DSIF Tracking and Monitor & Control Subsystem: Prototype Implementation

P. L. Lindley
DSIF Digital Systems Development Section

A developmental model DSIF Tracking and Monitor & Control Subsystem has been installed and used in the support of the Mariner Mars 1971 mission. The hardware and software necessary to support doppler measurements, including the ability to record the data locally as well as send it to the SFOF both in real-time and recall (replay) modes, is operating. Checkout of other functions is in process.

I. Introduction

The purpose of the DSIF Tracking and Monitor & Control Subsystem (DTS) is to provide effective and reliable tracking and data acquisition support for the complex planetary and interplanetary space flight missions planned for the 1970 decade. To satisfy this purpose, the DTS, which is presently in the developmental stage, must incorporate, enhance, or augment certain present capabilities of the DSIF stations.

Early descriptions of the then planned characteristics and capabilities of the DTS were given in Refs. 1 and 2. A more recent and comprehensive treatment may be found in Ref. 3.

The first implementation of the DTS is the Engineering Model, presently installed and being further developed at DSS 14, Goldstone. This should lead to fabrication and installation of three identical operational models for the present subnet of three 64-m antenna stations: DSS 43, Canberra; DSS 63, Madrid; and DSS 14, Goldstone.

II. Computer Selection

The Automatic Data Processing Equipment (ADPE) Acquisition Plan that was submitted to, and subsequently approved by, NASA Headquarters called for a two-year lease of a medium-scale, dual-processor digital computer meeting a set of agreed-upon technical requirements for the development of the DTS Engineering Model. Of the vendors solicited, four responded with proposals, which were then carefully evaluated both technically and financially with the understanding, however, that the resultant selection could have no direct influence or bearing on any subsequent purchase of one or more computers for operational models of the DTS.

The lease contract was awarded to Honeywell Inc., now Honeywell Information Systems Inc., for a Dual H-832

Computer System, including two magnetic disk units, two 9-track magnetic tape units, a card reader, a line printer, and a number of standard and special internal features and devices. Maintenance and a certain amount of software support were included in the lease contract for this computer system, which was installed and accepted as the DTS computer at JPL.

The H-832 DTS computer is a 32-bit-word machine with two central and two input/output processors and an internal high-speed core memory of 32,000 words. Its multi-processing and multi-programming capabilities suit it well for the real-time tracking and telecommunications requirements at high speed and with great reliability which underlie the entire DTS concept. Figure 1 shows the basic structure of the Dual H-832.

III. Development Installation

The DTS Computer was installed in the JPL laboratory of the DSIF Digital System Development Section in the summer of 1970, special airconditioning and a raised floor having been provided. The following months were spent in checkout of the computer hardware and software by Honeywell personnel, familiarization with the equipment and features by JPL engineers, and the development and testing of initial versions of external hardware and internal software for performing the first DTS functions. A temporary high-speed data line (HSDL) was installed between the laboratory and the Space Flight Operations Facility (SFOF) to support development of the telecommunications capability required between the SFOF and the DTS at a DSIF tracking station via the Ground Communications Facility (GCF).

A. Hardware Development

Two standard DSIF racks were provided and juxtaposed to the computer main frame, into which the specialized non-computer DTS hardware is being assembled, a function at a time. At present these racks contain a large input–output panel through which connections between the DTS and all other subsystems are made, two doppler resolver counters, assemblies for doppler counting and control, the interface assemblies for high-speed data input and output, and the pertinent power supplies. A video display and keyboard control have also been installed for later use in monitoring the subsystem.

B. Software Development

Software for the DTS has been, and continues to be, developed in two basic categories. One is the Executive. This controls the total operation within the computer and is an indispensable item in multi-processor and multi-program environments such as the DTS. It includes all input/output (I/O) functions and allocation of CPU time. The other is the growing group of User Programs. Each of these is a separate and independent unit of software, operating under control of the overall system (Executive) and is composed of subprograms and subroutines that fully support a given operational task.

At this time User Programs to support telecommunications (the transmission and reception of data via the HSDL) and dual-channel doppler tracking have been developed to the point of operability. The Executive has been developed to the point where it can fully support these programs and appears capable of providing control of other User Programs being developed.

A "DTS Test" program has also been developed, the main purpose of which is to facilitate initial checkout and identify malfunctions in new hardware assemblies being integrated into the subsystem.

IV. Installation at DSS 14

In order to help support the occultation phase of the *Mariner* mission with its 10/sec doppler readout capability, the DTS was transferred from the development laboratory at JPL to the control room of DSS 14 at Goldstone in July 1971. The move, locating of equipment, and power connections were accomplished in one 24-h period.

Since it was necessary to maintain a station configuration and cabling freeze over the period of the transfer, a Multi-Access Selector (MAS) had been conceived, built, and installed at DSS 14 earlier (see Fig. 2). This consists of a large assembly of relays, ganged in functional groups, and controlled from a special panel located on the Station Monitor and Control console (see Fig. 3). All inter-subsystem cables which, in its presence, would go to the DTS were routed through the relays of the MAS. Upon arrival at the station of the DTS, cable connections were made between it and the open relay contacts, without possible interference with station operation. This way it was made possible to engage the use of the DTS for one or more of its functional capabilities by simply pushing a button, and then return the station to the previous configuration in the same way.

Figures 4 and 5 show the installation of the DSIF Tracking and Monitor & Control Subsystem Engineering Model in the Control Room of DSS 14 as of December

1971. The details of the JPL racks which form a part of it are shown in Fig. 6.

V. *Mariner* Mars Occultation Support

The DTS has the capability of simultaneously tracking two streams of doppler data which would have been called upon had the first *Mariner* Mars 1971 flight been successful. As it is, only one channel has been required for support of *Mariner* for which the DTS has been on line since the spacecraft went into orbit around the planet Mars. Data have been accumulated in real time at the rate of ten doppler samples per second, each pass for approximately ten minutes going into and coming out of occultation. These were deemed to be the most valuable data for each pass; the DTS was not committed to track throughout an entire pass because this would have precluded its use for the concurrent development of the ranging function which is to be committed in the near future.

Data were accumulated on a magnetic disk pack for each period and, simultaneously, listed on the line printer for possible evaluation. Also they were made available for HSDL transmission to the SFOF in real time, and at any subsequent time specified in recall mode. Because of overloading of the computing facility in the SFOF, only limited use was made of these capabilities, beyond establishing their operability. At the end of each day's tracking requirement, the contents of the disk pack were transferred to magnetic tape for storage until a request from the SFOF should be received by the station to transmit the accumulated data for analysis, evaluation and use.

VI. Project Status and Near-Future Plans

Two of the functional capabilities to be provided for the DTS have been implemented previously at DSS 14, based on the use of XDS 900-series computers. One of these is the Antenna Pointing Subsystem (APS), which incorporates an XDS-910; the other is the experimental Tau Ranging Subsystem which uses pseudo-random codes and which is based on an XDS-920. Since the XDS-920 must now be committed full-time to function as one of two Telemetry and Command Processors (TCPs), since a ranging capability is desired as early as possible in the absence of this computer, and since such development work will facilitate the subsequent implementation of sequential-code ranging in the DTS, current development of both hardware and software aims at providing the Tau ranging capability by emulating the XDS-920 with the H-832 computer. To this end the existing JPL hardware of the Tau Ranging System has been retained and is being interfaced with the H-832 via the Discrete and Analog Input/Output Subsystem (DAIOS). By similar techniques it should be possible to emulate the XDS-910 of the APS, thereby also incorporating the angle tracking and antenna control function into the DTS within a few months.

Unfortunately, the lease of the H-832 will expire in May 1972 and, barring presently unexpected availability of funds for this purpose, cannot be extended. Some difficulty is foreseen in furthering DTS development in the interim between the end of this lease and the availability of purchased computers for the operational DTS installations planned for DSSs 43, 63, and 14 in the course of 1972.

ADPE Acquisition Plan AP-129 was written in May 1971, requesting the purchase of three medium-scale dual-processor computers for implementing DTSs in the above three stations of the 64-m antenna subnet. Approval of the plan has been received and it appears reasonable to expect the first operational DTS installation (at DSS 43) to be made by mid-year of 1973.

References

1. Lindley, P. L., "The DSIF Tracking Subsystem," in *The Deep Space Network*, Space Programs Summary 37-57, Vol. II, pp. 156–160. Jet Propulsion Laboratory, Pasadena, Calif., May 31, 1969.
2. Lindley, P. L., "The DSIF Tracking Subsystem," in *The Deep Space Network*, Space Programs Summary 37-58, Vol. II, pp. 126–127. Jet Propulsion Laboratory, Pasadena, Calif., July 31, 1969.
3. *Mark III DSIF 64-m (210 foot) Antenna Subnet Implementation Plan for DSIF Tracking Subsystem and DSIF Monitor & Control Subsystem*, Technical Report 890-13, May 12, 1971 (JPL internal document).

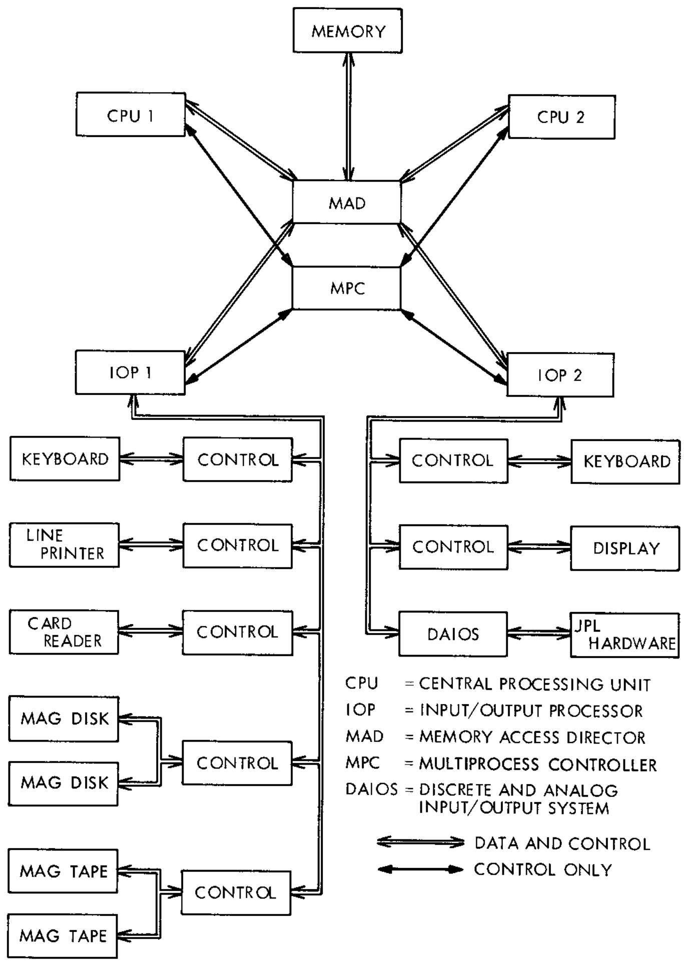

Fig. 1. Basic structure of H-832 computer

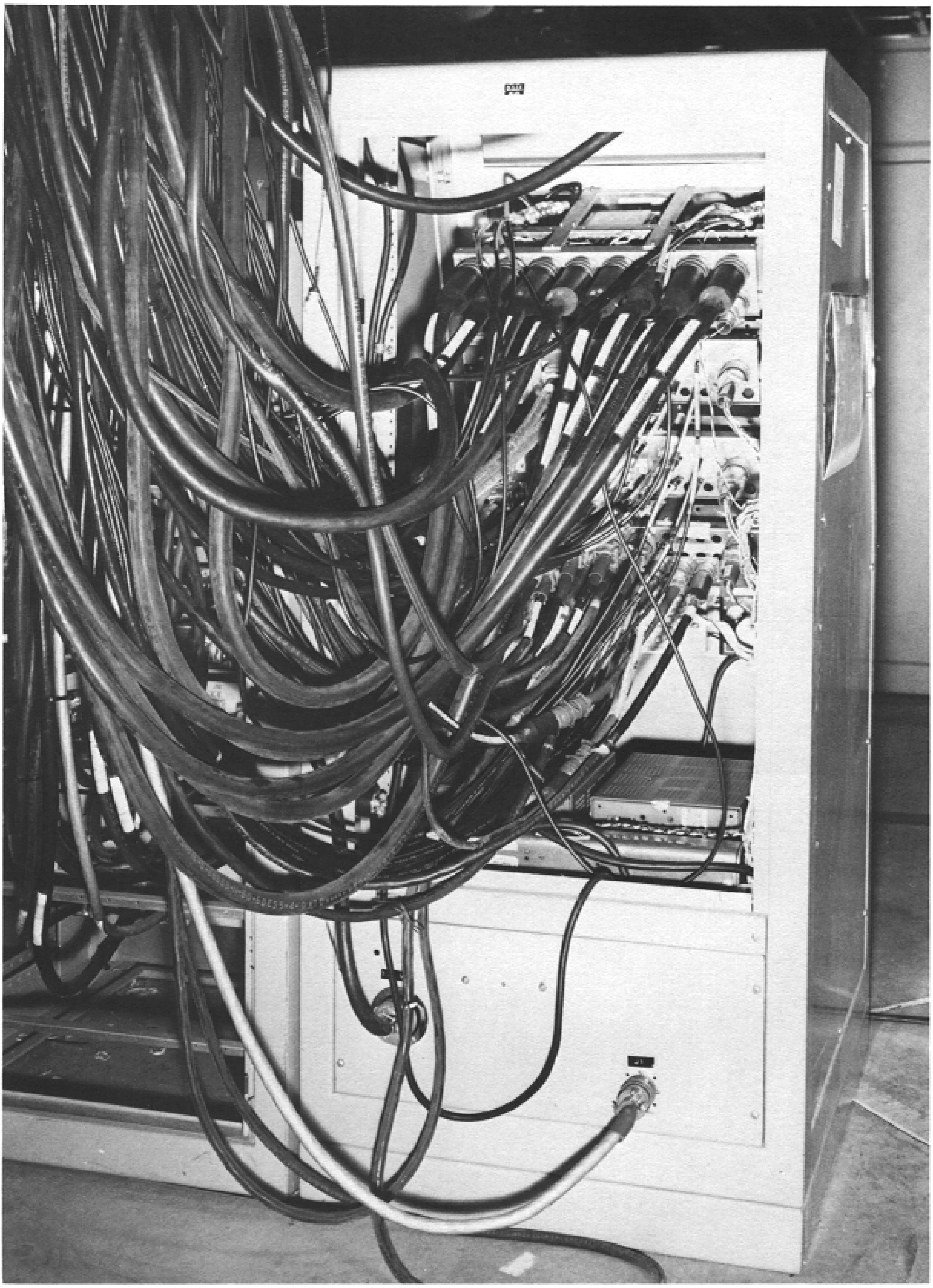

Fig. 2. Experimental multi-access selector (XMAS) at DSS 14

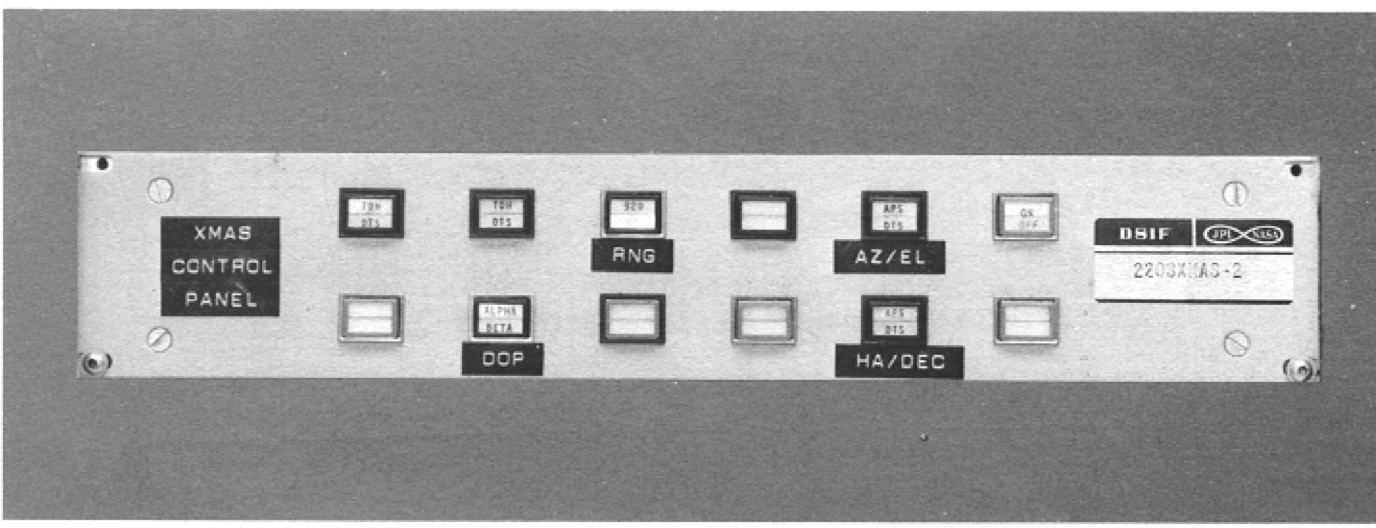

Fig. 3. XMAS control panel

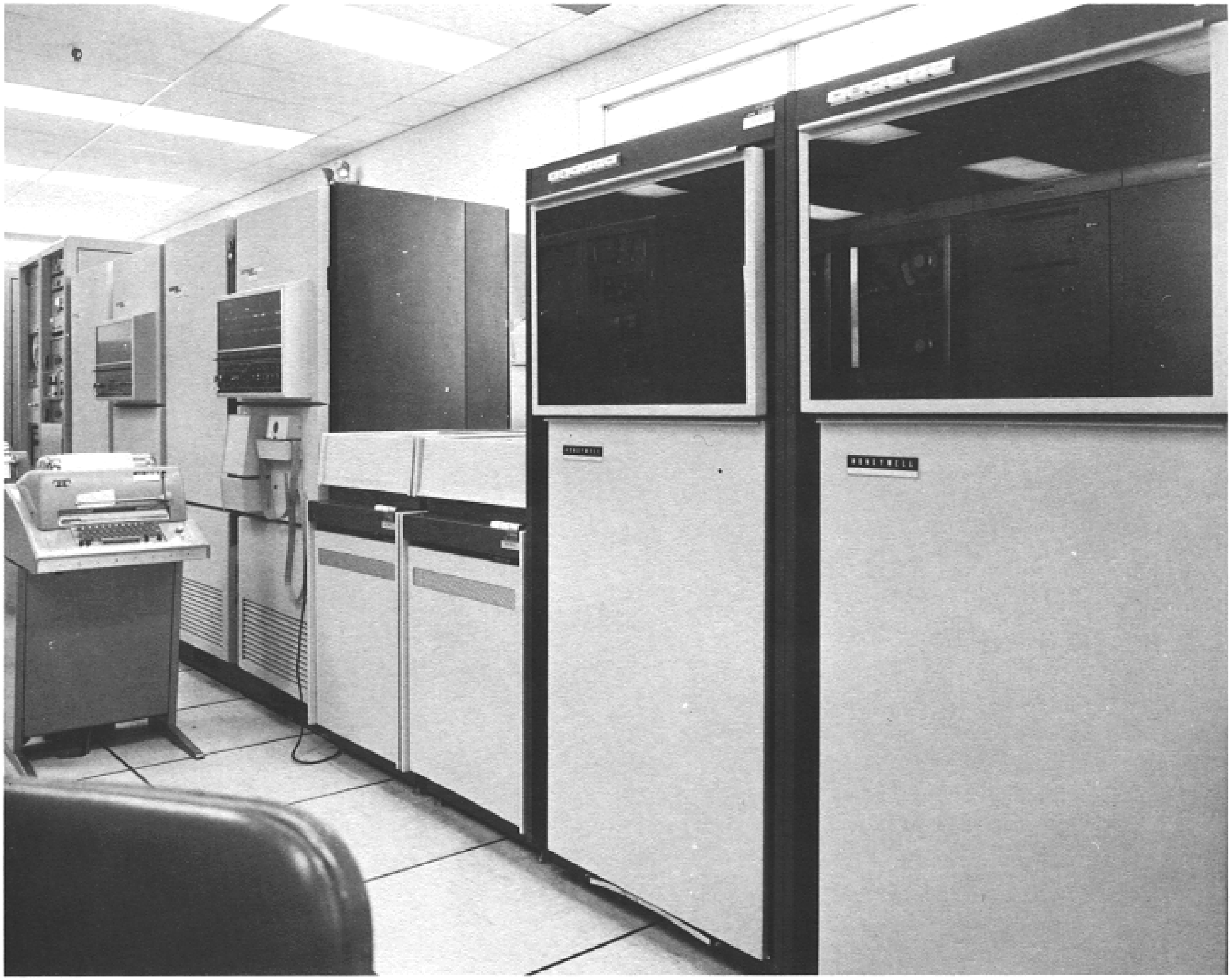

Fig. 4. DTS engineering model viewed from east end

Fig. 5. DTS engineering model viewed from west end

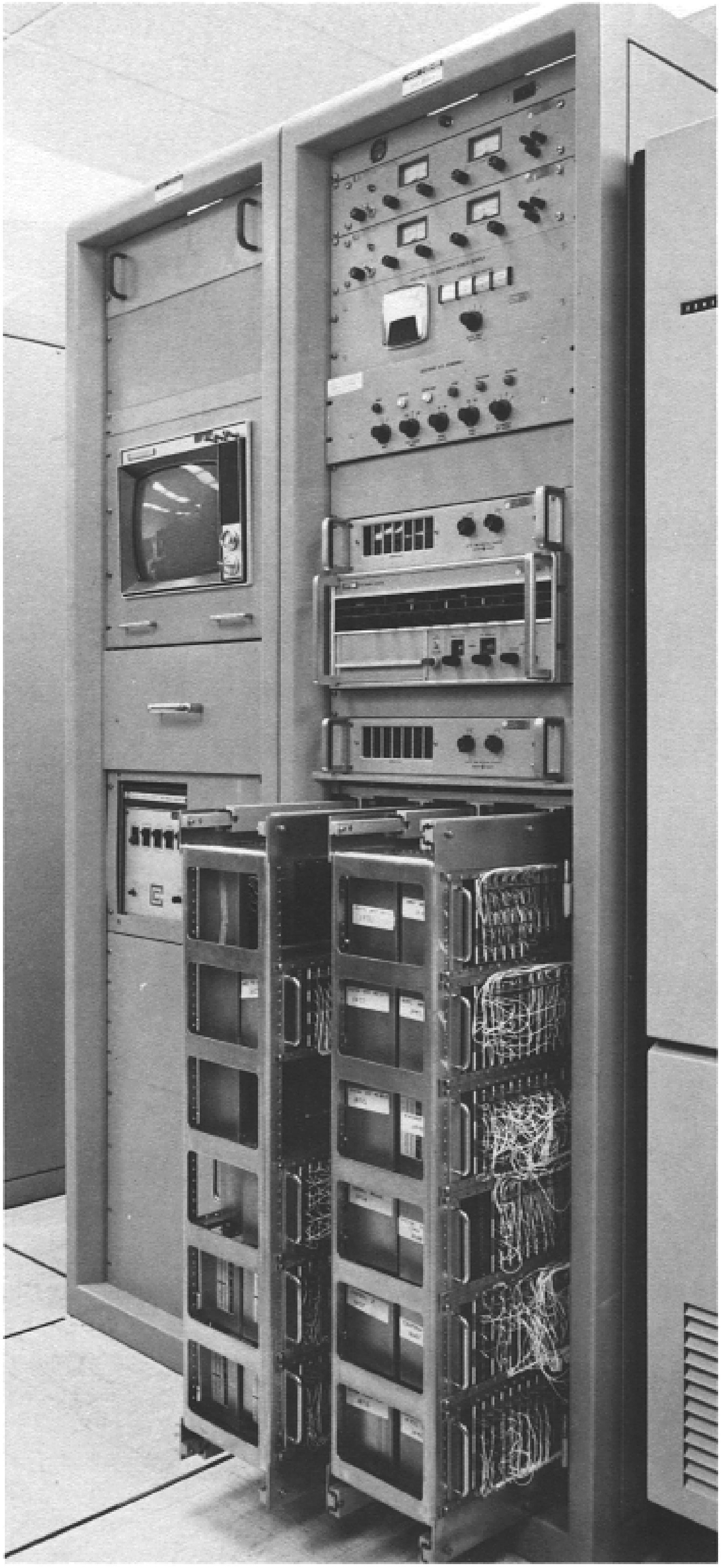

Fig. 6. JPL-built special equipment racks of the DTS