national standard. Other locations served by NASCOM were also being changed to eight-level teletype operation. The conversion was being made to standardize the world-wide NASCOM teletype network. ASCII is a more powerful format than Baudot since it allows additional characters to be printed and provides control functions not available in the Baudot format. In addition, at the time of the conversion, a new Time Division Multiplexor (TDM) was to be provided by NASCOM for installation at the JPL Central Communication Terminal that would make available a total of 50 teletype channels (including five special purpose 300 baud rate channels). The existing TDM System had provision for only 40 channels and did not make provision for 300 baud rate channels.

The DSN implemented the conversion at the Ground Communication Facility (GCF), the Deep Space Stations (DSS's), and the Network Operations Control Center (NOCC). The GCF, DSS's and the NOCC are all elements of the DSN. The conversion work was coordinated with other eight-level conversion work being implemented at NASCOM locations such as the Ames Research Center (ARC), the overseas NASCOM Switching Centers at Canberra, Australia, and Madrid, Spain, and the NASCOM Primary Switching Center at the Goddard Space Flight Center (GSFC) in Greenbelt, Maryland. The GSFC Switching Center consists, in addition to its testing and monitoring capabilities, of a communication processor that automatically switches and routes messages between overseas stations, the JPL communications center, and NASA locations.

The TTY signals are multiplexed and converted into 56 kbps wideband circuits and transmitted via satellite between GSFC, JPL, and overseas locations.

The following paragraphs generally describe the four TTY assemblies that comprise the TTY Subsystem that was converted to eight-level ASCII operation.

A. Central TTY Assembly (CTT)

The CTT consists of all the TTY equipment that is located in the JPL-Pasadena Space Flight Operations Facility (SFOF) Central Communications Terminal. The CTT also consists of

TTY equipment that serves the NASCOM West Coast Switching Center (WCSC). The WCSC is an integral part of the Central Communications Terminal.

B. Area TTY Assembly (ATT)

The ATT consists of the TTY equipment located in the GCF-10 Message Center at Goldstone, California.

C. Station TTY Assembly (STT)

The STT consists of the TTY equipment located at DSS 11, 12, and 14 in Goldstone, California, and at two overseas locations in Spain (DSS 61/63 and 62), and one in Australia (DSS 42/43).

D. External TTY Distribution Assembly (ETD)

The ETD consists of the TTY equipment serving the following facilities, projects, and remote JPL-Pasadena locations:

(1) The GCF-20 Message Center located in the SFOF Bldg. 230, room B31A.

(2) The Network Operations Control Center (NOCC) located on the first floor of the SFOF Bldg. 230.

(3) Locations serving projects such as Voyager and IRAS.

(4) Various remote installations located at JPL-Pasadena and also a remote off-Lab JPL building at Hill Street in Pasadena.

II. Significant Functional Characteristics

The following paragraphs describe the differences between the significant functional characteristics of both the old five-level Baudot format Teletype Subsystem and the new ASCII format Teletype Subsystem.

A. Old Five-Level TTY Subsystem

All transmit and receive TTY circuits in the old TTY Subsystem operated as neutral 130 V dc current mode 60 milliampere loops. Power isolation had to be provided between the common carriers (Pacific Telephone Co. and Western Union Co.) and the CTT. The JPL TTY circuits operated at 100 WPM using five-level Baudot code at a line rate of 74.2 baud. Model 28 Teletype Corp. machines were used extensively throughout the subsystem.

A few circuits operated at 110 baud for use by remote customers served by NASCOM. The subsystem employed a Voice Frequency Telegraph System (VFTG) between JPL and Goldstone as well as between the overseas DSS stations and the NASCOM Switching Centers at Madrid, Spain, and Canberra, Australia. The Databit, Inc., Model 922 TDM System between JPL and GSFC accepted data from a maximum of 40 outbound TTY channels in dc loop current form. The TDM System converted the outbound TTY circuits to a 4.8 kbps aggregate high-speed data (HSD) channel that was multiplexed onto a 56 kbps wideband channel for transmission, via satellite, to GSFC.

B. New Eight-Level TTY Subsystem

1. **Overview.** The new TTY Subsystem uses the standard eight-level ASCII eleven-unit code in an asynchronous mode at a 100 WPM, 110 baud, line rate. The subsystem uses NASCOM-provided Teletype Corp. Model 40/2 Keyboard Display Printers (KDPs) and Receive-Only Printers (ROPs), and Model 4210 Magnetic Tape Terminals.

The interface between the Data Terminal Equipment (DTE) and the Data Communication Equipment (DCE) is specified by the Electronic Industries Associated (EIA) RS-232-C Standard. This specification is applicable to all DTE and DCE equipment employing serial binary data exchange.

The EIA Standard specifies that a signal is considered in the marking condition when the signal is between minus 3 V and minus 25 V, and considered in a spacing condition when the signal is between positive 3 V and positive 25 V.

The subsystem employs a new NASCOM-provided Model T-96 character-interleaved TDM system between JPL and GSFC. It multiplexes up to 50 outbound TTY channels and converts them into one 7.2 kbps HSD aggregate channel. The HSD channel is multiplexed, along with six other HSD channels, onto a 56 kbps wideband channel for transmission, via satellite, to GSFC.

2. **Model 40/2 teletype equipment.** Brief functional descriptions and features of the KDP, ROP, and Magnetic Tape Terminal are provided below:

a. KDP. The Model 40/2 KDP consists of a display monitor (CRT), operator console (keyboard), controller (logic unit), and printer. Characters can be entered and sent on the line directly from the console keyboard or from the display monitor after entry and editing. The display monitor logic can store up to 72 lines (5,760 characters) of data. The KDP can also display received data on its monitor and prepare hard copies on its tractor-feed impact printer. The KDP has a full ASCII printer with an 80-column maximum line length and EIA interface. The KDP console has editing controls for scrolling, line and character insertion/deletion, cursor tab and movement, segment advance, and control character functions. The KDP and Magnetic Tape Terminal are connected together through a NASCOM-provided EIA switch to permit the interchange of data between the two and permit the KDP to transmit on-line.

b. ROP. The Model 40/2 ROP is an electromechanical line-at-a-time tractor feed impact printer which has the same features as that of the KDP printer. The ROP provides hard copies of the data received from the line. The ROP has a key-and-lamp strip that monitors the paper supply and status of the power supply, permits the interruption of incoming transmission, and signals that an invalid character parity has been detected.

c. Magnetic Tape Terminal. The Magnetic Tape Terminal is a combined send/receive unit arranged for half-duplex operation as an adjunct to the model 40/2 KDP. It is compatible with ASCII code. The data storage medium is 1.27 cm computer grade magnetic tape. The magnetic tape is provided in a cartridge with a 159,000 character capacity. It has a forward/reverse search capability of 400 characters per second and a forward/reverse fast access capability of 4000 characters per second. When accessed directly to the line, it operates at 110 baud. When sending to or receiving from the KDP, it operates at a high-speed rate of 1200 bps. The Magnetic Tape Terminal is arranged to perform the following:

(1) Store outbound TTY traffic for record.

(2) Record incoming traffic during unattended periods.

(3) Recall messages prepared for outbound traffic.

(4) Automatically transmit a large amount of messages, or a multiple-page message, previously stored on its tape.

III. Overview of the Implementation Plan

In 1978, JPL and NASCOM agreed to the following details of the eight-level TTY Subsystem implementation plan.

(1) The definition of the GCF/NASCOM interface, including the electrical signal and mechanical characteristics, and the exact location of the interface for each TTY assembly was established.

(2) NASCOM was to provide the Model 40/2 TTY equipment, VFTG assemblies, TDM System, and the overseas jack modules.

(3) JPL was to provide equipment racks, test sets and test interface equipment, modems, digital bridging equipment, mounting assemblies, and most of the TTY Subsystem cabling.

(4) The configuration of each TTY assembly within the TTY Subsystem was determined, taking into account engineering and operational considerations and budgetary restraints. (The configuration of each assembly is described in Part IV and depicted in Figs. 1 through 4.)

(5) The subsystem cut-over considerations of the new DSN TTY Subsystem would be on a circuit-by-circuit basis with the NASCOM communications processor providing code conversion during the transition period.

A. JPL Equipment Procurement Considerations

Most of the TTY supporting equipment was procured, whenever possible, from commercial sources on an off-the-shelf basis. For cost effectiveness, commercially available EIA cables were procured and used whenever possible. All other cables, test interface panels, and hardware mounting assemblies were designed and fabricated at JPL. Commercially available EIA patch, monitor, and test jack modules were procured for the JPL-Pasadena and Goldstone locations.

B. Installation and Cut-Over of the New TTY Subsystem

The new TTY Subsystem was installed and tested locally at all locations as a separate entity. Noninterference was maintained at all times with the operational capability of the existing TTY Subsystem. The overseas stations were the first to be cut-in to service followed, in August of 1980, by the JPL-Pasadena and Goldstone locations. Close liaison and coordination had to be maintained at all times between JPL and NASCOM to ensure an orderly transition from the old to the new TTY Subsystem.

IV. Functional Description of the Eight-Level TTY Assemblies

Refer to Figs. 1 through 4, which depict the general configurations and interface relationships of the four TTY assemblies.

A. Central TTY Assembly (CTT)

In the CTT there are one KDP and two ROPs. These are considered part of the WCSC. The KDP is used in the full-duplex mode on a TTY orderwire channel between JPL and GSFC. The ROPs are used to monitor, for test purposes, any of the TTY channels that are routed through the CCT. All 50 channels are routed through the jack modules that access each circuit for patching, monitoring, and testing purposes. Each circuit is individually cabled to a TTY TDM where they are converted to a 7.2 kbps aggregate HSD circuit. The HSD circuit is also accessed to a jackfield for patching, monitoring, and testing purposes. The HSD circuit is then cabled, along with six other 7.2 kbps HSD circuits, to a wideband TDM where they are multiplexed and converted into one 56 kbps wideband circuit. A data service unit converts the wideband signals to baseband bipolar line signals for transmission, via satellite, to GSFC.

All TTY channels to JPL on-Lab and off-Lab locations are either directly cabled or transmitted to their locations via JPL-owned asynchronous modems. The modems convert the TTY RS-232 signals to frequency shift keying (FSK) signals for transmission, over leased or private lines, to their respective locations where they are converted back to RS-232 TTY signals for input to TTY machines.

B. Area TTY Assembly (ATT)

In the ATT there are two TTY channels. One is full-duplex and the other is a receive-only channel. Both are interfaced with the CTT via modems, and the FSK audio signals are transmitted between the CTT and the ATT via Western Union microwave channels. The two channels are accessed to RS-232 jack modules for patching, testing, and monitoring. The receive-only channel is connected, via a digital bridge assembly, to six locations. One location is an ROP at the ATT. The five other locations are remote (see Fig. 2). The RS-232 signals from the digital bridge assembly are converted to FSK by modems and transmitted to those remote locations via intersite facilities. The FSK signals at the remote locations are converted back to RS-232 by modems and interfaced to an ROP at each location. The full-duplex channel is accessed to a prime and backup set of ROPs and Magnetic Tape Terminals via a fallback switch and two EIA RS-232 switches. The fallback switch selects which set is accessed to the line. The RS-232 switches provide for local or on-line modes of operation for each set of KDPs and Magnetic Tape Terminals. Two ROPs are also accessed to the jack modules allowing them to be patched to copy receive traffic.

C. Station TTY Assembly (STT)

TTY signals are exchanged between GSFC and the overseas NASCOM Switching Centers at Canberra, Australia, and Madrid, Spain, by multiplexing them and converting them into 56 kbps wideband signals that are transmitted via satellite. The switching centers convert the multiplexed TTY signals back to RS-232 signals for monitoring and testing. The switching centers interface with the individual stations via NASCOM provided Voice Frequency Telegraph Systems (VFTGs). The VFTGs use frequency division multiplexing techniques to transmit up to four RS-232 channels over one voice frequency line. At the stations the multiplexed signals are again converted to RS-232 channels and connected to jackfields for patching, monitoring, and testing.

Each station has prime and backup sets of KDPs magnetic tape terminals, ROPs, and EIA switches which are utilized as described under "Area TTY Assembly (ATT)."

D. External TTY Distribution Assembly (ETD)

TTY channels are distributed from the CCT to the various JPL on-Lab locations either directly by cable or by JPL-owned modems. Each modem converts the voice frequency line signal between the CTT and ETD back to an RS-232 TTY signal for input to a ROP at each location. The ROP provides hard copy of the TTY message. The TTY channel that serves the GCF-20 message center is full-duplex. The channel is connected to a jackfield and routed through a fallback switch to either a prime or a backup set of KDPs, Magnetic Tape Terminals, ROPs, and EIA switches. The functions of these equipments were described under "Area TTY Assembly (ATT)."

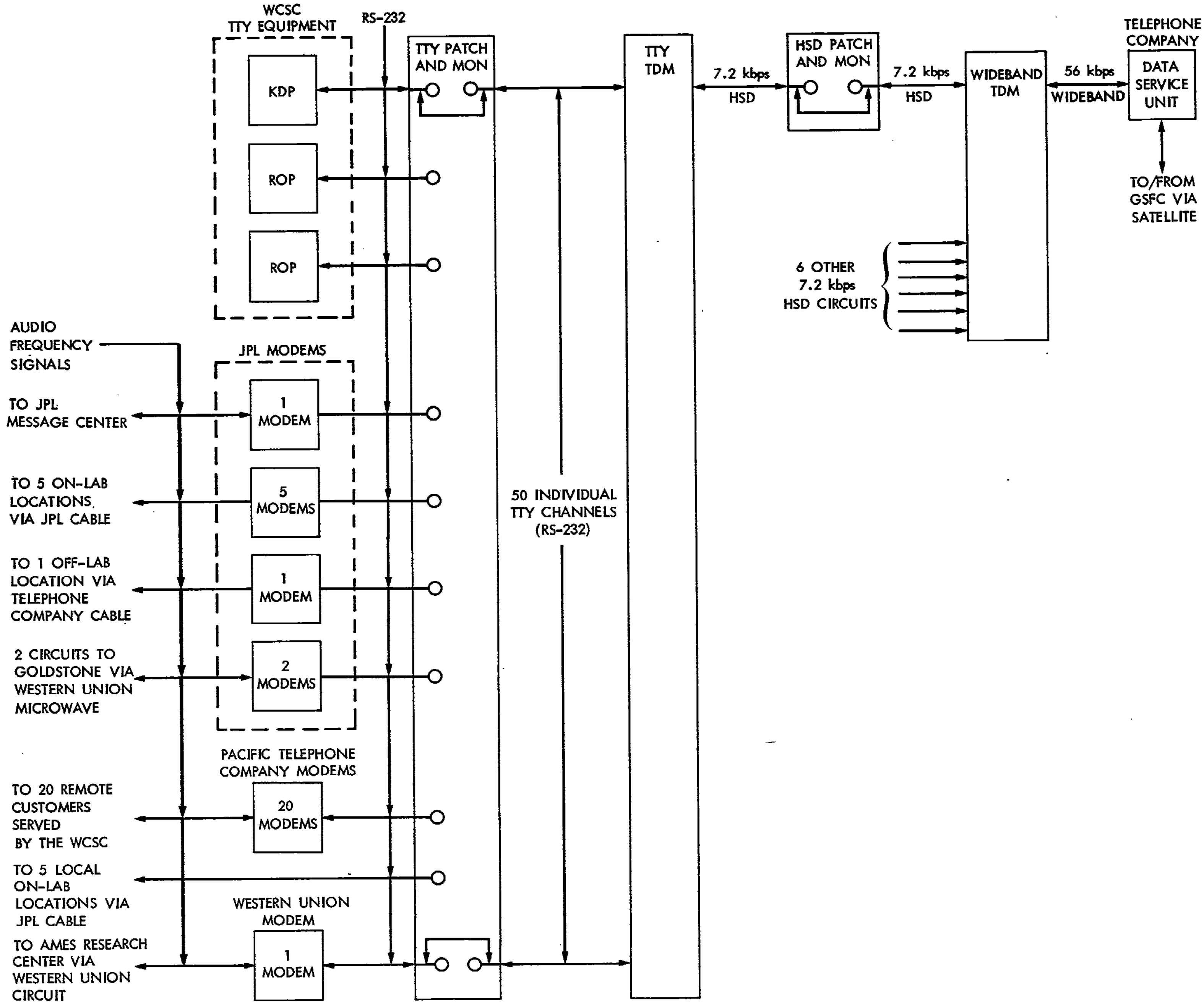

Fig. 1. Central TTY assembly (CTT), eight-level TTY configuration

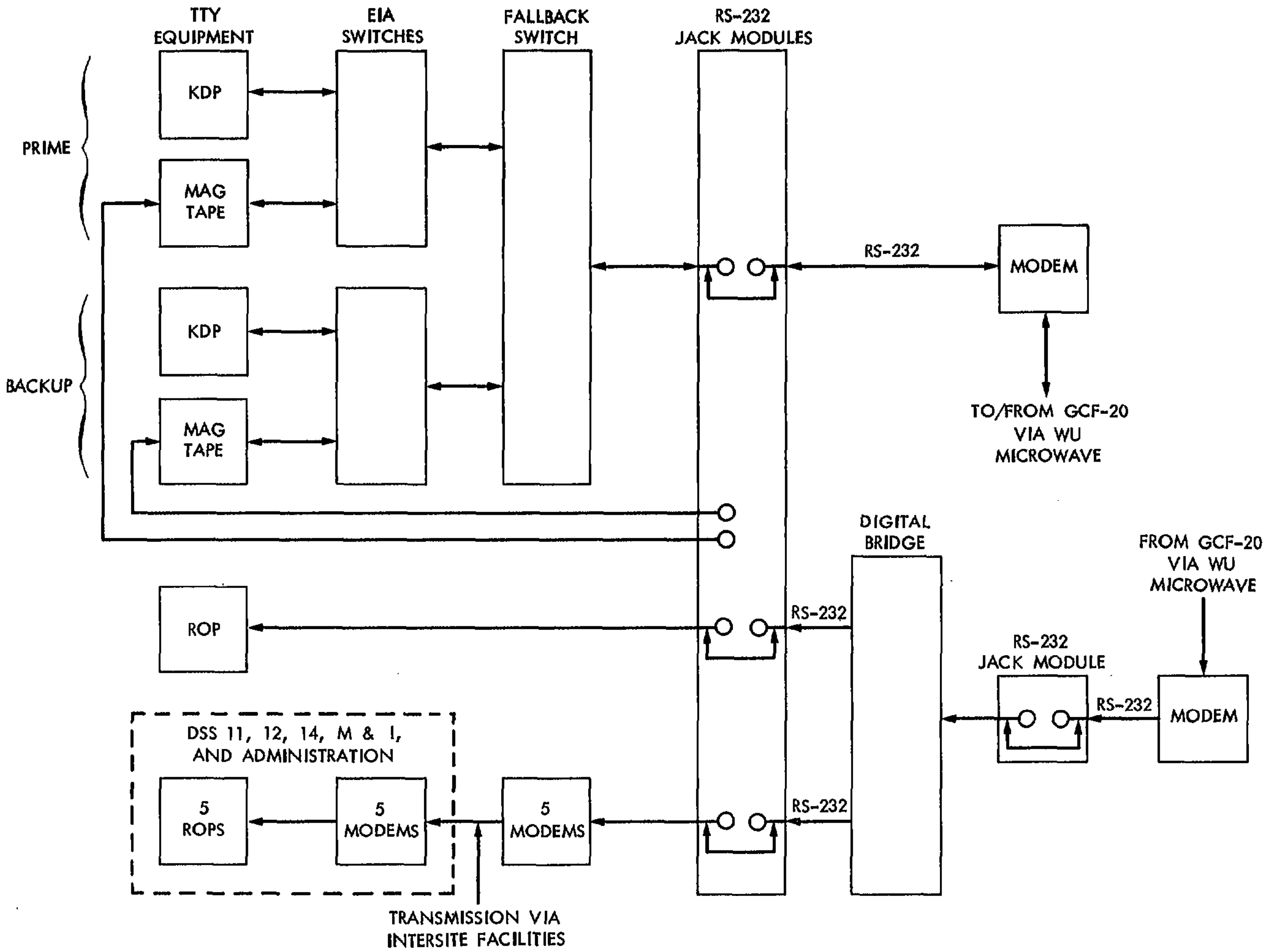

Fig. 2. Area TTY assembly (ATT), eight-level TTY configuration

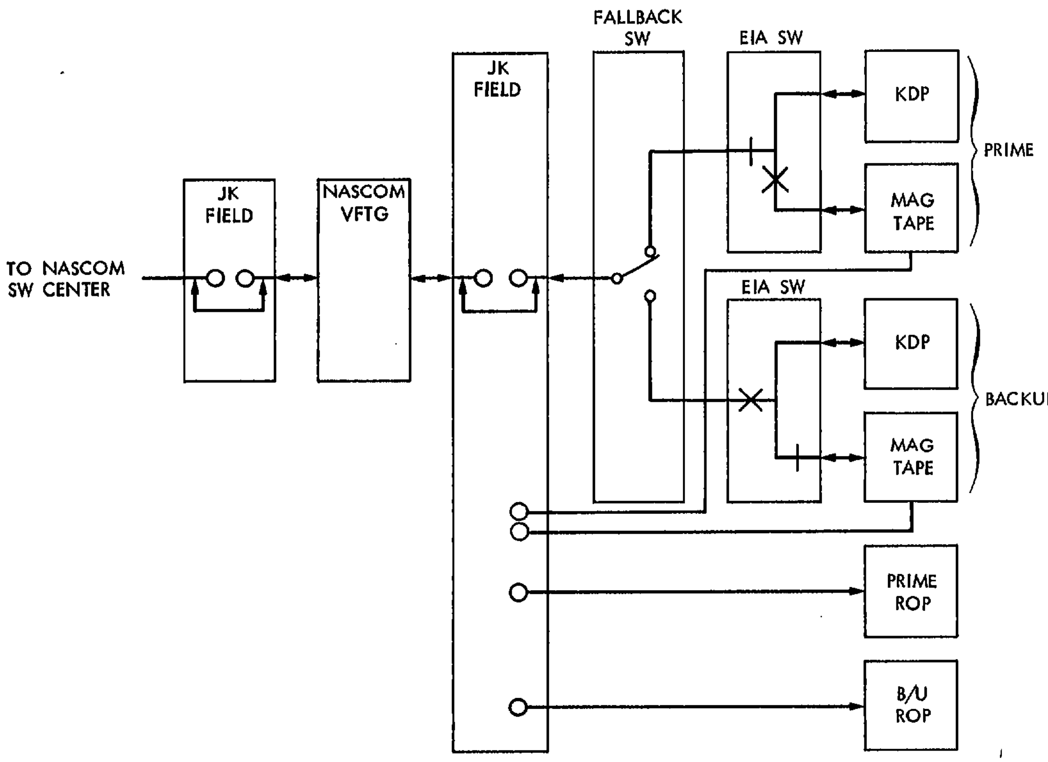

Fig. 3. Overseas stations, eight-level TTY configuration

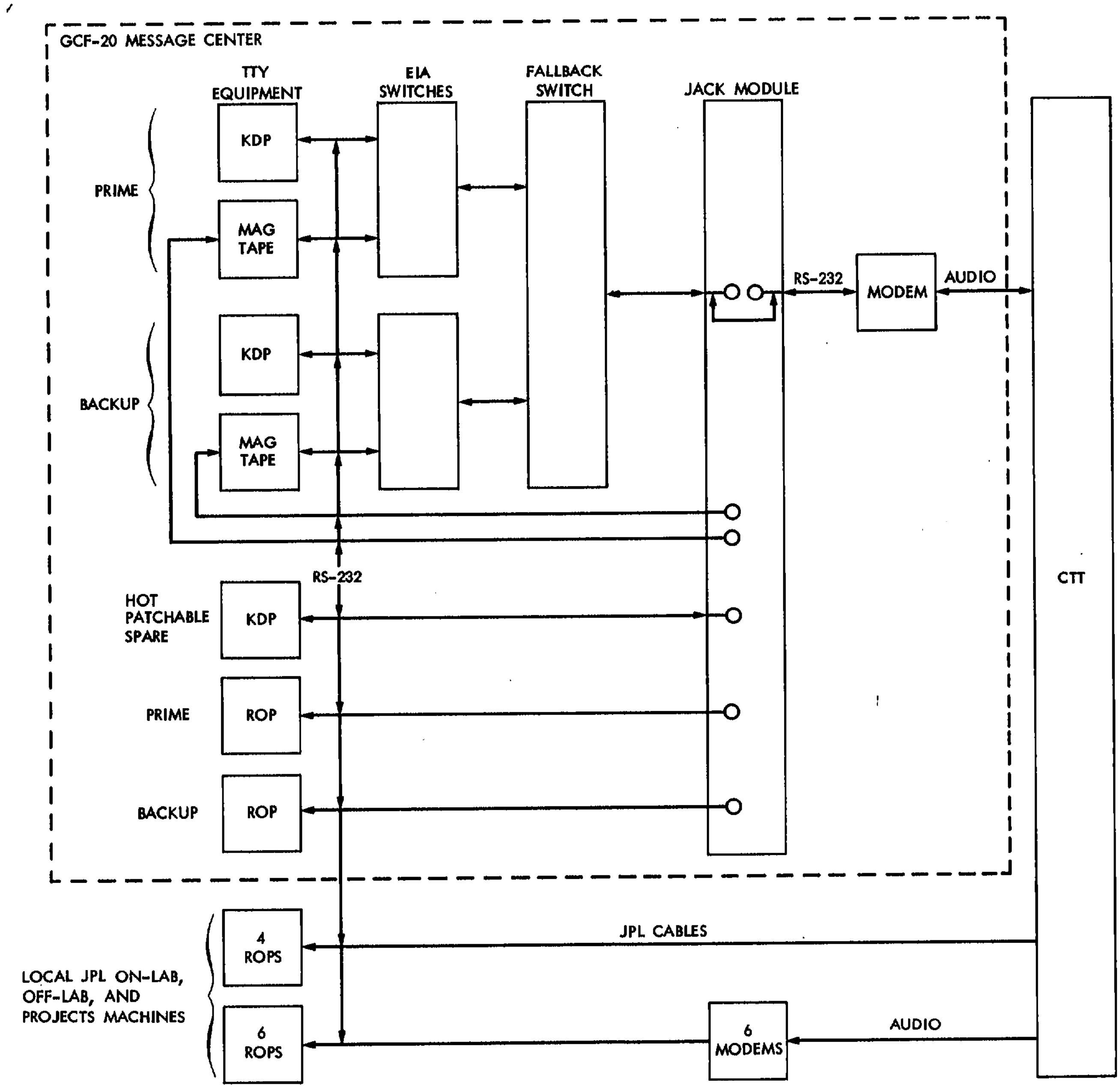

Fig. 4. External TTY distribution assembly (ETD), eight-level TTY configuration