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Digital Data System:

Physical Design

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The mechanical design of equipment required to build the Digital Data System is described. Economic and technical constraints influencing partitioning, electrical interconnection, and styling are related. An overview is given of the hardware used for terminating loops, multiplexing data streams, and testing for system performance.

I. INTRODUCTION

Communications systems developed to serve a young and growing market and to provide service to a broad geographical area have always presented challenges. Not the least of these challenges is the physical partitioning and packaging of the various subsystems that make up a total service. For the DDS, the task has been to provide private-line data service at several customer bit rates for a changing cross section of users, and to introduce such service into many large cities initially, with a capability of expanding to serve small towns all over the country.

Like most systems faced with interconnecting stations scattered so diversely, the basic DDS layout comprises a hierarchical structure beginning with interconnected hub offices located in large metropolitan areas. Fanning out from these hubs are local offices and the individual subscribers to the service. Equipment in the DDS offices performs the general functions of terminating loops to the customer, multiplexing and demultiplexing data streams, and monitoring and testing the integrity of the system. Station apparatus located at the customer's premises provides the interface between the customer's data terminal and the DDS.

Hub offices are partitioned into four functional sections each of which may be located in separate areas of a central office building or all may be grouped together in one dedicated DDS area.

Local offices have, in general, less equipment and, although they function similarly to hub offices, the integrated nature of their design places all of the equipment in one functioning section. Within certain constraints, the equipment frames in both hub and local offices, though functioning in a given section, may be installed in separate building areas. This has advantages in small installations but for administrative reasons, when floor space permits, one completely dedicated area for DDS equipment, sufficient for all future growth in an office, is more desirable.

All offices may serve customer stations directly; however, customer circuits must be routed to the associated hub office before interconnection to their destination in order that the serving test center located therein may provide maintenance access for rapid evaluation and restoral in the event of trouble on a customer's circuit.

The geographical and functional diversity of DDS equipment posed a challenge in developing packaging schemes that would permit economical arrangement in all locations, keep the amount of new hardware low, and be compatible with the system maintenance plan. This paper discusses the physical implementation of DDS with emphasis on the problems encountered and their solution.

II. TECHNOLOGIES USED

2.1 Components

Circuits for the DDS use conventional discrete components—transistors, diodes, capacitors, etc.—and silicon integrated circuits. The latter, providing either 5 V TTL logic or operational amplifier functions, are used in 16-pin dual-in-line packages (DIPs). Initial production used ceramic packages, with a cutover to plastic DIPs as they became available. One factor that makes possible the high system reliability is the low failure rate of the sealed-junction, beam-lead technology used in Western Electric silicon ICs.

2.2 Printed-wiring boards

The first level of interconnection in the system is provided by double-sided, glass-epoxy, printed-wiring boards. For central office applications, the basic board size is 7.5 by 10 inches which provides for up to 50 connections to other circuitry in the system through gold-plated fingers on the board edge. A maximum of 35 DIPs are mounted on a board, using 0.025 inch as the minimum width for printed conductors and the space between them. More components could be placed on the board if these minima were reduced, but in most cases, it was not economical to do so. For station apparatus, the printed-wiring boards take on special shapes and are described in a later section. In general, however, the boards equipped with integrated circuits were designed with a matrix of wide, printed power and ground paths with filtering capacitors to reduce interference.

2.3 Circuit pack partitioning

In general, there are four conditions that affect the partitioning of DDS circuits into circuit packs:

(*i*) The amount of circuitry on *one* printed-wiring board is compatible with the capability of one 50-pin connector. This results in a circuit pack with one printed-wiring board mating into one connector with a single faceplate.

(*ii*) The amount of circuitry on *two* functionally related printed-wiring boards is compatible with the capability of one 50-pin connector. This results in a circuit pack comprising one "mother board" with a "daughter board" permanently mounted and electrically strapped to it. Only one set of 50-pin connector fingers is provided, those associated with the "mother board," and accordingly, only one faceplate is provided.

(*iii*) The amount of circuitry on *one* printed-wiring board requires more connector capacity than the 50 pins provided. This results in a circuit pack comprising one "mother board" for the components and one or two small, permanently mounted "daughter boards" each providing connector fingers for an additional 50-pin connector. As before, only one faceplate is provided.

(*iv*) The circuitry on *two* printed-wiring boards, though each is independently compatible with the 50-pin connector system, is functionally dependent, thus making it desirable that they be mounted as a unit. This results in a circuit pack with a "mother board" and a "daughter board" each having the 50-pin connector fingers, but both permanently mounted together with only one faceplate.

2.4 Faceplates

When the circuit packs are assembled into a shelf (Fig. 1), the faceplates are the most visible part of the DDS equipment. Thus, appearance and human-factors considerations play an important part in the faceplate design. Switches, test points, indicator lights, and jacks are mounted on the faceplate. Since these are used by maintenance personnel they must be logically grouped and identified. The faceplates are molded of gray polyvinyl chloride, chosen for its appearance, strength, fire retardance, and insulating qualities. Five standard widths

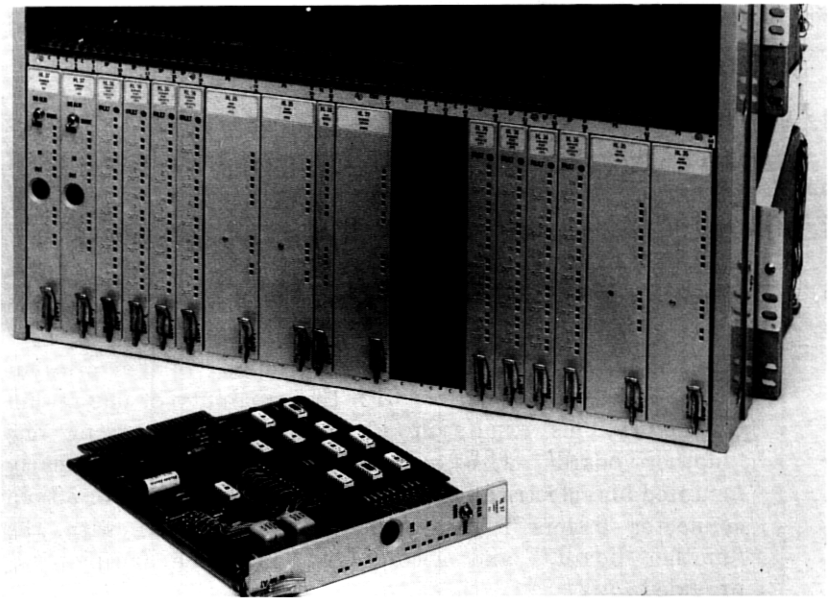

Fig. 1—Typical DDS circuit pack and equipment shelf.

are employed that span the range of component heights used in the system.

2.5 Backplane wiring

The second level of interconnection is between circuit packs, which plug into molded edgeboard connectors. The connector contacts provide early make and late break capability to enable connection to the ground system at those times when power is being connected or disconnected as a circuit pack is being inserted or removed. For each finger contact on the board, the connector provides a terminal post that can be wire wrapped.

On the backplane, the field of these posts at the rear of a hardware shelf, wires are run between connectors to interconnect the boards (Fig. 2). In addition to being a very laborious operation, which contributes significantly to equipment cost, the backplane wiring is a potential source of undesirable interference between conductors. Detailed procedures have been specified for routing wire during manufacture to help ensure that such noise problems do not arise and that a given set of connections are always made in the same manner.

An additional complication on the backplane arises from the distribution of battery and ground. To keep voltage drops low and avoid overloading conductors during accidental short circuits, the use of

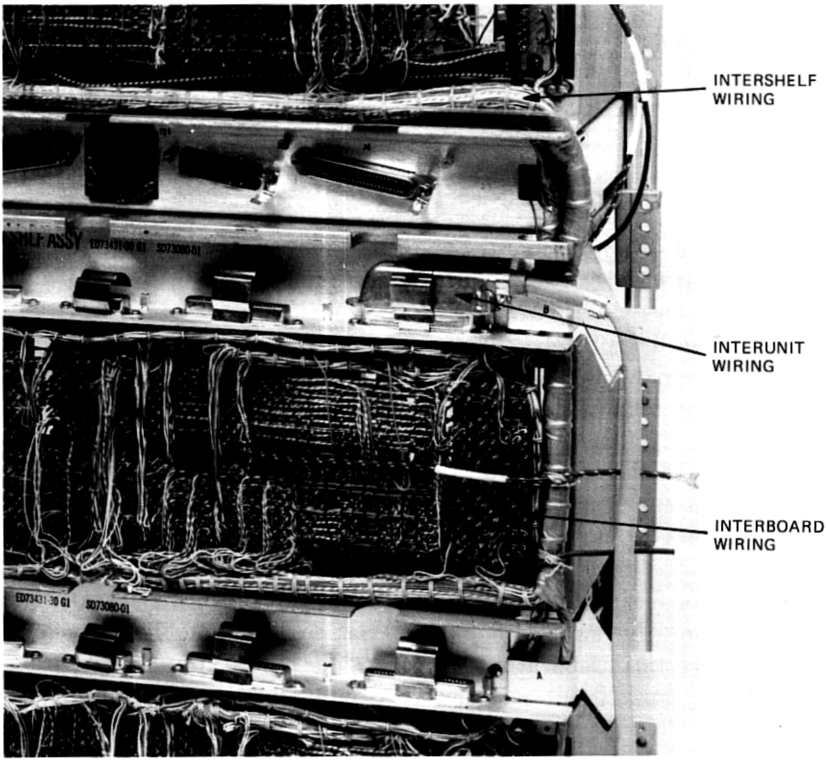

Fig. 2—Backplane wiring on DDS equipment.

large gauge wires was necessary initially in the designs. Since these had to be hand soldered rather than wrapped, adding to the bulk and expense of the backplane wiring, special dual feeds and returns of lighter wire were instituted where possible.

2.6 Intershelf wiring

The third level of interconnection involves wiring between shelves. When the shelves are combined to form a functional, orderable assembly, the wiring is done primarily by factory installed local cables that are terminated directly on the pins of the backplane or on connectors for external interconnections (Fig. 2).

When the wiring involves the interconnection of assemblies to form a subsystem of DDS equipment in one 11-foot 6-inch bay or one or two 7-foot bays, cables with connectors on both ends are used. The connectors mate with those mounted on panels at the rear of the various assemblies. The emphasis here is on simplifying the job for the installer. Rather than to carefully route wires from one location to another, the installer simply secures a connectorized cable of adequate length and plugs it in at both ends.

The following sections describe the application of these technologies to the design challenges presented by several DDS units.

2.7 Equipment shelves

Most of the circuitry in the DDS is provided on plug-in circuit packs, housed in die-cast aluminum shelves like those shown in Fig. 1. Each shelf has 68 printed-wiring-board guides on the upper and lower surface of the shelf base and is arranged for mounting in a 23-inch-wide bay with an overall depth of 12 inches. The shelf itself has no top so that when two shelves are mounted, one above the other, the top guides for a given printed-wiring board are provided on the underside of the shelf above. For single-shelf applications, a die-cast aluminum cover provides the top guides. A maximum of 36 board connectors may be arranged on the rear of the shelf, but the number of guides for the boards allows for extensive flexibility in the choice of circuit-pack widths.

Because of desired circuit-pack partitions and in order to take full advantage of the two-piece characteristic of the shelves, which at minimum vertical separation house circuit packs approximately 5.5 inches high, DDS circuit packs were chosen to be approximately 7.5 inches high. The remaining 2 inches above the printed-board connectors in the rear are then occupied by special brackets for mounting cable connectors and/or terminal strips.

2.8 Power units

Throughout the system, circuits requiring various voltages (+24, +12, +5, −12 or −24 V dc) are used. Central office equipments operate from a primary battery source of either −24 or −48 V. Ferroresonant power converters have been selected and equipment partitions chosen to minimize the number of different power units required.

A major constraint in the DDS is that the failure of a single power unit must result in an alarm with no loss of service on any customer channel. Accordingly, when circuits are totally protected by 1-for-N protection-switching schemes, and power needs are great enough to justify it, power units are utilized on a one-per-circuit basis. In addition, circuitry that is simply redundant is arranged so that each independent half obtains its power from a separate power unit. Circuits with low power requirements, which allow several to operate from one power unit, are arranged so that two such power units, each serving many circuits, are protected by a third "hot" spare. The spare can, without interruption, take over the load of either of the first two power units if an alarmed failure condition occurs.

To meet these central office demands, four basic power units are provided, each available with either −48-V input or −24-V input capability. The four include one with a 50-W output capacity at +5 and −12 V, one with a 100-W output at +5 V, one with a 100-W output at −12, +5, and +12 V and one with a 100-W output at +24 V.

III. CENTRAL OFFICE EQUIPMENT FRAMES

In general, the assemblies, the equipment frames, and the interconnection methods used have resulted in a physical design that provides for easy ordering, short installation intervals, and flexible system configurations. This flexibility includes provisions for using much of the same hardware in both hub office applications and local office applications even though the system requirements and design constraints are quite different for each. Growth capability has been a prime consideration and system rearrangement during growth phases has been facilitated by coordinated connectorization and cabling methods.

The assemblies have been designed and coded so that they may be ordered and installed without regard for the standard system arrangements; however, specific assembly arrangements have been coded which provide bays, engineered as subsystems, that can be ordered partially or completely equipped, installed easily, and interconnected to form the various operating systems required in the overall DDS network. The bays are available in 11-foot 6-inch or 7-foot sizes using unequal flange cable-duct type frames.

In accordance with the subsystem approach, there are essentially nine subsystem configurations. These nine subsystems are:

(*i*) Office-channel-unit arrangements.
(*ii*) Subrate-data-multiplexer arrangements.
(*iii*) T1 data-multiplexer, large-office arrangements.
(*iv*) T1 data-multiplexer, local-office, initial-bay arrangements.
(*v*) T1WB4 data-voice-multiplexer, hub-office arrangements.
(*vi*) T1WB4 data-voice-multiplexer, local-office arrangements.
(*vii*) Nodal or secondary timing-supply arrangements.
(*viii*) Multipoint-junction-unit arrangements.
(*ix*) Serving-test-center arrangements.

Though most of the subsystems are available in both 11-foot 6-inch and 7-foot bay sizes, there are certain differences in the actual quantities of the various circuits included when the subsystem is supplied in one size or the other. For 11-foot 6-inch bay installations, each of the nine subsystems is provided in a single-bay frame. For 7-foot bay installations, they are each provided in one of three ways: by a single-bay frame, by a two-bay arrangement using a double-bay frame, or by a two-bay arrangement using two single-bay frames. The two-bay arrangements using two single-bay frames provide the option of adding the second bay at a later date as growth requires. A typical bay arrangement is shown in Fig. 3, which indicates the standard configuration for office-channel-unit bays.

All DDS assemblies are arranged for front mounting. The mounting holes in the bay framework and on the equipment are arranged so that the equipment may be mounted in vertical increments of $\frac{1}{2}$ inch.

On the rear of each bay framework, with the exception of the cross-connect bays used in the serving test center arrangements, isolated ground busses are provided by insulated vertical rods so that each equipment assembly can be connected to any of three ground systems. The three ground systems are signal ground, battery return ground, and frame ground.

3.1 Office-channel-unit arrangements

The office-channel-unit (OCU) subsystem comprises one bay clock, power, and alarms (BCPA) shelf for distributing power and timing and for accumulating bay alarm signals; three three-shelf OCU and power supply assemblies, three associated two-shelf OCU assemblies; and, when required for specific local-office applications, up to six subrate-data-multiplexer jack-and-connector panels (SM-JCP's). Each of the OCU assemblies can accommodate 20 OCUs and, accordingly, the subsystem has a maximum capacity of 120 customer channels. This subsystem is provided in a 7-foot two-bay arrangement. By deleting one three-shelf OCU and power supply assembly, one two-shelf OCU assembly, and, accordingly, two SM-JCPs, the subsystem is provided in one single 11-foot 6-inch bay with a maximum capacity of 80 customer channels (Fig. 3).

When employed in hub offices, this subsystem is never provided with SM-JCPs since jack access is obtained at the testboard in the same building. When employed in local offices, the SM-JCPs are provided only for OCU assemblies operating at subrate speeds, in conjunction with subrate data multiplexers (located in other bays). An additional attribute of this subsystem is its use, in local offices, of 5- and 10-channel integral subrate multiplexing.

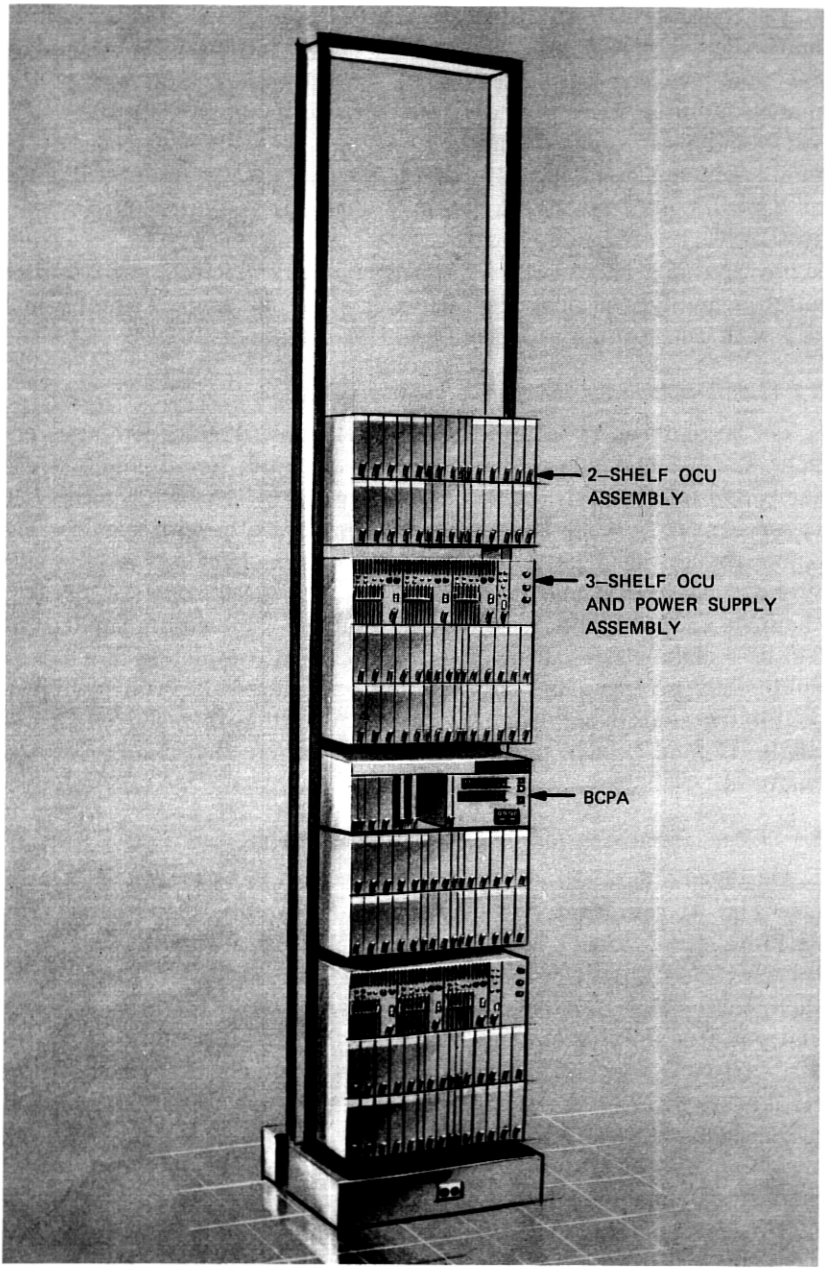

Fig. 3—Standard arrangement for office channel unit bay.

3.2 Subrate-data-multiplexer arrangements

The subrate-data-multiplexer (SRDM) subsystem comprises one BCPA shelf, one 5-V power supply shelf for distributing redundant 5-V power to the entire subsystem, one three-shelf SRDM and performance monitor assembly, and five two-shelf SRDM assemblies. The SRDM and performance monitor assembly, as well as each SRDM assembly, can accommodate 40 (at a 9.6-kb/s data rate) or 80 (at a 4.8- or 2.4-kb/s data rate) 64-kb/s, DS-0 channels. Accordingly, the subsystem has a maximum capacity of 480 DS-0 channels. The subsystem is provided in a 7-foot two-bay arrangement. By deleting one two-shelf SRDM assembly, the subsystem is provided in one single 11-foot 6-inch bay with a maximum capacity of 400 DS-0 channels.

3.3 T1 data-multiplexer, large-office arrangements

The large-office, T1 data-multiplexer (T1DM) subsystem comprises one BCPA shelf; one T1 data-multiplexer performance monitor (T1DM–PM) shelf; and four four-shelf T1DM assemblies, three of which contain four in-service T1DMs while the fourth contains three in-service T1DMs and one T1DM arranged as the spare for the other 15 T1DMs in the subsystem. Each of the in-service T1DMs can accommodate 23 DS-0 channels and, accordingly, the subsystem has a maximum capacity of 345 DS-0 channels. This subsystem is provided completely in a 7-foot, double-bay arrangement. By deleting one four-shelf T1DM assembly, containing four in-service T1DMs, the subsystem is provided in one single 11-foot 6-inch bay with a maximum capacity of 253 DS-0 channels.

3.4 T1 data-multiplexer, local-office, initial-bay arrangements

The local-office, initial-bay subsystem for offices employing T1DMs (see Fig. 4) comprises one four-shelf local timing supply and T1DM assembly (containing a local timing supply with a subset of the BCPA features, one in-service T1DM and one spare T1DM), one T1DM–PM shelf, three single T1DM shelves for in-service use, two three-shelf OCU and power supply assemblies, one two-shelf OCU assembly, four (one for each in-service T1DM) multiplexer jack-and-connector panels (M-JCPs), and three (one for each OCU assembly) subrate-data-multiplexer jack-and-connector panels (SM-JCPs). Each in-service T1DM can accommodate 23 DS-0 channels and each OCU assembly can accommodate 20 customer channels. Accordingly, the subsystem has a maximum capacity of 92 DS-0 channels and 60 customer channels. This subsystem is provided completely in a 7-foot two-bay arrangement. By deleting one three-shelf OCU and power supply assembly

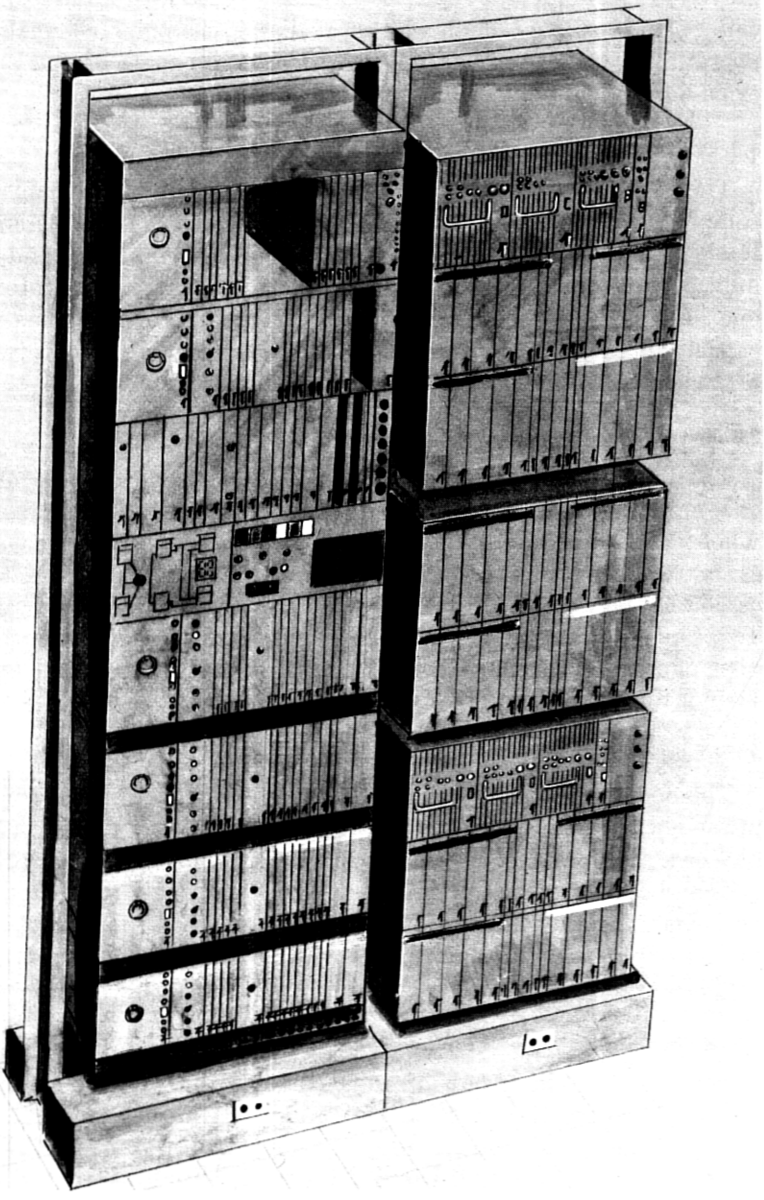

Fig. 4—Seven-foot, TIDM, local-office, initial-bay arrangement.

and its associated SM-JCP the subsystem is provided in one single 11-foot 6-inch bay with a maximum capacity of 92 DS-0 channels and 40 customer channels. As in the case of the OCU subsystem, when employed in local offices, 5- and 10-channel integral subrate multiplexing can be used so that if all of the available customer channels were operating at subrate speeds, only one-fifth to one-tenth of that number of DS-0 channels would be required.

3.5 T1WB4 data-voice-multiplexer hub-office arrangements

The T1WB4 data-voice-multiplexer (T1WB4) hub-office subsystem comprises one BCPA shelf and seven two-shelf T1WB4 assemblies. Each of the seven T1WB4s contains its own monitoring and spare multiplexing circuitry, and accommodates 12 port circuits providing one DS-0 channel each. Accordingly, the subsystem has a maximum capacity of 84 DS-0 channels and is provided in either a 7-foot, two-bay arrangement or in one single 11-foot 6-inch bay.

3.6 T1WB4 data-voice-multiplexer local-office arrangements

The local-office subsystem for offices employing T1WB4s comprises one BCPA shelf; one two-shelf T1WB4 assembly with an associated M-JCP; and either additional T1WB4 assemblies with one M-JCP for every two T1WB4s or a number of three-shelf OCU and power supply assemblies and two-shelf OCU assemblies, each with associated SM-JCPs. The exact quantities of additional T1WB4 assemblies or OCU assemblies depend on whether the subsystem is provided in 7-foot bays or 11-foot 6-inch bays and on exactly which option is chosen.

3.7 Nodal or secondary timing-supply arrangements

The nodal or secondary timing-supply (NTS or STS) subsystem comprises nothing more than one NTS or one STS in either a single 7-foot bay or a single 11-foot 6-inch bay. It is considered as a separate subsystem because, after obtaining reference timing signals from two DS-1 channels entering the office, its functions are completely independent from all the other subsystems in that office except that it supplies timing to them.

3.8 Multipoint-junction-unit arrangements

The 11-foot 6-inch bay arrangement for the multipoint-junction unit (MJU) comprises one BCPA shelf, and four two-shelf MJU assemblies with two associated power supply shelves. In the 7-foot, two-bay arrangement, six two-shelf MJU assemblies and three associated power supply shelves can be provided in addition to the BCPA shelf.

Each two-shelf MJU assembly may be equipped with up to sixteen full duplex (FDX) MJUs. An FDX MJU consists of either one or two identical circuit packs. When one circuit pack is utilized, a three-branch, multipoint circuit is provided. With the addition of the second circuit pack, a five-branch, multipoint circuit is formed.

3.9 Serving-test-center arrangements

The serving-test-center (STC) subsystem comprises a number of testboards for DS-0 channel test access and a number of cross-connect bays with complete flexibility for interconnecting the DS-0 channels from the various subsystems through the testboards.

3.9.1 Testboard

The testboard (Fig. 5) is the heart of the STC. It contains the test equipment needed to troubleshoot and maintain DDS circuits. A strong concern in the physical design of this unit was ease of operation by test center personnel.

There are two major sections to the testboard: a jack field for accessing individual DDS circuits and a control panel with writing shelf.

The jack field is composed of horizontal panels each providing 30 jack modules. Each module has a designation pin color-coded according to the particular customer's data rate. In many cases, by using this feature a craftsperson can troubleshoot the circuit without obtaining a circuit-record card. The jack module containing six miniature jacks represents a significant size reduction over existing central office jacks. Its small size permits up to 450 customers' circuits to appear in one testboard. Each jack module may be replaced individually.

The control panel has a sloping face that accommodates the portable digital test sets as well as other control units associated with generating test codes and establishing voice communications with the testboard. A writing shelf is provided for the test operator's use.

The emphasis in the physical design of the digital test sets was placed on arranging indicators, keys, switches, and designations in a logical and readily usable fashion. Figure 6 shows the test sets and the power and signal cords housed therein. Both sets use identical cases, framework and brackets, power supplies, and cords. The structure consists of two aluminum extrusions mounted on the sides that provide mechanical support for the printed boards, and a formed aluminum shell and cover. The sets may be completely disassembled and yet remain electrically operative for diagnosing trouble in their operation.

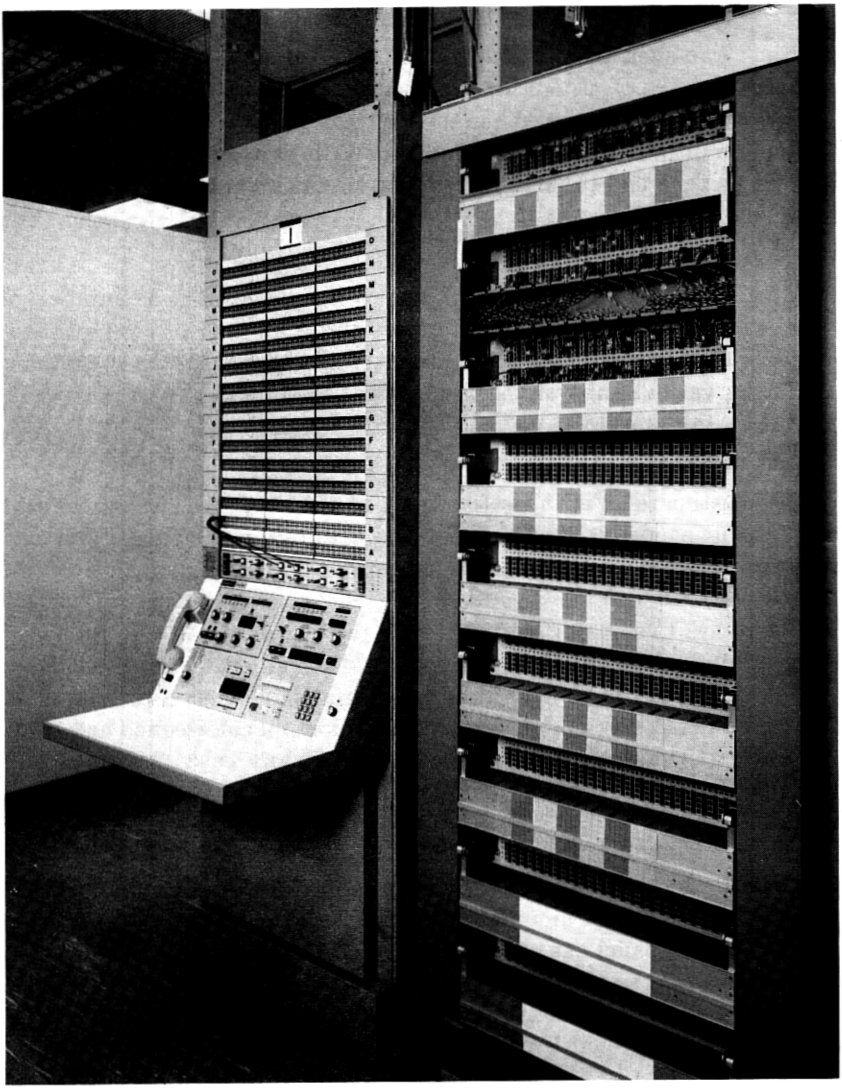

Fig. 5—950A testboard and cross-connect bay.

3.9.2 Cross-connect bay

To provide flexibility in interconnecting DDS equipment, all signals at the DS-0 level (64 kb/s) pass through a cross-connect field. This also provides access to each customer's circuit for the testboard. Constraints on the physical design included tight performance specifications on the plug-in contacts, ease of making and rearranging connec-

Fig. 6—Digital transmitter and receiver test sets.

tions, and provision for growth as the number of customers served by a particular office grows.

A versatile cross-connect system was developed that uses permanently wired, rear terminations from the various DDS equipment and quick-change, pluggable, front-panel connections for arranging the individual circuits. Each cross-connect panel (see Fig. 7) contains 400 quad (four-wire) terminations which accept latching quad jumpers. To eliminate patching errors and to assure optimum reliability, this patching system features polarized plugs with protected contacts for "hit-free" operation. The jumper plug housings have built-in latches that assure firm retention when installed in the panel, yet allow easy removal with a simple tool. The plugs are color-coded for fast, positive identification of jumper length and have snap-in, stamped-and-formed contacts that offer minimum cost and maximum serviceability.

The jumper contacts have a cantilever-beam engagement spring to insure controlled contact pressures with minimum wear on the gold-plated surfaces. An external retention spring provides quick assembly and firm seating in the jumper plugs, allowing on-site assembly of nonstandard length jumpers and the ability to repair defective units.

Each panel is equipped with a plastic wiring duct that functions as a fanning strip and provides a path for routing the quad jumpers. A hinged duct cover, which keeps the jumpers in place and has designation cards on both sides for equipment-termination records, is provided with each panel.

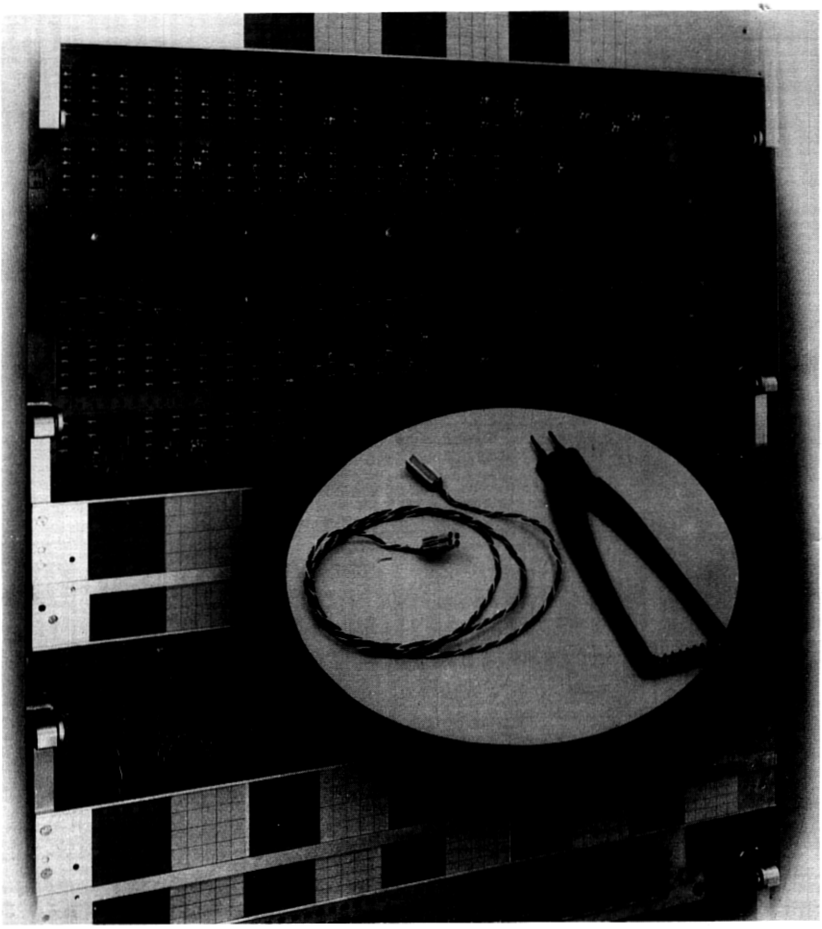

Fig. 7—Cross-connect panel, jumper, and removal tool.

The panels are combined in a cable-duct type bay (see Fig. 5). Filler plates that support wiring ducts increase the size of the bay, resulting in a typical width of approximately 42 inches.

The bay is equipped with one to nine quad-terminal-panel assemblies, according to job requirements, which provide a maximum of 3600 quad terminations. The quad terminals on each panel are arranged in two groups of 4 rows and 50 columns. Based on a random interconnection of equipment and a normal distribution of jumper wires in the horizontal ducts, the DSX-0 cross-connect is limited to six bays to ensure that the wire-handling capacity of the ducts is not exceeded.

3.10 Office arrangements

The several subsystems described above are utilized in various combinations to form the two basic types of DDS office configurations: the hub office and the local office. The local offices each "home" directly or indirectly on a given hub office. Each subsystem contains equipment that is physically independent from that contained in any other subsystem within the limitations imposed by certain cable-length requirements. Locations of the various 11-foot 6-inch bays or the 7-foot two-bay combinations in any given office may vary because of restrictions imposed by the location of related equipment such as the main distribution frame, the DSX-1 cross-connect, or, in hub offices, the DSX-0 cross-connect and its associated testboards.

3.10.1 Hub offices

A hub office is an office in the DDS that combines the T1 data streams from a number of local offices into signals suitable for transmission over DDS facilities, and provides test access by means of an STC subsystem. Hub offices, in general, will have equipment functioning in four different sections.

(*i*) Serving-test-center cross-connect section.
(*ii*) Long-haul-access multiplexing section.
(*iii*) Local-access multiplexing section.
(*iv*) End-access section.

The STC cross-connect section comprises testboards, multipoint-junction-unit subsystems and at least the STC cross-connect portion (DSX-0A) of the DSX-0. The testboards and DSX-0A function together and are in close physical proximity. The multiplexer cross-connect (DSX-0B) functions both with the long-haul-access equipment and with the local-access equipment. Accordingly, the DSX-0B may be split and each portion placed with its associated equipment, or, if a centralized cross-connect area is more desirable and cabling restrictions permit, the DSX-0B may be placed contiguous to the DSX-0A.

The long-haul-access multiplexing section comprises T1DM subsystems, SRDM subsystems, and the nodal or secondary timing supply subsystem. As mentioned above, the required DSX-0B cross-connect bays may be located within this section. The local-access multiplexing section comprises T1DM subsystems, T1WB4 subsystems, and SRDM subsystems. Again, the required DSX-0B cross-connect bays may be located in this section. The end-access section comprises only OCU subsystems.

3.10.2 Local offices

A local office is an office in the DDS that passes to a hub office circuits that enter the building over local loops or over T1 lines from other local offices. Such an office will usually have equipment functioning in only one section. It is expected that local offices will be small initially. Accordingly, the subsystems that make up the initial bay or bays comprise combinations of various equipments to make efficient use of bay space. A local office employing T1DM service may initially have a T1DM local-office, initial-bay subsystem. A local office employing T1WB4 service must have a T1WB4 local-office subsystem.

Additional OCU growth is obtained by the installation of OCU subsystems. When more efficient multiplexing than that available with the 5- or 10-channel integral subrate multiplexing accommodated in OCU assemblies is required, SRDM subsystems are employed. The DSX-0 cross-connect and test-access functions may be performed by multiplexer and subrate-data-multiplexer jack-and-connector panels, rather than by cross-connect bays and testboards as in hub offices.

IV. STATION APPARATUS

Two types of station apparatus are available to interface with the customer for transmission and reception of digital data over DDS facilities. If the customer requires an EIA interface for 2.4-, 4.8-, or

Fig. 8—Data service unit.

Fig. 9—Channel service unit.

9.6-kb/s operation or a CCITT interface for 56-kb/s operation, a DSU (see Fig. 8) is provided. If the customer requires only the bipolar signal as received from the local loop, a CSU (see Fig. 9) is provided.

Since these units are located on the customer's premises, they play a major role in determining how the customer views DDS. They must be easy to install and maintain, perform well, and present a favorable appearance. In terms of physical design, factors such as styling, size, and human engineering are particularly important. Both the DSU and CSU relate closely in these factors to the new family of analog data sets being offered by the Bell System. All are packaged in low-profile aluminum or aluminum-finished housings with black molded covers, and provide status indicators to help the customer monitor system operation.

4.1 Data service unit

The circuitry for the DSU is partitioned into the following functional blocks: customer interface, transmit logic, line driver, line receiver, timing recovery, receive logic, test circuits, and power supply. To minimize the number of circuit pack codes and interconnecting wires, two basic circuit boards were designed. The logic board, 70 square inches in area, contains the transmit and receive logic. It is used in all DSUs regardless of data rate. The analog board, 100 square inches in area, contains, with the exception of the power supply, the balance of the circuitry, including the interface connector, a test switch, and light-emitting-diode indicators (LEDs). Since the analog board is speed dependent, four coded circuit packs are manufactured from the same basic board design. The power supply, utilizing a ferroresonant transformer, is packaged separately in a metal enclosure to eliminate high-voltage exposure on the two circuit boards.

For the overall unit, a low-profile shape was chosen that allows stable stacking of several DSUs. The dimensions of the unit are approximately $11\frac{1}{2}$ inches wide, 4 inches high, and $10\frac{1}{2}$ inches deep. It weighs approximately 10 pounds.

As shown in Fig. 10, the circuit boards are arranged horizontally. Service option switches are located at the edges of the boards for installer access. Special design consideration was required in arranging the boards and power supply and in selecting and placing components to ensure proper operation in a maximum 120°F operating ambient.

Tooling costs and assembly operations were reduced by the design of two aluminum extrusions that provide the circuit-board guides,

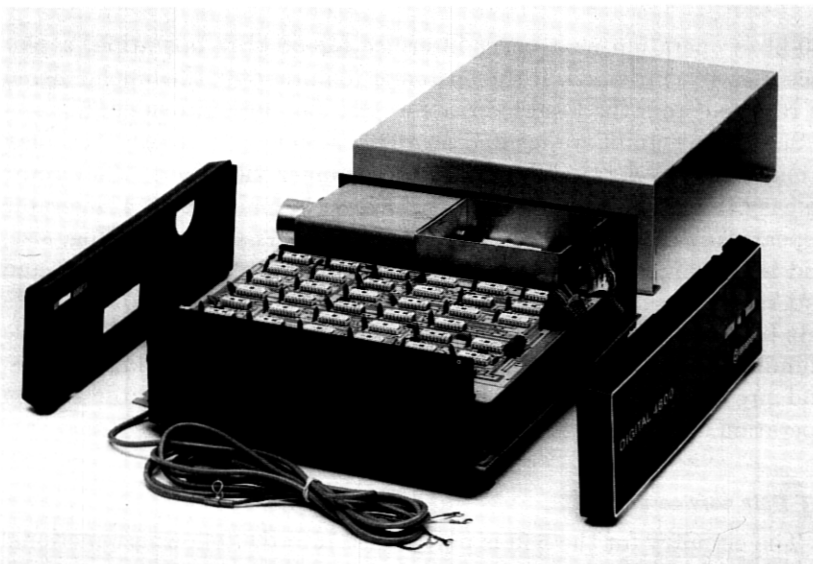

Fig. 10—Internal construction of DSU.

power supply shelf, and mounting rails, as well as the basic chassis assembly. The front and rear covers, injection molded of clear polycarbonate and back-painted black, snap onto the chassis and brushed aluminum housing. Both covers accept the test switch and indicator panel, which is connected by cable to the analog board. This allows the customer controls to be placed on the same or opposite surface as the interface connector and power cord.

DSUs may be stacked and mechanically fastened together in arrangements of up to three sets. When larger numbers are required, a cabinet arrangement for up to ten DSUs is provided. In this case, the units are mounted vertically on edge with the aluminum housing removed for maximum heat dissipation.

4.2 Channel service unit

For the CSU, study of circuit partitioning yielded four basic functional blocks: transmitter, receiver, test circuit, and power circuit. Since no customer control is required, a wall-mounted package which occupies no table or cabinet space is felt to be the most desirable method of packaging for customer convenience, although care must be taken to occupy the least amount of wall space. The basic CSU structure is a nest of two circuit boards, each approximately 35 square inches in area, assembled with components facing each other. One circuit board contains the receiver circuitry and the other the transmit, power, and test circuitry. A fully shielded shunt-type ferroresonant transformer provides the necessary DC voltages on either board. Both boards are speed dependent, so a total of eight circuit pack codes are required.

The housing is a two-piece injection-molded polycarbonate shell. The top is molded of clear material and back-painted black; the base is finished with aluminum paint to give the same material appearance as other new Bell System data station sets. The entire package measures approximately 8 inches wide, 5 inches high, and $2\frac{3}{4}$ inches off the wall.

Multiple arrangements of up to 20 CSUs can be provided in a cabinet.

V. CONCLUSION

The physical design of DDS equipment is a response to the performance and economic challenges of this new system. Central office hardware emphasizes flexibility and provision for growth, while station sets are marked by modern styling and ease of operation. Future designs will build upon these bases as new digital data communications services are offered.

VI. ACKNOWLEDGMENTS

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