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The 5ESS *Switching System:*

Physical Design/Hardware

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The reliability, availability, and versatility of the *5ESS*™ switch are highly dependent on the physical design of the hardware. We present a comprehensive description of the system and equipment designs, with particular emphasis on the advanced interconnection technology used, such as the fine-line, multilayer, printed wiring boards; ceramic substrates for functional modules; and high-performance, device-level packaging. The system design features described include new cabinet and office arrangements, the use of *Fastech*™ equipment, and new power and alarm systems. The office layout is flexible to allow growth in any size installation, and the modular architecture of the *5ESS* switch makes it easy to install. We also present various testing and installation methods and summarize the physical design requirements and objectives for all equipment in the *5ESS* system.

I. INTRODUCTION

The *5ESS* switch physical design emphasizes a wide range of system sizes, high packaging density, modular architecture, and advanced interconnection technology. The system design features minimum office interconnect and a variety of shipping modes, including block unitization, hot slide, and full unitization. Substantial floor-space reductions occur over predecessor analog switching systems. Equipment designs emphasize ease of engineering and growth, simplified human engineering, and distributed power conversion. Standardization of apparatus design is a keystone to a highly manufacturable design. In

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addition, advances in the interconnection technologies of hybrid integrated circuit, fiber optics, and printed wiring board have resulted in a highly reliable, small-size-equipment realization. The high standards of reliable field performance have been assured through the distributed nature of the architecture and the use of redundancy where needed. Sparing costs have been minimized through application of reliability data to sparing calculations. The physical design, when taken with the flexible architecture, maintenance system design, and circuit design, offers a digital switch that is compact, easy to engineer and enlarge, highly maintainable, and reliable.

II. *5ESS* SWITCH INTERCONNECTION TECHNOLOGY

The *5ESS* switch achieves low cost, high reliability, and high manufacturability by using a standardized, state-of-the-art interconnection technology coupled with forced air and convection cooling systems. High packaging density and optimum performance are made possible by fine-line, multiple-layer printed wiring boards, thin- and thick-film ceramic substrates for functional modules, and high-performance, device-level packaging. These technologies are optimally merged in minimum design time through the extensive use of Computer-Aided Design (CAD)* tools. Later sections deal with the four major levels of interconnection within each *5ESS* switch unit design.

2.1 Unit-level interconnection

The *5ESS* switch uses the *Fastech* packaging system,[1] which provides a dense, high-performance, standardized interconnection technology. Each *Fastech* unit consists of one or more apparatus mountings and backplane printed wiring boards to support and interconnect the circuit packs (see Fig. 1). Each apparatus mounting contains about 20 to 22 circuit packs, and typical *5ESS* switch units use one or two apparatus mountings.

The apparatus mounting is designed to support circuit packs and alignment to backplane pin fields. Circuit pack location is highly flexible. Pack spacing in *5ESS* switch units varies from three-quarters of an inch to one and one-half inches. The apparatus mounting is also designed to minimize resistance to vertical airflow, thus increasing the effectiveness of the forced air cooling system.

The backplane printed wiring boards vary from two layers to six layers, and are interconnected by plated-through holes. All backplanes provide printed power and ground interconnection and some backplanes also provide printed signal paths. Pins are placed on a 0.125-inch grid and extend on both sides of the printed wiring board. On the side of

* Acronyms and abbreviations used in the text are defined at the back of the *Journal*.

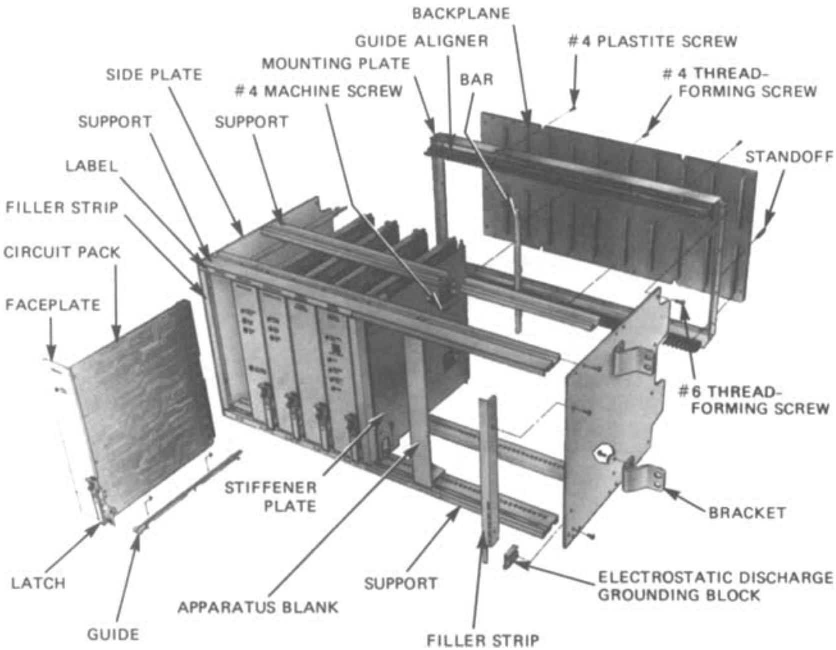


Fig. 1—*Fastech* hardware.

the backplane away from the circuit packs, intraunit connections are made by automatically wrapped discrete wiring. Connectorized cables are also terminated on these pin fields to connect interunits. The cable connectors are guided and retained on the backplane by cable apparatus mountings. On the component side of the backplane, pin length is varied to improve the sequencing of power, ground, and signal connections on pack insertion. Each circuit pack code is individually "keyed" to prevent insertion into the wrong pack location.

2.2 Circuit-pack-level interconnection

The system uses a single-size circuit pack, 7.67 by 13.375 inches, to maximize manufacturability and design uniformity. These circuit packs represent the smallest replaceable module within the system. Both double-sided and multiple-layer printed wiring board structures are used. The typical multiple-layer boards contain two or four signal layers, a single power layer, and a single ground layer. These boards are designed with a standard 0.100-inch grid of plated-through holes for interconnection and component placement. The standardized hole grid simplifies computer-aided design and automated assembly. Multiple-layer printed wiring boards are used for high-density, high-performance applications within the switch (see Fig. 2).

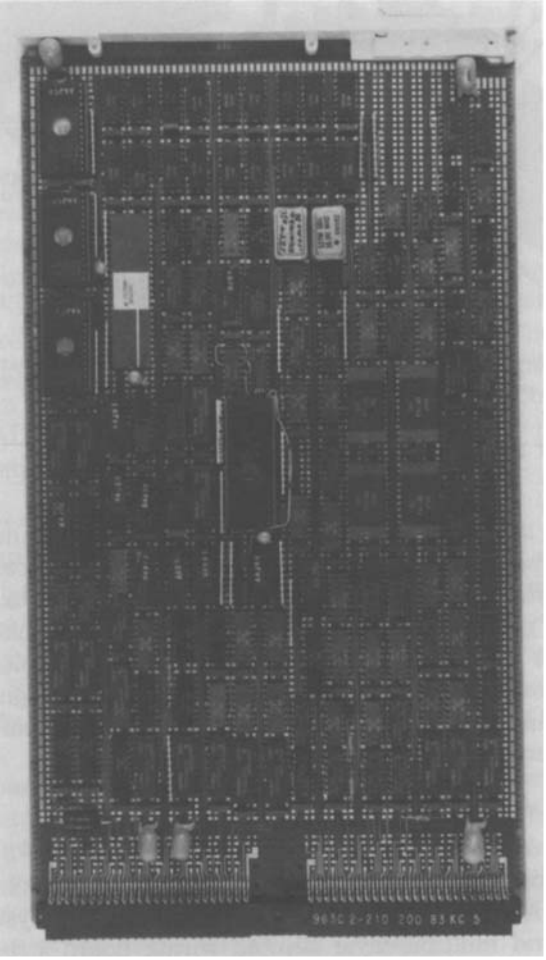


Fig. 2—Multilayer printed wiring board.

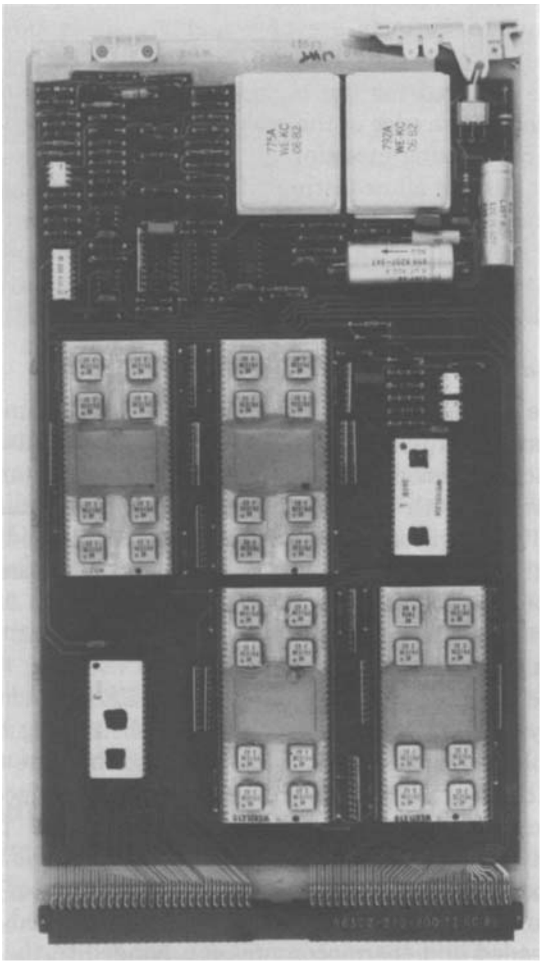


Fig. 3—Double-sided printed wiring board.

The double-sided printed wiring board structure is typically used for high-volume circuit packs associated with line or trunk termination circuitry of the *5ESS* switch (see Fig. 3). This structure allows a more flexible grid for the plated-through hole placement and results in a lower-cost interconnection medium.

The circuit packs use either 200-contact or 300-contact connectors for interconnection to the unit backplane. These connectors provide a matrix of contacts designed to engage the backplane pin-field grid on 0.125-inch centers. Contacts are of a highly reliable bifurcated and selectively gold-plated design to ensure design life. Because of the high insertion force required for the high numbers of interconnections, a latch is provided on the edge of the circuit pack to engage the apparatus mounting, thereby easing insertion.

Circuit pack designs allow testing either through the edge connector or through direct contact with pads on the noncomponent side of the printed wiring board. In certain cases, component locations are printed on the printed wiring board to simplify circuit pack assembly, inspection, and testing.

2.3 Functional-module-level interconnection

To improve density, testability, and cost of certain functions, particularly analog trunk and analog subscriber line terminations, numerous functional modules are used. These modules are based on ceramic substrates with both thin- and thick-film interconnection technologies. The provision of precision resistors, controlled impedance, a high conductivity, and the resulting high density significantly enhance the performance of each of these modular functions. The *5ESS* switch uses over 20 active and 100 passive ceramic modules. An example of this module is shown in Fig. 4.

The ceramic module technology used in the *5ESS* switch is designed to be a highly reliable package capable of withstanding the stresses due to high-voltage transients of an analog subscriber line (600V), and the stresses of the central office environment. Floating surface crossovers and programmable vias enhance routing density and provide the equivalent of two layers of interconnection on each of the sides of the ceramic. An extensive CAD system simplifies the layout of the module and evaluation of performance criteria. Silicon integrated circuits are either beam leaded and thermocompression bonded to the ceramic or placed in leadless chip carriers and reflow soldered to the ceramic. Edge-clip lead frames, reflow soldered to the ceramic, provide connection to both sides of the ceramic.

2.4 Silicon-integrated-circuit-level interconnection

The device-level packaging strategy was established to avoid proliferation of packages, to provide both printed wiring board and ceramic

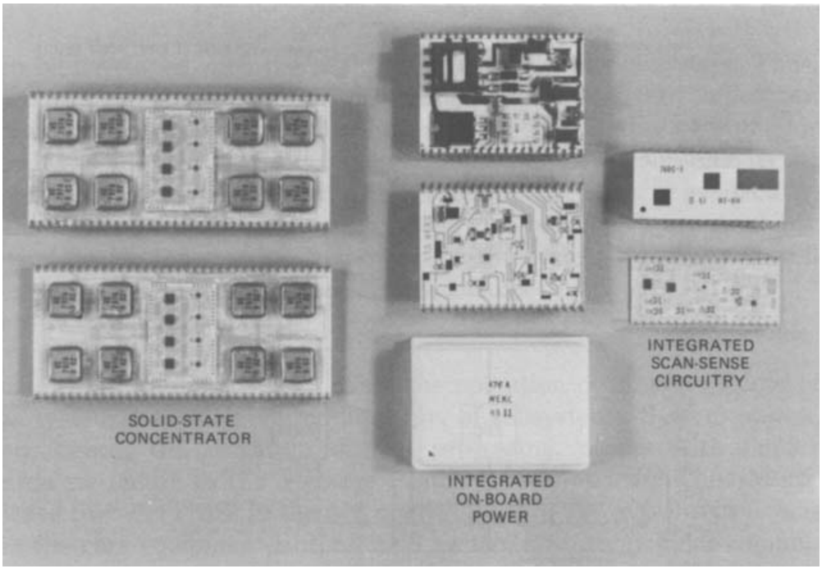


Fig. 4—Typical ceramic modules.

module compatibility, to provide a reliable interconnection medium, and to use an extensive postmolded plastic packaging capability. This strategy calls for use of the following three elements: (1) Dual In-Line Packages (DIPs) for devices requiring from 2 to 40 interconnections to printed wiring boards, (2) pin-grid arrays or surface-mounted leaded chip carries for devices requiring greater than 48 interconnections to printed wiring boards, and (3) either beam-leaded or leadless ceramic chip carrier packages for use on ceramic modules. Many devices in the *5ESS* system do not require hermetic seals; therefore, plastic packages are used. For those devices requiring hermetic seals for reliability, ceramic packaging is used.

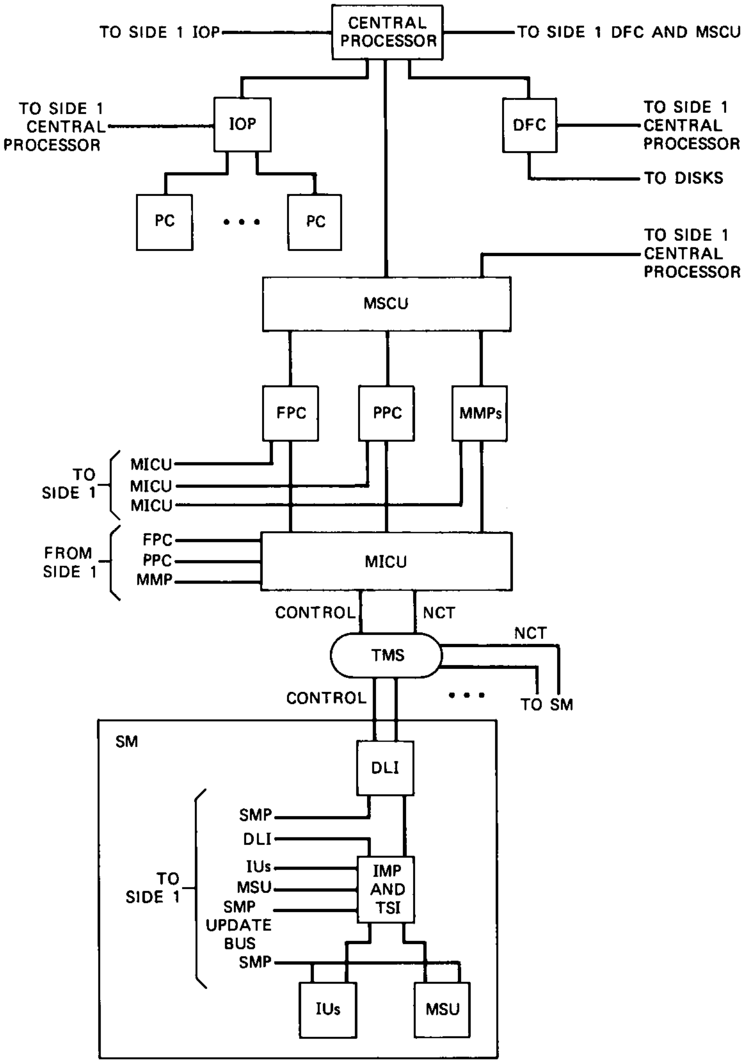
III. RELIABILITY

3.1 Hardware reliability

The *5ESS* switch has been designed for a robustness and availability that is the industry standard. High availability is achieved, as a principle, early in the design phase by paying attention to hardware reliability requirements, and by evolving architectures that are the most feasible engineering solution.

3.2 System architecture

The architecture of the multimodule *5ESS* switch is shown in Fig. 5. The basic units of the switch are organized into four primary communities, the Administrative Module (AM), the Communications



DFC – DISK FILE CONTROLLER
DLI – DUAL-LINK INTERFACE
FPC – FOUNDATION PERIPHERAL CONTROLLER
IMP – IMPROVED MODULE PROCESSOR
IOP – INPUT/OUTPUT PROCESSOR
IU – INTERFACE UNIT
MICU – MESSAGE INTERFACE CLOCK UNIT
MMP – MODULE MESSAGE PROCESSOR
MSCU – MESSAGE SWITCH CONTROL UNIT
MSU – METALLIC SERVICE UNIT
NCT – NETWORK CONTROL AND TIMING
PC – PERIPHERAL CONTROL
PPC – PUMP PERIPHERAL CONTROLLER
SM – SWITCHING MODULE
SMP – SWITCHING MODULE PROCESSOR
TMS – TIME-MULTIPLEXED SWITCH
TSI – TIME-SLOT INTERCHANGER

Fig. 5—Multimodule architecture.

Module (CM), and the Switching Module (SM). An important feature of the *5ESS* switch is its modularity; a wide range of switch configurations, from the single module office to the large multimodule system, can be developed with the basic building blocks of the system. Thus, by the graceful introduction of additional hardware, any office can grow from its initial size into a large system. This feature accounts for the high availability of this local digital switch, with each unit in the system having been improved with respect to function and availability. This section presents an overview of the long-term hardware reliability estimates for the system. It shows that the system reliability is well within the requirements for electronic switches.

3.3 System reliability

Hardware faults that can affect the operation of large segments of the system are mitigated by duplexing of subsystems. System outage, and, hence, the cessation of call processing, occurs with duplex hardware failure in the Message Switch (MSG) and the Time-Multiplexed Switch (TMS) in the AM or the CM. The above two subsystems are the core equipment in the *5ESS* switch; all intermodular communications rely on the successful operation of these core units.

Figure 6 is the reliability block diagram for the *5ESS* switch, which is obtained from Fig. 5 by associating subunits that interact as a failure group and by identifying the cross-couplings in the system architecture. The SMs are shown in the last block for completeness only. They are not to be construed as part of the TMS reliability subblock.

3.4 Interface module reliability

The core units in the SMs are the Switching Module Processor Unit (SMPU), the Time-Slot Interchange Unit (TSIU), and the Local Digital Service Unit (LDSU). These units maintain intramodule communications; in combination with the Dual-Link Interface (DLI) and the TMS, they improve intermodule communication. The outage of the SM occurs on any duplex hardware failure within its core equipment SMPU-TSIU-LDSU.

Other than during system outage, any SM may become isolated when the hardware dedicated to the SM is unavailable. Module isolation may occur during simplex operation of the TMS with the loss of the DLI, or with the loss of the core units in the SM.

3.5 Interface units reliability

Each Interface Unit (IU), except the Digital Line Trunk Unit (DLTU), has two service groups operating in the active-active load-sharing mode. The service of an interface unit is lost on the occurrence of coincident critical hardware failures of both service groups. Because of load sharing, the loss of a service group increases blocking or degradation of service. In general, noncritical hardware outages in the

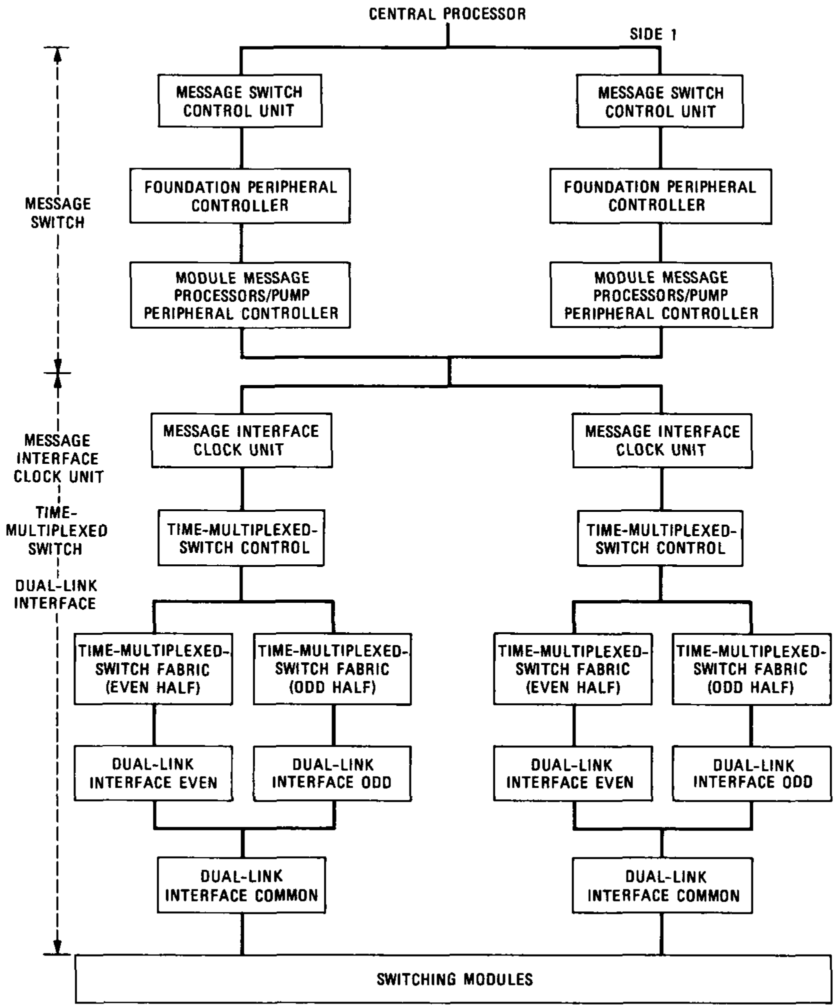


Fig. 6—Reliability structure of *5ESS* multimodule.

IUs affect service quality to a small community of customers. On the Digital Service Units (DSUs), the analog Trunk Unit (TU), and the DLTU, the service circuits and trunk are randomly assigned according to traffic loadings. The circuits that fail in these units are taken out of service, while surviving circuits share the load.

IV. SYSTEM DESIGN

4.1 Cabinets

The system uses a newly designed four-posted cabinet to house the equipment units. The cabinets are 6 feet high, 2 feet 6 inches wide, and 1 foot 9 inches deep (see Fig. 7). Each blue and white cabinet will

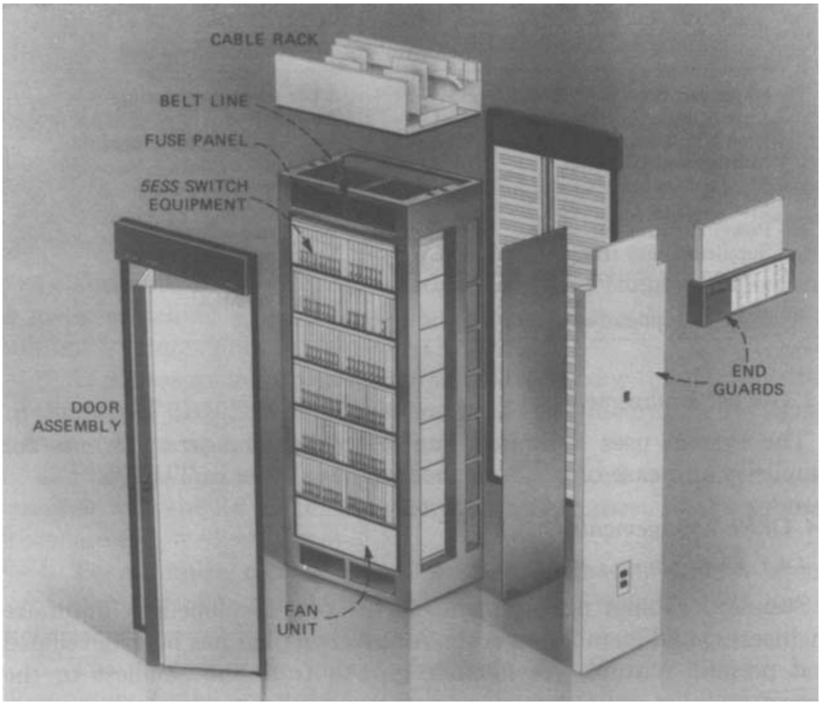


Fig. 7—Exploded view of 6-foot cabinet.

accommodate six 8-1/2 inch high *Fastech* equipment shelves. To maintain system integrity, forced air cooling is used, provided by a fan unit located at the bottom of each cabinet (not one of the six mounting positions). Fans are triplexed per cabinet, deliver 250 through 300 Cubic Feet per Minute (CFM) of filtered air, which is drawn from the wiring aisle. An arrangement of fan flaps prevents loss of air flow if a fan fails. Alarms detect individual fan failures. The cabinet design also includes two fuse/filter units for power distribution at the top of each cabinet. The 6-foot design precludes the need for external earthquake bracing in any office location.

4.2 Teletypewriter and telephone jack access

Teletypewriter (TTY) and telephone jack access is provided by the fuse/filter units located in the message switch and Switching Module Control (SMC) cabinets. These access points are multiplied throughout the office. Access is also provided at the Master Control Center (MCC), at each Supplementary Trunk Line Work Station (STLWS), and at the distributing frame for connection to other areas of the central office and to remote switching modules.

Table I—Cabinet configurations

Cabinet	Acronym	Number required
Switching module control	SMC	1 per switching module
Line interface	LNI	As required
Line trunk peripheral	LTP	1 to 4 per interface module
Master control center	MCC	1 per office
Message switch	MSG	2 per office
Miscellaneous	M	As required
Power distribution	PCFD3	1 to 6 per office
Supplementary trunk line work station	STLWS	1 to 6 per office initial TLWS provided as part of MCC
Time-multiplexed switch	TMS	2 per office

4.3 Cabinet arrangements

The system uses a limited number of cabinet arrangements for simplicity and ease of office engineering, as shown in Table I.

4.4 Office arrangements

4.4.1 Floor plans

Standard cabinet arrangements have been developed to minimize engineering and installation costs. A universal plan has been developed that permits natural, yet flexible, growth from the smallest to the largest installation. Other plans are also available for single module and remote switching module applications. Figure 8 depicts a typical multimodule office floor plan, and Fig. 9 shows a remote module plan. Some constraints on cabinet placement must be observed.

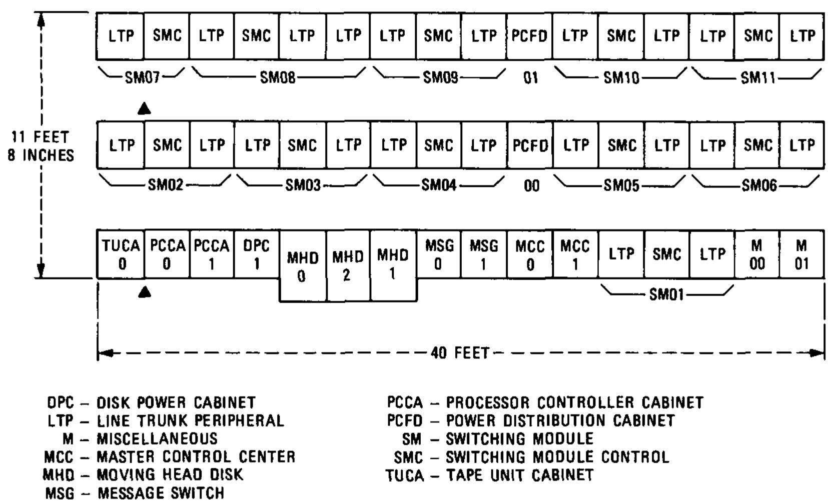


Fig. 8—Typical multimodule office floor plan.

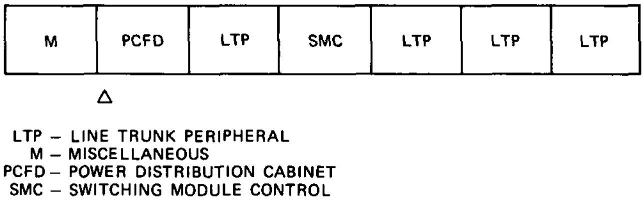


Fig. 9—Remote module floor plan.

1. The SMC and Line Trunk Peripheral (LTP) cabinets comprising a given switching module must be arranged in a specific pattern to minimize intercabinet cable lengths.
2. The message switch cabinets must be located within 50 cable feet of the AT&T 3B20D2 computer to maintain the integrity of the signals between these equipment entities.
3. Power distribution cabinets are to be placed in line with one another and should be centrally located with respect to the cabinets they serve.
4. To minimize cable congestion, the distributing frames should grow perpendicular to cabinet lineups; however, other layouts can be accommodated.
5. The system floor plans have been designed to fit the New Equipment-Building System (NEBS) building bay standards. The system's modular design makes it readily adaptable to existing buildings.

4.4.2 Cable rack, end guards, and office lighting

The system uses a newly designed overhead cable rack system. Cabinet-supported cable racks, 10 inches high and 21 inches deep, are positioned in 90- and 30-inch increments. Unlike previous systems, it has only two cable compartments, one of which provides separation and mechanical protection for the fiber optics, while the other contains all other intercabinet cables. Interlineup connection uses telescoping cross-aisle cable racks to simplify engineering and installation.

There are end guards at the ends of each cabinet lineup and at each exposed cabinet position within the lineup. Aisle directories naming the cabinets in each lineup, and lighting control switches are on the ends of lineup end guards.

The cabinet-supported cable rack is also arranged to support the via cable rack system and an optional overhead lighting system.

4.4.3 Distributing frames

4.4.3.1 Conventional or open type. The Low-Profile Conventional Distributing Frame (LPCDF) or similar conventional mainframes may be used with the *5ESS* switch, particularly in office sizes up to 6000

Table II—Cosmic II mainframe arrangements

COSMIC II Type	Termination Field (Pairs) Facility	Termination Field (Pairs) Equipment
Mini	6,000	7,600
Combined	30,000	48,000
Subscriber	100,000	100,000
Trunk	30,000	36,600

lines. This conventional-type distributing frame meets the needs of the NEBS standards and is a floor-supported, earthquake-resistant, low-profile version of the early distributing frames. Standard equipment arrangements are available to minimize jumper congestion.

4.4.3.2 COSMIC II. The COSMIC II distributing frame is a modular mainframe that can meet the wide range of office configurations. Depending on the best planned office size in terms of total terminations, one of the arrangements shown in Table II can be used.

4.4.4 Protection

The first stage of protection is provided by a new distributing-frame-mounted gas tube protector. Most newer connectors will accept the plug-in unit, although older connectors, such as the C50 and 300 type, will not.

For single-entity wire centers, all exchange cable pairs should be terminated on Distributing Frame (DF) connectors that accept the new protectors. Some retrofitting may be required in existing wire centers that reuse older DFs. A secondary strategy is used in multientity wire centers where retrofitting costs could be prohibitive. In these applications, two options exist:

1. Use of a newly designed horizontal mainframe connecting block, which provides gas tube protection as well as equipment termination and jumper access.

2. Placement of the Line Interface (LNI) cabinet between the mainframe and the equipment cabinets. The LNI cabinets may be installed in the equipment lineups or may be placed in a separate area to meet local requirements. Each LNI cabinet provides protection for 2048 pairs at an 8:1 Line Concentration Ratio (LCR).

4.5 Office alarms

Office alarm equipment reports hardware conditions such as fuse operation, voltage and current levels, and software triggers such as diagnostic failures. Such alarm conditions are reported by the system to the MCC, where a video display identifies the exact location of the reported trouble. The alerting function of the office alarm plan is provided by an audible and visual alarm system. Distinctive audible devices alert the user to the trouble, indicating the particular level of importance. Visual indicators may also be provided at switch room exits. The traditional aisle pilot lamps are not provided, to ensure that the user begins the search for the trouble location by using information at the MCC and not by following visual indicators.

4.6 Power

4.6.1 Overview

The *5ESS* switch requires only −48V power from a dc power plant. The individual voltages required by each circuit are provided by dc-dc power converters equipped in each unit or by on-board power converters. Ringing and tone voltages are provided within each switching module. Common system equipment requiring other than −48V or ring and tone voltages must be supplied via bulk converters or separate plants provided by the customer.

4.6.2 Power plants

The power plant used with the system is a −48V plant with a voltage range at the power distribution cabinet of −42.75 to −52.5V. The −48V power may be obtained from any modern power plant with the required voltage range, including the 111A, 151B or C, 153A or 155A plants, or the new *Lineage*™ 2000 plant. Power plants can be operated in parallel to supply power for large offices.

Existing power plants using Counter-Electromotive Force (CEMF) or end-cell switching (one or two cells) may be used, as long as they do not violate the system grounding constraints. Older plants incorporating SCR-type rectification will require additional protection to prevent damage to the *5ESS* switch from lightning or power transients.

4.6.3 Battery reserve plant

A battery reserve plant is required to continue service during outages of commercial power and to provide proper filtering for the power plant. Typically, there is a three-hour reserve for attended offices, and an eight-hour reserve for unattended offices. This plant should be designed to meet local job conditions using parallel strings of rectangular or round cells.

4.6.4 Standby power

A standby alternator can operate the central office if a prolonged commercial power outage occurs. For small offices, a receptacle may be provided to connect a portable ac generator, whereas a stationary engine should be used in larger offices. Local conditions will dictate the configuration of this reserve system.

4.6.5 *Power sharing*

In some applications it may be economically attractive to share a battery plant between the *5ESS* switch and other central office equipment. The rules for power sharing are the same as those defined in previous electronic switching systems. Power for the non-*5ESS* switching equipment must be supplied from a separate power distribution cabinet/frame located in the non-*ESS*™ switch area. Power feeders supplying the frame must be run via the ground window and have the ground side of the feeders bonded to the single-point ground. All shielded cables running between the two areas must have their shields grounded at the *5ESS* switch end and be isolated from the ground at the other end.

4.6.6 *Power distribution*

Power distributing cabinets are used to distribute the −48V power to the equipment cabinets. They are centrally located in the area of the cabinets they serve in order to minimize feeder congestion and to maintain the required voltage drops in the feeders. Typically, one power distribution cabinet is required for 36 equipment cabinets.

4.6.7 *Grounding*

The *5ESS* switching equipment is connected to an isolated ground plane that has no contact with building ground or other foreign ground planes except for a single connection to the floor central office ground. The single-point ground system eliminates the possibility of transient current flow through the *5ESS* switch ground plane from the sources outside the system.

4.7 *Office interconnection*

All connections between equipment entities in the *5ESS* switch are fully connectorized. All signal and tip and ring leads are terminated on the unit backplanes using *Fastech* backplane connectors. Connectorized mainframe blocks are used to terminate tip and ring leads from the line units, as well as leads from the trunk units, metallic service units, and the Trunk Line Work Station (TLWS).

Control and data signals between the SMC and its peripheral units are completed using double-ended connector cables that run directly between cabinets as opposed to being run in the overhead racking system. Optical fibers are used to complete the highly critical connections between the switching modules and the TMS or MSG.

This high degree of connectorization greatly reduces the installation interval, simplifies the growth procedures, and eases factory assembly and testing.

4.8 Factory testing/installation

The system is tested in the factory in segments called blocks. A core system, consisting of the 3B20D computer, the CM, and one or two SMs, is tested and shipped as a unit. Individual SMs are tested and shipped as separate blocks to the office site, where full system testing is completed by the installer. This method eliminates duplication of tests and minimizes the cost of factory testing.

The system can also be installed on site in a temporary facility, tested, cut into service, and then moved into its final position after the replaced equipment has been removed from service. This method, known as "hot slide-in," can be done in several ways. Figure 10 depicts the sequence followed in hot slide-in of an office. The entire system can be moved in three lineup blocks, or the core system can be moved independently of the switching modules. The switching modules need only be located within 1000 cable feet of the TMS/MSG before or during the hot slide-in procedure. These methods greatly simplify installation and add another dimension of flexibility to the *5ESS* switch.

V. EQUIPMENT PHYSICAL DESIGN

5.1 Switching module

The SM terminates lines and trunks, and converts their signals into the digital format of the *5ESS* switch. The SM also performs much of the call-processing function.

Physically, the SM consists of two to five cabinets, which may be configured to suit the type and quantity of lines and trunks the particular SM serves. A distinction is made between the types of cabinets that comprise the SM, the SMC, and the LTP, as described below.

Equipment that is common to all SM designs is housed in the SMC. This common equipment consists of the SMPU, the TSIU, and the LDSU. The SMC cabinet equipped with these common elements is shown in Fig. 11. Only one SMC cabinet exists for each SM. Later paragraphs describe the units of the SMC.

5.1.1 Time-slot interchange unit

The TSIU is a two-shelf unit that provides time-slot switching, Network Control and Timing (NCT) link interface, signal processing, data interface, and control interface. The unit is fully duplicated, with each simplex half associated with the corresponding simplex half of the SMPU. The halves are referred to as side 0 and side 1, as viewed

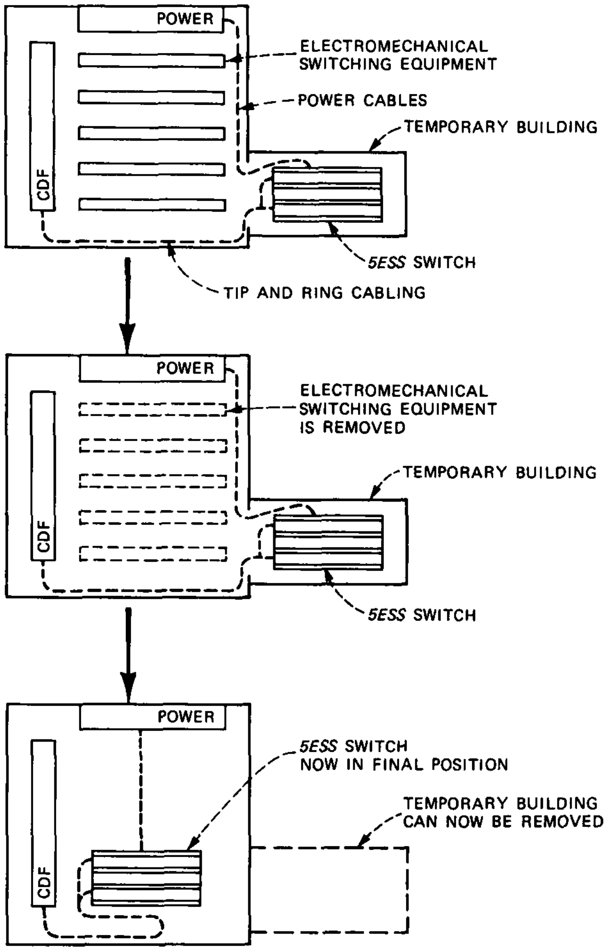


Fig. 10—Hot slide-in sequence.

from the front of the unit. At any given time, only one side is active and the other is in a standby mode.

Figure 12 is a physical layout of the unit, showing the physical partitioning of the TSIU's function. Note that the TSIU halves are mirror imaged. A brief description of these functions follows.

5.1.1.1 Time-slot switching. The TSIU performs the switching of 512 time slots per 125-μs frame from IUs to the TMS, and from the TMS to the IUs. It also can switch peripheral time slots with peripheral time slots (i.e., for intramodule calls), and TMS time slots with TMS time slots (for maintenance). This Time-Slot Interchanger (TSI)

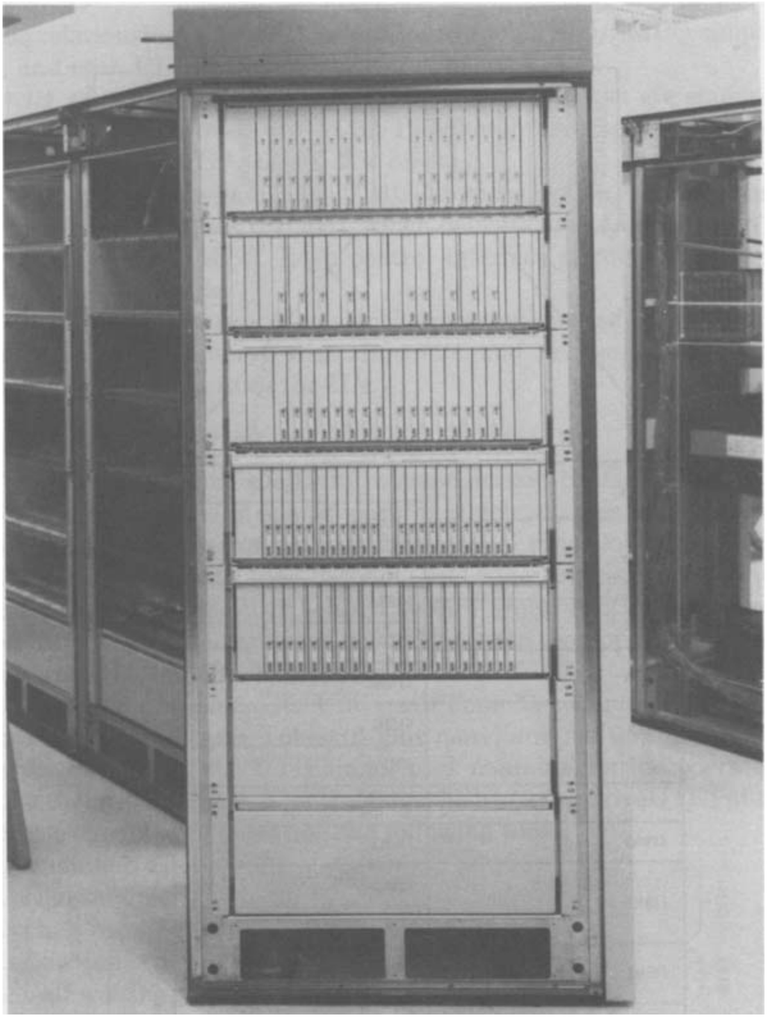


Fig. 11—SMC cabinet.

function is provided on five TN-type multilayer circuit packs in the unit.

5.1.1.2 Dual-link interface. The TSIU provides an interface to the NCT links with its DLI circuits. The DLI extracts timing from the NCT links for the SM, accommodates the optical transmit and receive circuits required to terminate the fiber-optic NCT links, and provides the SMPU with a message time slot from the 256 time slots of the NCT links. Two DLI circuit packs are equipped in the TSIU, but are associated with the TMS from a reliability group standpoint. Because

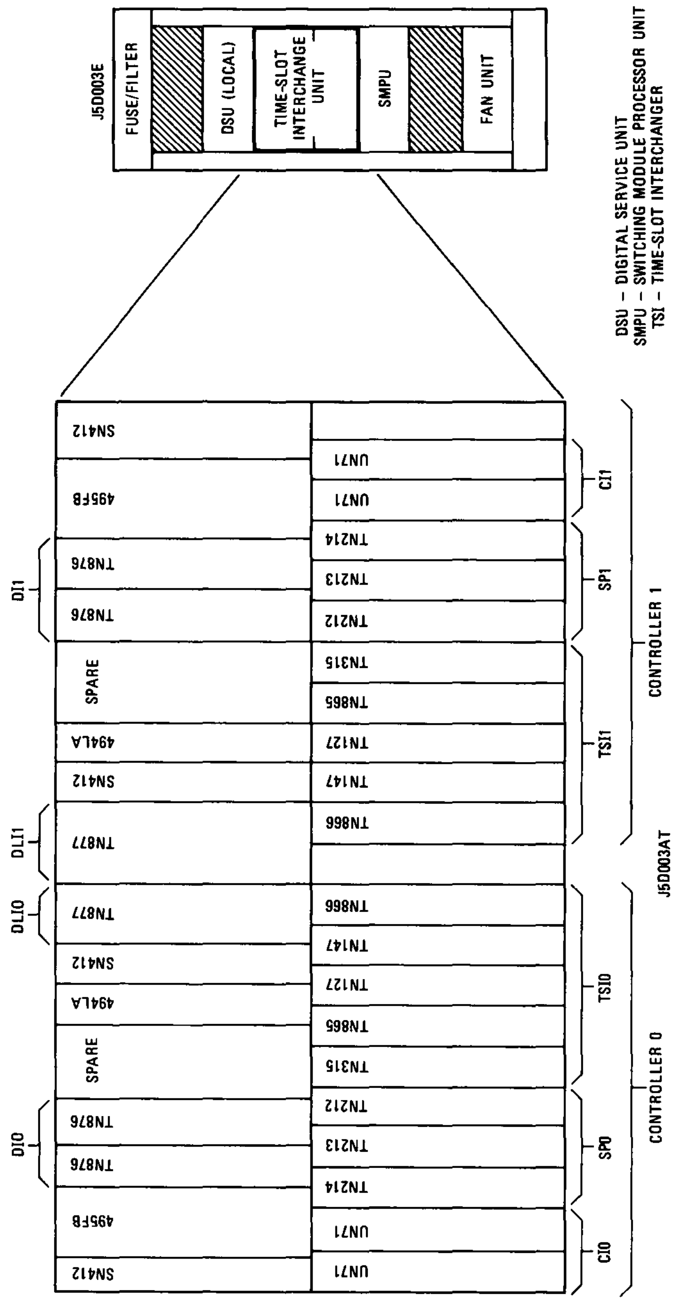


Fig. 12—Time-slot interchange unit.

of this relationship, each DLI is coupled to each TSIU/SMPU simplex half, and each DLI has its own power converter.

5.1.1.3 Data interface. Two data interface circuit packs are equipped on the TSIU to provide up to 32 Peripheral Interface Data Buses (PIDBs) from the TSIU to the IUs of the SM.

5.1.1.4 Control interface. The TSIU provides up to 46 Peripheral Interface Control Buses (PICBs), which deliver control information to the IUs from the SMPU. Each control interface circuit pack has 23 control ports available.

5.1.1.5 Signal processing. The signal processor, housed in the TSIU, is a three-board complex that transmits and receives address and supervisory signaling from the IUs.

5.1.2 Local digital service unit

The LDSU is a one-shelf unit located in the SMC cabinet. It is divided into two service groups, each of which requires 32 time slots, which are not a subset of the 512 TSI internal time slots. The LDSU provides each SM with tone decoding and tone generation functions. Figure 13 depicts the LDSU. Each service group has its own power conversion and common circuit, and is then equipped with tone generators and decoders as required.

5.1.2.1 Tone decoding. The Universal Tone Decoder (UTD) of the LDSU recognizes Touch-Tone (16-tone pairs) and multifrequency (15-tone pairs) signals. The UTD circuit pack contains four decoders.

5.1.2.2 Tone generation. The Universal Tone Generator (UTG) of the LDSU is capable of generating the following tones:

1. Audible ring
2. Dial tone
3. High tone
4. Low tone
5. Call waiting
6. Preemption
7. Multifrequency signals (15-tone pairs)
8. Touch-Tone signals (16-tone pairs)
9. Common Channel Interoffice Signaling (CCIS) continuity check tones (1780 and 2012 Hz).

The UTG has 32 channels of tone generation per Multilayer Board (MLB)-type circuit packs.

5.1.3 Switching module processor unit

The SMPU is a one-shelf unit housing the SM memory and microprocessor complex. The SMPU performs most of the call-processing and maintenance functions for the lines and trunks terminating on the IUs of the SM. The SMPU is fully duplicated and operates in

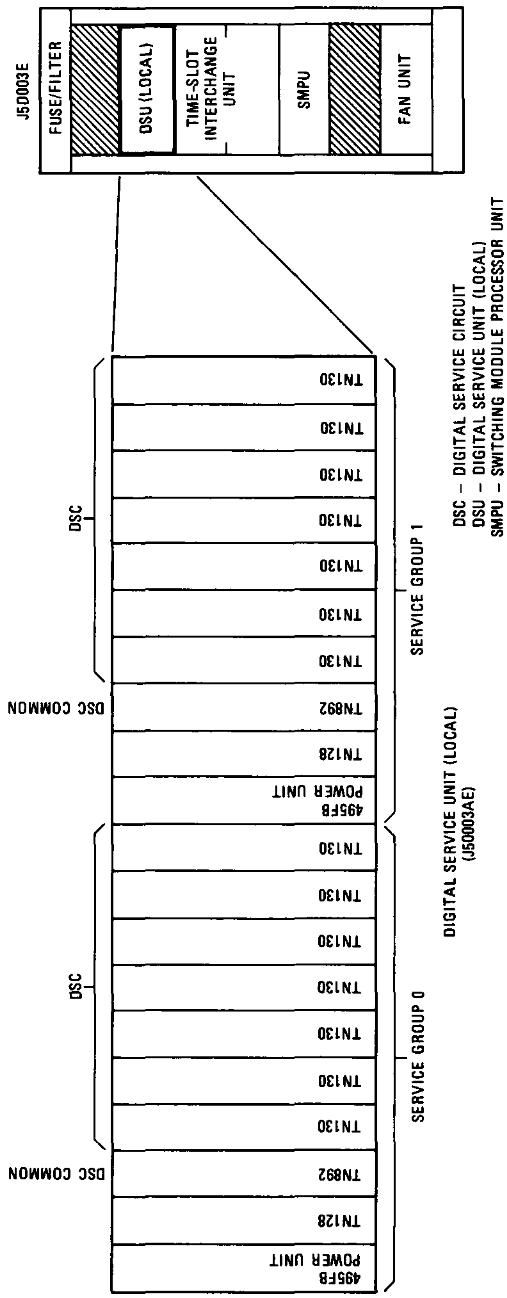


Fig. 13—Local digital service unit.

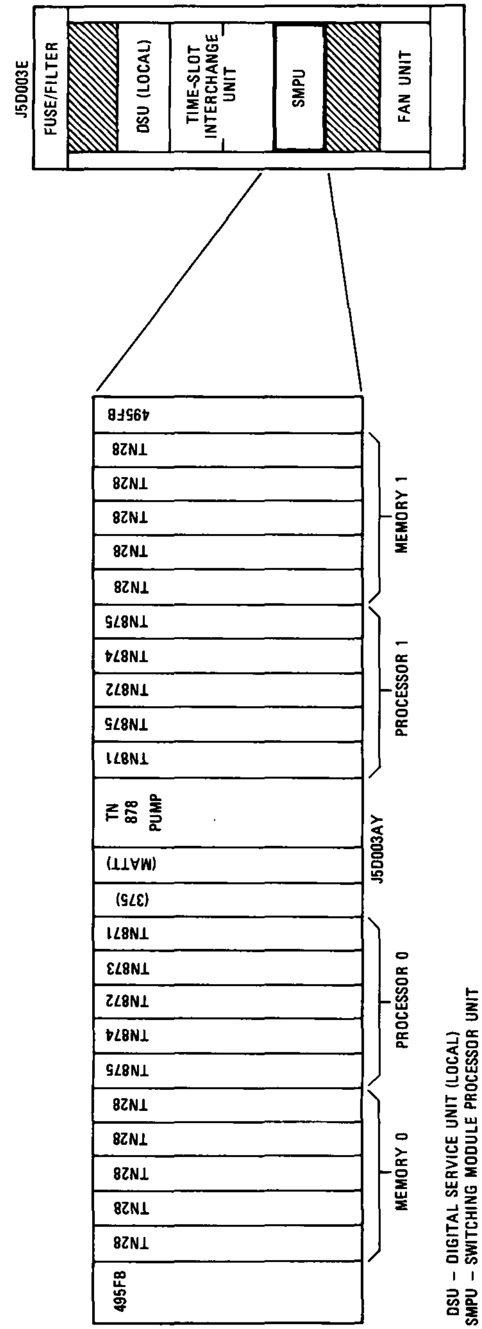


Fig. 14—Switching module processor unit.

an active/standby mode, as described in Section 5.1.1. The active simplex half has total control over the entire SM, and also updates the standby side's data. Figure 14 is a physical layout of the SMPU.

5.1.3.1 Microprocessor. The SMPU is based on the microprocessor. The entire processor complex is accommodated on five multilayered circuit packs.

5.1.3.2 Memory. Most of the SMPU program text and data are kept in RAM with backup on the moving head disk of the 3B20D computer. Five memory planes can be housed within each service group of the SMPU. At this writing, 1M-byte planes are used, with 2M-byte planes planned for the near future, allowing 5M bytes or 10M bytes for the SM.

5.1.3.3 Fast pump. The SMPU also contains the fast-pump controller circuit, which enables the central processor to down load memory to both sides of the SMPU in an expeditious manner. One PIDB is used as a channel to provide the means for data transfer.

5.2 Line trunk peripheral cabinet

The LTP cabinets house all the IUs of the SM. There may be up to four LTPs associated with one SM, and each LTP has six unit positions available for equipage. LTPs equipped with IUs are shown in the SM configured in Fig. 15.

5.2.1 Line unit

The *5ESS* switch line unit provides the interface to virtually all types of analog subscriber lines (see Fig. 16). The unit's modular design allows smooth growth from termination for 256 lines at a 4:1 concentration to termination of 512 lines at an 8:1 concentration. The line unit is a functionally partitioned, two-shelf unit containing up to 50 circuit packs at the 512-line capacity. The line unit provides all line interface functions, including battery feed, overvoltage protection, ringing, supervision and scan, analog-digital encoding and decoding, the hybrid function, two stages of line concentration, and test access. Unit 5V power is derived from one fully duplicated bulk dc-dc converter. Control interface to the peripheral interface control bus and control fanout is provided by two additional fully duplicated circuit packs.

5.2.1.1 Concentrator. The line unit concentrator is partitioned into grids, each of which terminates 64 analog lines. A minimum of four and a maximum of eight grids may be equipped in each line unit. The grid is contained on three circuit packs, two of which perform overvoltage protection, scan functions, and the first stage of concentration for 32 lines each. The third circuit pack performs second-stage concentration, and provides −48 Vdc to +300 Vdc power conversion and control for the grid. Each 64-line grid is configured in a simplex arrangement, whereas all other line unit functions are fully duplicated.

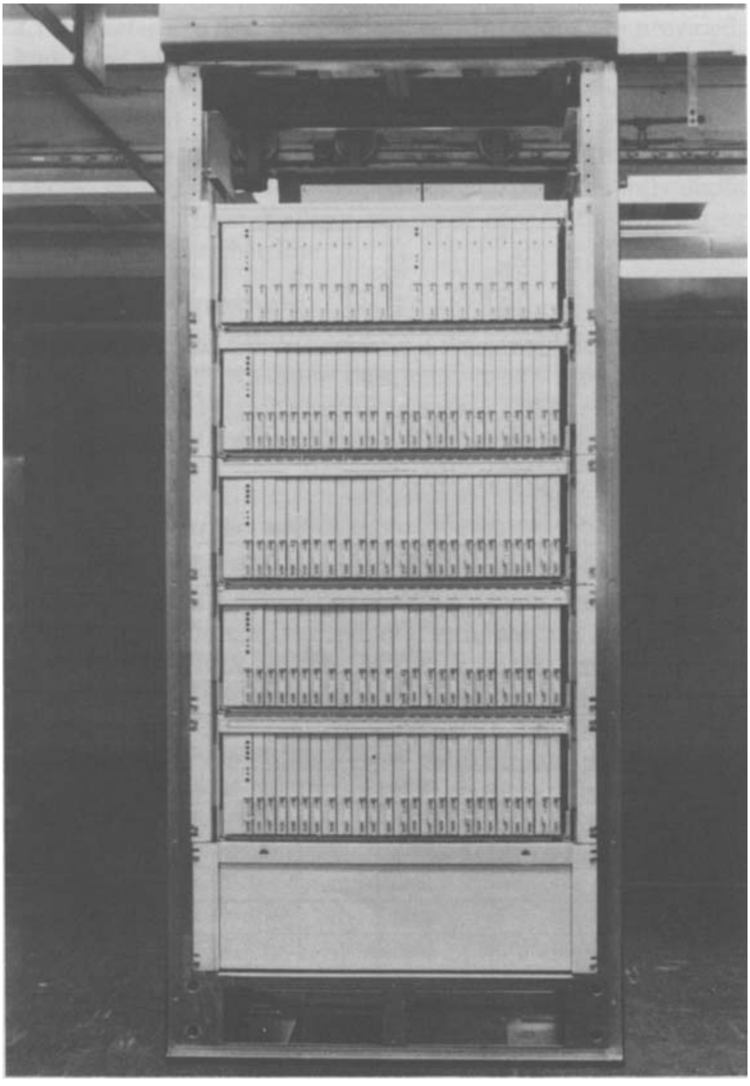


Fig. 15—Line trunk peripheral cabinet.

5.2.1.2 Channel. The battery feed, encoding-decoding, and hybrid function is provided on the channel circuit packs. Eight channel packs, each containing circuitry for eight individual channel circuits, are equipped in all line units. These packs provide 64 Pulse Code Modulation (PCM) outputs, which may be accessed by any of the 512 analog line terminations through the concentrator. The interface of these PCM channels to the peripheral interface database structure is performed on one fully duplicated circuit pack.

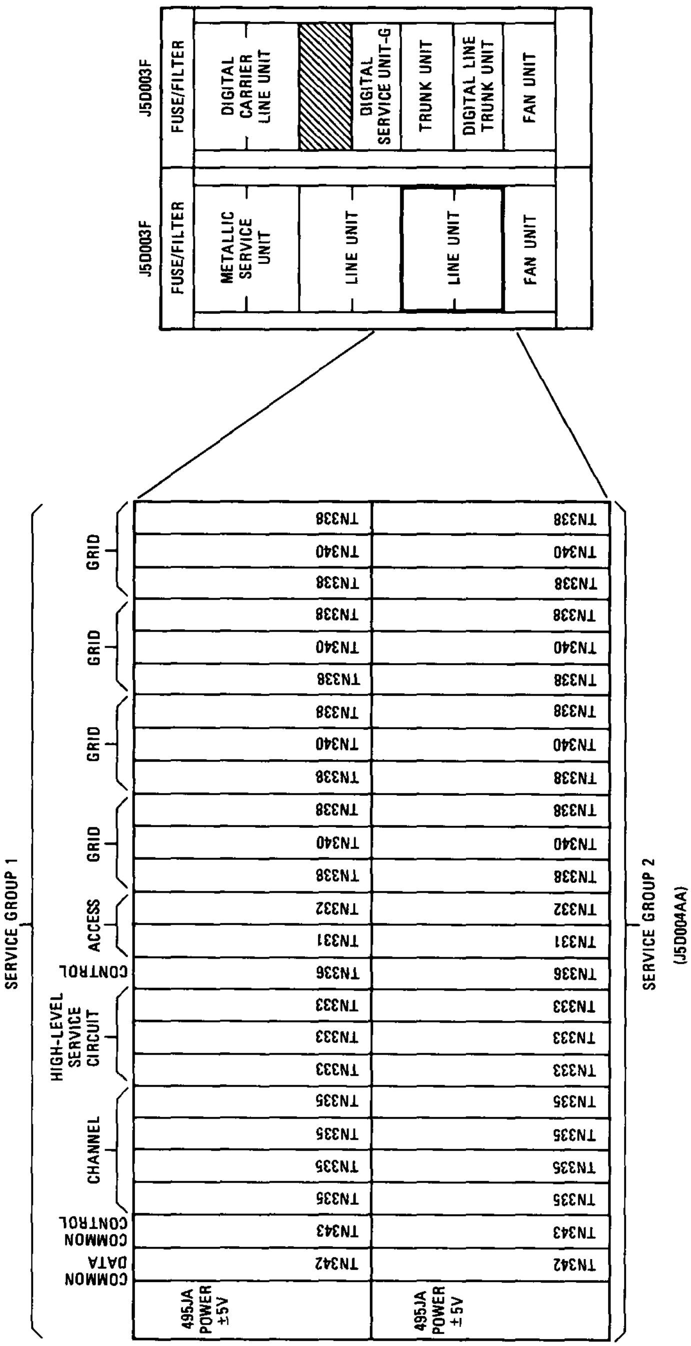


Fig. 16—Line unit.

5.2.1.3 Ringing and test. Ringing and test functions are provided from the high-level service-circuit pack. A minimum of four and maximum of six of these high-level service circuits may be equipped in each line unit. The ring and test functions are connected to individual subscriber lines through the ring and test access network and the concentrator. The access network, contained on two circuit packs, is fully duplicated for high availability, and allows access of any of the ringing or test circuits to any subscriber line.

5.2.2 Digital line trunk unit

The DLTU of the *5ESS* switch will interface with a large number of existing digital transmission terminals. It is a single-shelf unit that contains up to ten Digital Facility Interface (DFI) circuit packs, each of which terminates a single T1 line. These circuit packs use the MLB technology.

5.2.3 Digital carrier line unit

The Digital Carrier Line Unit (DCLU) is used to terminate T1 lines from integrated *SLC®* 96 carrier systems, where up to 96 subscribers without concentration at the remote terminal are provided with 96 channels to the *5ESS* switch. Mode II is the carrier-concentrator mode, where up to 96 subscribers share access to 48 channels to the *5ESS* switch. The DCLU is a two-shelf unit equipped with DFI, data multiplexers, control multiplexers, equalizers, and power units. Each DCLU terminates up to 30 T1 lines and consists of two service groups. A maximum of six *SLC* 96 carrier remote terminals may be terminated on a DCLU. These circuit packs use the MLB technology.

5.2.4 Trunk unit

The TU provides for the termination of high-traffic voice-frequency trunks. Specifically, it can terminate interoffice trunks and trunks to switchboards, operator positions, and announcement machines. Simplex equipment can terminate up to 64 trunks. A TU is a single-shelf unit divided into two separate service groups, each with its own power and common circuitry. Each service group terminates up to 32 trunks. Each trunk circuit pack is double-sided and contains four trunk circuits. The TU provides an interface for the following multipurpose trunk types:

1. Loop supervision, outgoing, two-wire local
2. Loop supervision, outgoing, two-wire toll
3. Loop supervision, incoming, two-wire local
4. Loop supervision, incoming, two-wire toll
5. E&M supervision, two-wire local
6. E&M supervision, two-wire toll

7. E&M supervision, four-wire local
8. E&M supervision, four-wire toll
9. Local test desk.

5.2.5 Modular metallic service unit

The Modular Metallic Service Unit (MMSU) consists of a one-shelf basic unit and up to three additional growth units. Each shelf is split into two service groups, and each service group has its own power and common circuitry. It can also accommodate up to nine metallic service packs whose functions are outlined below.

5.2.5.1 Metallic access. The MMSU provides the metallic access function on one circuit pack. Metallic access provides an access network that can interconnect analog facilities to test equipment.

5.2.5.2 Scan and signal distribution. A scan circuit pack and a signal distribute pack in the MMSU monitor the power supply status and maintenance status of the periphery.

5.2.5.3 Gated-diode-crosspoint compensation. The Gated-Diode-Crosspoint (GDX) compensator pack corrects leakage during testing of analog lines.

5.2.5.4 Automatic line insulation testing. One Automatic Line Insulation Testing (ALIT) circuit pack performs internal testing functions, such as insulation of all customer lines, short circuit, and foreign potential, and other specific tests on individual lines.

5.2.6 Global digital service unit

The Global Digital Service Unit (GDSU) is a one-shelf unit with two service groups. The unit design (i.e., backplane) is identical to the LDSU design, but is equipped with a different set of circuit packs, which perform lower-usage digital service functions. Each service group has its own power, common circuit, and space for up to eight service circuits, whose type and quantity are equipped as the needs of the office require. The GDSU may be shared among SMs in an office, being accessed by the switching network. GDSUs connect to the TSIU in the SM by way of PIDBs. The primary GDSU functions are described below.

5.2.6.1 Universal conference circuit. The Universal Conference Circuit (UCC) double-sided circuit pack of the GDSU contains five three-port conference circuits. At this writing six-port conferencing is planned for 1985.

5.2.6.2 Transmission test function. The Transmission Test Facility (TTF) of the GDSU performs all the voice-frequency tests required in the office. Four circuit pack codes provide

1. Facility testing
2. CODEC testing
3. Noise, loss, and frequency response measurements

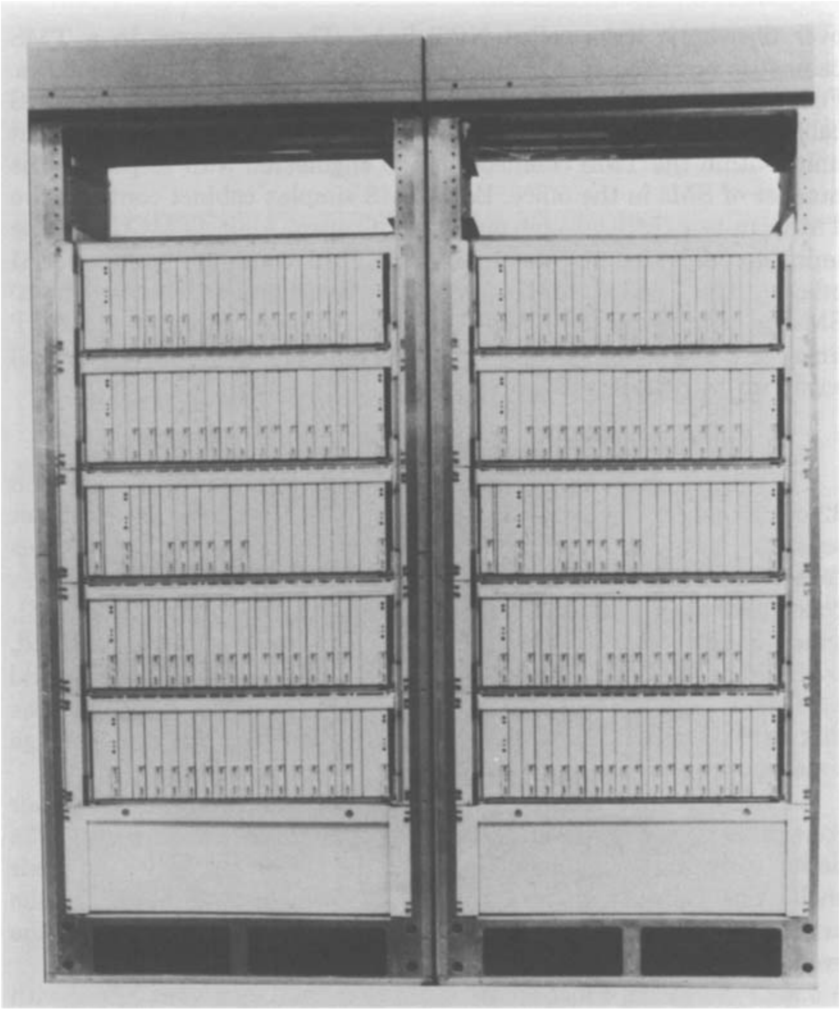


Fig. 17—Time-multiplexed switch cabinet.

4. 100 test line
5. 102 test line
6. 105 test line
7. Remote office test line
8. Touch-Tone test line.

5.3 Time-multiplexed switch

A *5ESS* switch equipped with more than one SM requires a TMS. The TMS cabinet (see Fig. 17) provides space-division switching of time slots between two or more switching modules. The TMS routes control, data, and PCM-encoded voice between the switching modules over fiber-optic links called NCT links. The equipment in a TMS cabinet is arranged to accommodate from 2 to 30 switching modules. For reliability, the TMS equipment is duplicated in a second TMS cabinet and operates in a duplex two-cabinet configuration. Equipment units within the TMS cabinets are job engineered with respect to the number of SMs in the office. Each TMS simplex cabinet contains two TMS Units (TMSUs) and one TMS Control Unit (TMCU). These units are provided for the minimum TMS configuration (two SM offices). The TMS (office) capacity can be smoothly increased to 30 SMs by populating the TMSUs with additional circuit packs, NCT links, and power converters. The TMS can be expanded quickly and easily in the field in this manner.

5.3.1 TMS switch unit

The TMSU is a single-stage space switch with 32 input ports and 32 output ports. There are two TMSUs in each simplex TMS cabinet separated by a TMCU. The TMSU located above the TMCU switches "even" time slots, and the TMSU located below the TMCU switches "odd" time slots. The even and odd TMSUs are connected to the TSI, which handles both even and odd time slots and is fully duplicated, by full-duplex optical-fiber data links. Each link carries even or odd time slots only. The exception to this even/odd arrangement is the link to the MSGS unit, which must carry both even and odd message time slots.

A TMSU is a two-shelf unit arranged to mount a total of 4 power converters (2 per shelf) and 27 *Fastech* multilayer circuit packs. The power converters supply power to all the circuit packs within their shelf. The capacity to switch 2 to 30 SMs is determined by the arrangement of circuit packs, NCT links, and power converters in the even and odd TMSUs.

5.3.1.1 NCT links. Fiber-optic transmitters and receivers, along with fiber-optic cable, make up the NCT links that are positioned on the backplane of the TMSU. They connect directly behind the Link Interface (LI) circuit packs that are housed on the equipment side of the backplane. Figure 18 shows a typical fiber-optic connection.

5.3.1.2 Fanout, fabric, and link interface. TMSUs are configured with the clock and data fanout circuit packs in the center of each shelf. Located on each side of the fanout pack are the fabric circuit packs, and outside the fabric are the LI packs. This scheme allows for the shortest path switch nets and better timing control.

5.3.2 TMS control unit

The TMCU provides the control path setup and the craft interface for all units in the TMS cabinet. The TMCU is a single-shelf unit

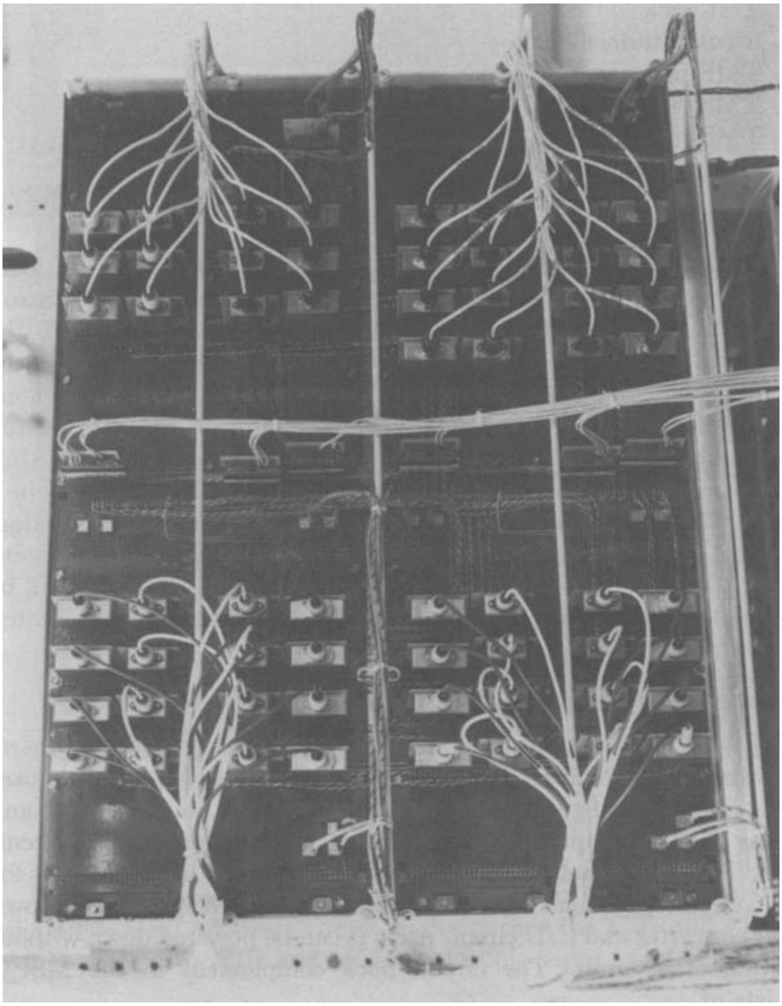


Fig. 18—Fiber-optic connections.

containing two power converters and seven circuit packs, including the control and display pack. The TMCU is equipped with a full complement of circuit packs and power converts regardless of the multimodule office size. The circuit pack complement contains one of each of the following packs:

1. Message Link Interface (MLI) pack
2. Test pack
3. Clock interface pack
4. TMS maintenance pack
5. TMS control pack
6. TMS interface pack
7. Control and display pack.

5.4 Message switch cabinet

The MSG in the *5ESS* switch provides synchronous control-data paths between the AM and the SMs, provides a synchronous control-data path for module-to-module communications, and timing to the rest of the *5ESS* switch; it also synchronizes the switch to the switching network. For each simplex cabinet, the MSG contains one Message Switch Control Unit (MSCU), three to four Message Switch Peripheral Units (MSPUs), and one Message Interface Clock Unit (MICU). For high reliability, the MSG equipment is duplicated in a second MSG cabinet and operates in a duplex two-cabinet configuration. Equipage of the units within the MSG cabinets is job engineered with respect to the number of SMs in the office. Growth procedures will be described in the sections that follow. Figure 19 shows a message switch cabinet.

5.4.1 Message switch control unit

The MSCU is an interface between the AM and the peripheral controllers in the MSPU. The MSCU is a single-shelf unit that houses in its normal configuration one power converter, one Control and Display (C/D) circuit pack, and either six or seven MSCU circuit packs. Two additional positions have been reserved in the MSCU for a test circuit pack and its converter. Since the MSCU has its own power converter and C/D circuit pack, it can be powered down without affecting other units. The circuit pack complement in the MSCU consists of

1. One control and display
2. One duplex dual-serial bus selector
3. One bus interface controller
4. One peripheral interface controller
5. Two Microcontrol Stores (MCSs)
6. One or two input/output microprocessor interfaces.

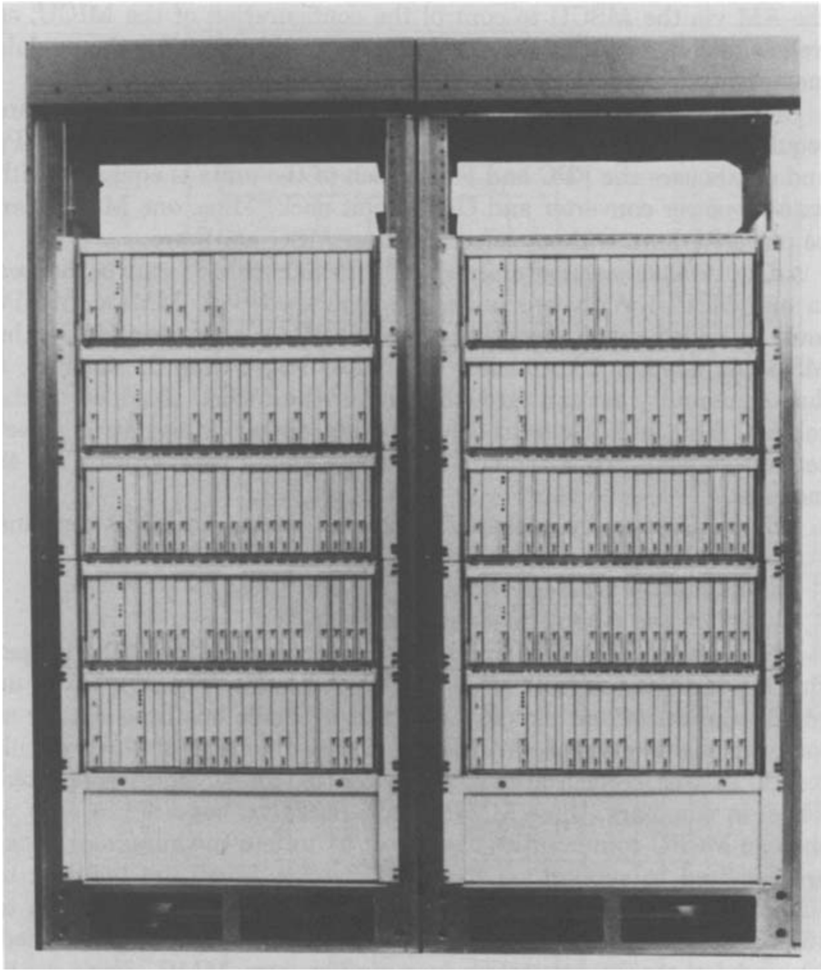


Fig. 19—Message switch cabinet.

The quantity of input/output microprocessor interfaces depends on the office size. All these circuit packs, except the C/D and MCS, are MLB types. The C/D and MCS are Double-Sided Rigid (DSR) types.

5.4.2 Message switch peripheral unit

The MSPU is a single-shelf unit that houses the Module Message Processor (MMP), Foundation Peripheral Controller (FPC), and Pump Peripheral Controller (PPC). The MMPs handle message traffic between the MSCU and the modules via the MICU and TMS. The FPC passes control data over the control and diagnostic access link from the AM via the MSCU to control the configuration of the MICU, as well as to control the TMS. The PPC can quickly initialize the module memory.

In the minimal multimodule MSG configuration, three MSPUs are required for a simplex MSG cabinet. Two of these units house MMPs and one houses the FPC and PPC. Each of the units is equipped with its own power converter and C/D circuit pack. Thus, one MSPU can be powered down without affecting other MSG hardware.

5.4.2.1 Module message processor. Up to four MMPs can be housed in one MSPU. With two units fully equipped with MMPs (MMPs must be added simultaneously to two MSPUs per simplex MSG), the MSG can support 32 modules. For offices larger than 32 modules, a dual-community version (growth unit) of the MSPU is added to the cabinet. This unit contains two separate power groups (two power converters and two C/D circuit packs) and allows growth to 48 modules.

The MSG grows by adding MMP circuit packs. An MMP contains

1. One Message Switch Peripheral Processor (MSPP)
2. One module message processor 1
3. One or two module message processors 2.

These packs are added simultaneously to each of two MSPUs per simplex MSG for support of up to 32 modules (see Fig. 20). When an MMP consists of four circuit packs, it can handle one time slot for as many as eight modules. An MMP may also consist of three circuit packs. In this configuration, up to four modules can be supported. Thus, in summary, three MMP circuit packs are required in each of the two MSPU communities to support up to four modules, four packs are required to support up to eight modules, seven are required to support up to 12 modules, eight packs are required to support up to 16 modules, etc. When MSPU communities 2 and 3 are fully equipped, 32 modules can be supported. In a similar way, MMP circuit packs can be added to each community in the dual-community (growth-unit) version of the MSPU for growth to 48 modules. All circuit packs of the MMP are MLB-type packs.

5.4.2.2 Foundation peripheral controller. Each MSG cabinet has one FPC, which contains one each of the MSPP or FPC codes of MLB-type circuit packs.

5.4.2.3 Pump peripheral controller. Each MSG cabinet has one PPC, which contains one each of the MSPP or PPC codes of MLB-type circuit packs.

5.4.3 Message interface clock unit

The MICU is a single-shelf unit that houses the Message Interface (MI), LI, and Network Clock (NCLK). The MICU provides system

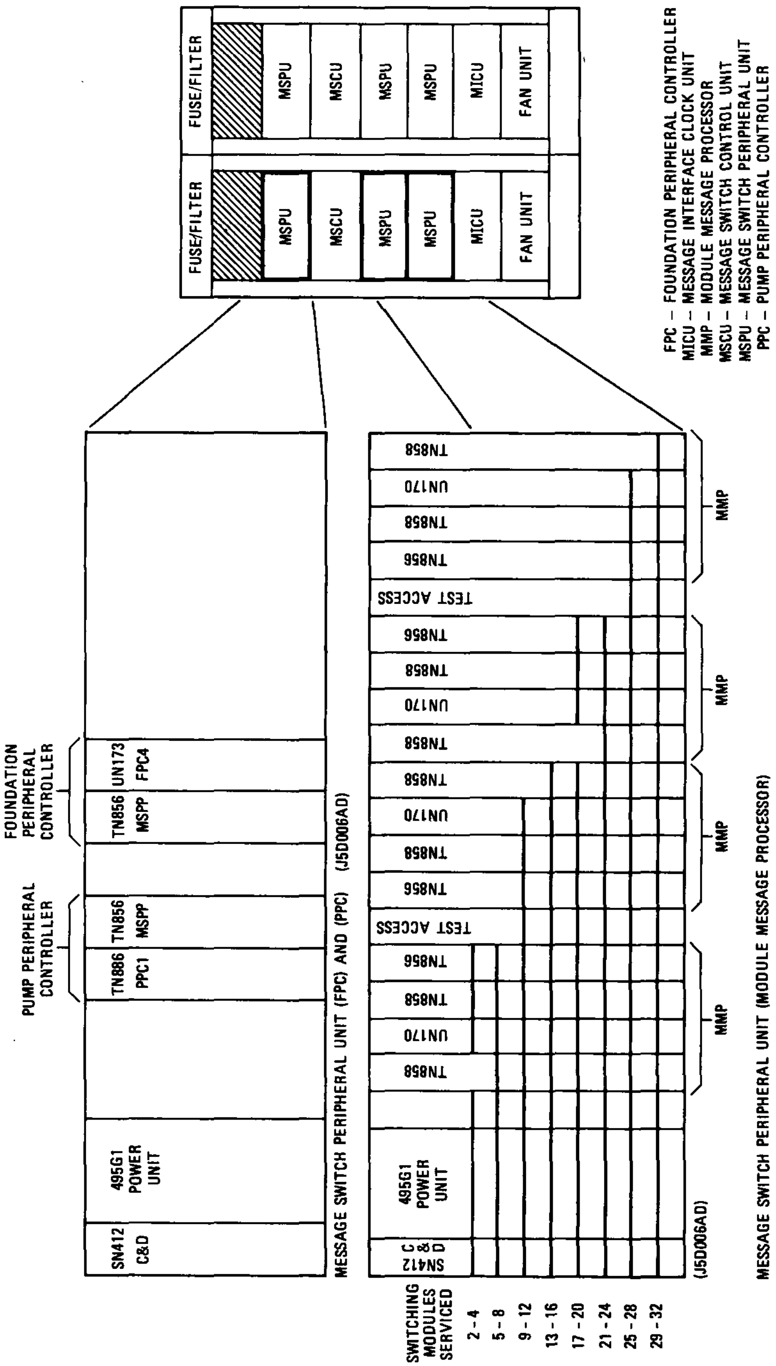


Fig. 20—Message switch peripheral unit.

synchronization and the interface for transmitting message time slots between the module controllers via the TMS and the AM.

5.4.3.1 Message interface. The MI consists of one each of the four MLB-type circuit packs listed below:

1. Message interface 1
2. Message interface 2
3. Message interface 3
4. Message interface 4.

It multiplexes and demultiplexes the message time-slot information between the MMPs and the LI.

5.4.3.2 Link interface. The LI consists of two MLB-type link interface circuit packs (link interface 1 and link interface 2). It provides the termination for the NCT link in the MICU. The LI transmits and receives data as 256 control time slots over the link to and from the TMS.

5.4.3.3 Network clock. The NCLK comprises three circuit packs—the controller, the digital phase-locked loop, and the synchronizer. Two versions (two different circuit packs) of the synchronizer are available—one for use in offices that are tied to T1 lines (slaved offices), and one for stand-alone offices. The NCLK provides master system timing and synchronization for the *5ESS* switch. The NCLK always contains three MLB-type circuit packs per MICU.

5.5 Miscellaneous cabinet

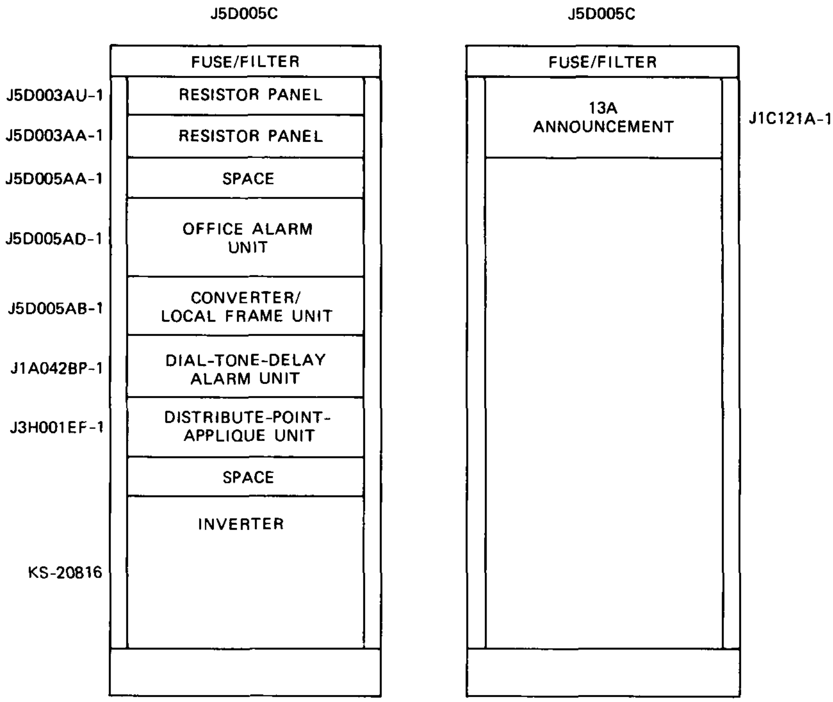
The miscellaneous cabinets, two of which are required for minimum equipage, house peripheral units that do not require module time slots or control ports. Each cabinet is equipped with two fuse and filter units but does not require fan units. The miscellaneous cabinets are equipped with the following units: inverter, office alarm unit, converter and local frame (tel jack) unit, resistor panel, 13A announcement system, external sanity monitor, and inductor unit. Figure 21 shows a maximum configuration of the two cabinets, and each unit is described in the paragraphs below.

5.5.1 13A announcement system

The 13A announcement system is a multichannel system allowing one to eight channels to provide recorded announcements of various lengths. Each channel can record and play one message. A maximum of four units can be mounted in one cabinet.

5.5.2 Inductor unit

The inductor unit provides a filter for the powering of the 13A announcement systems. This 4-inch by 2-foot 1-inch unit is required only when 13A announcement systems are used.



NOTE: A MINIMUM OF TWO CABINETS ARE REQUIRED FOR MISCELLANEOUS EQUIPMENT. A MAXIMUM OF FOUR 13A ANNOUNCEMENT CIRCUITS CAN BE MOUNTED IN A MISCELLANEOUS CABINET.

Fig. 21—Miscellaneous cabinet.

5.5.3 Resistor panel

The resistor panel is a 4 inch high, 23-1/4 inch wide unit that provides a mounting for cables and current-limiting resistor assemblies.

5.5.4 Inverter

The inverter unit is required to provide emergency 117V ac to the data-set cabinet and equipment at the master control center. This unit is 26-1/4 inches high, 23 inches wide, and 15 inches deep.

5.5.5 Converter and local frame (tel jack) unit

The converter unit is a 4-inch high, 2-foot 2-inch wide mounting plate equipped with a housing for a 131-type dc-to-dc power converter that supplies the external sanity monitor. Also mounted on this unit is the circuitry required for interframe communications.

5.5.6 External sanity monitor

The external sanity monitor provides a test of the call process that establishes a call between two switching modules. The equipment required to do this is mounted on the

1. Dial-tone-delay alarm unit, which is 4 inches high by 25 inches wide;
2. Distribute-point-applique unit, which is 2 inches high by 25 inches wide; and the
3. Converter and local frame (tel jack) unit, previously described.

5.5.7 Office alarm unit

The office alarm unit is a *Fastech* 8-inch-high apparatus housing equipped with the following functions:

1. Office alarm circuit
2. Scan-applique circuit
3. Remote alarm unit
4. Broadcast dynamic control.

5.6 Data-set cabinet

The data-set cabinets are used to house various operational support systems that interface with the *5ESS* switch. These cabinets are equipped with shelves and various styles of apparatus mountings to accommodate these systems. Two cabinets are required; one cabinet has backup ac power (protected ac), and the other is supplied with conventional ac power (essential ac).

Each 6-foot-high, 21-inch-deep, 30-inch-wide cabinet contains a cooling unit. The following list details by function which systems are in each cabinet.

5.6.1 Protected ac cabinet

The protected ac cabinet contains the following systems:

1. Automatic Message Accounting Teleprocessing System (AMATS)
2. Automatic Message Accounting Recording Center (AMARC)
3. 2 Switching Control System Center (2SCCS).

5.6.2 Essential ac cabinet

The essential ac cabinet contains the following systems:

- Central Trunk Test Unit (CTTU)
- Engineering and Administrative Data Acquisition System (EADAS)
- Remote Memory Administration System (RMAS)
- Service Evaluation System-2 (SES-2)
- Recent Change and Verify Local (RC/V LOCAL)

- Software Change Administration and Notification System (SCANS)
- Automatic Line Insulation Testing Repair Service Bureau (ALIT RSB)
- Verify Repair Service Bureau Local Test Desk (VFY RSB LTD)
- Belt Line (TTY A&B)
- Recent Change and Verify Switching Control Center (RC/V-SCC)
- Recent Change and Verify Network Administration Center (RC/V-NAC).

5.7 Remote switching module

The Remote Switching Module (RSM) is an SM located remotely from a host *5ESS* switching equipment office and connected via T1 carrier facilities. An RSM is a *5ESS* switching equipment SM connected by digital facilities through a Facilities Interface Unit (FIU) to a host *5ESS* switching equipment multimodule office. The RSM is capable of terminating lines and pair gain systems. The RSM can be divided into the following equipment types.

5.7.1 Digital facility interface

The RSM Digital Facility Interface (R-DFI) consists of a group of circuit packs that plug into a DCLU and act as an interface between the T1 lines from the host office and the FIU.

5.7.2 Facilities interface unit

The FIU consists of several subunits. These subunits are Multiplexers (MUXs), LIs, and a Clock Control (CLK CNT). The FIU recovers data, control, and timing from the T1 line and formats this information into a pair of NCT link signals that it routes over fiber-optic pairs called NCT links to the RSM SM (see Fig. 22).

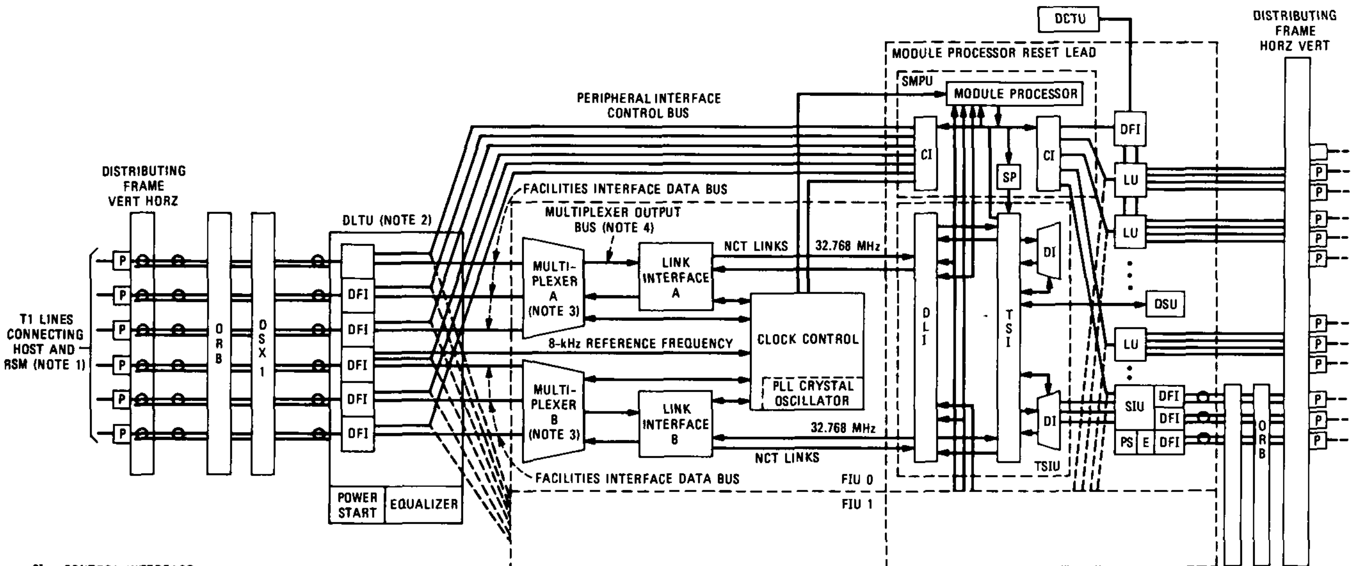
5.7.3 Switching module

The RSM SM consists of the following units:

1. Time-slot interchange unit
2. Switching module processor unit
3. Modular metallic service unit
4. Digital service unit
5. Interface units—line units, trunks units, and DCLU, as required.

5.7.4 Optional equipment

Optional equipment for the RSM includes the 13A Recorded Announcement Unit (RAU) and Directly Connected Test Unit (DCTU).



CI – CONTROL INTERFACE
DCTU – DIRECTLY CONNECTED TEST UNIT
DFI – DIGITAL FACILITY INTERFACE
DLTU – DIGITAL LINE TRUNK UNIT
DI – DATA INTERFACE
DSU – DIGITAL SERVICE UNIT
DSX – DIGITAL CROSS-CONNECT
E – EQUALIZER
FIDB – FACILITIES INTERFACE DATA BUS
FIU – FACILITIES INTERFACE UNIT
LU – LINE UNIT
NCT – NETWORK CONTROL AND TIMING
ORB – OFFICE REPEATER BAY
P – PAIRS
PICB – PERIPHERAL INTERFACE CONTROL BUS
PLL – PHASE-LOCKED LOOP
PS – POWER START
RSM – REMOTE SWITCHING MODULE
SIU – *SLC* CARRIER INTERFACE UNIT
SMPU – SWITCHING MODULE PROCESSOR UNIT
SP – SIGNAL PROCESSOR
TSI – TIME-SLOT INTERCHANGER
TSIU – TIME-SLOT INTERCHANGE UNIT

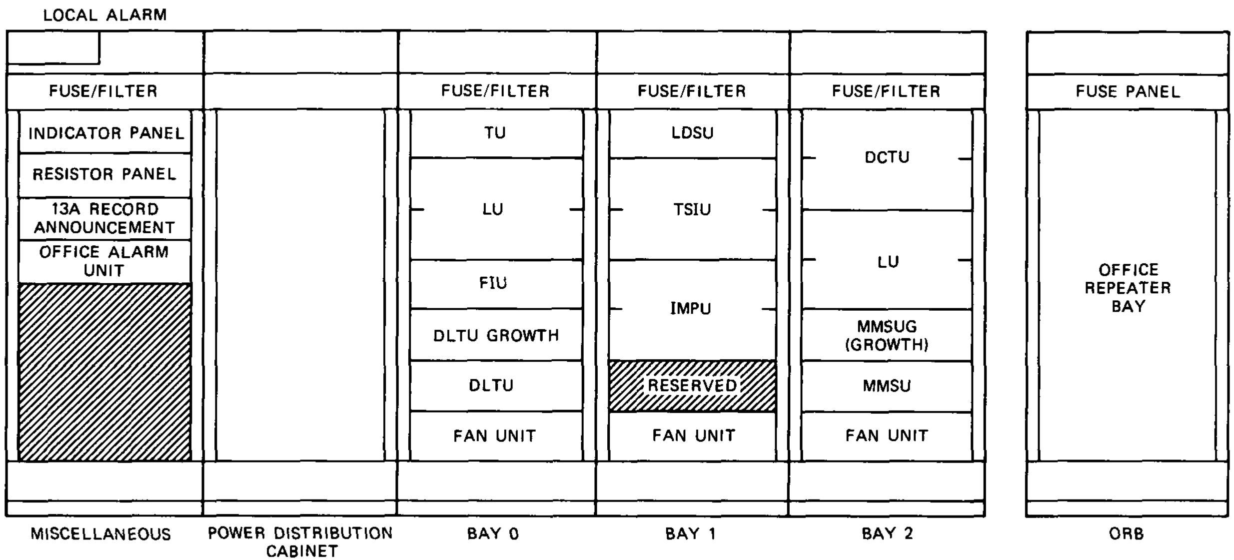
NOTE 1: A T1 DIGITAL CARRIER LINE IS A TRANSMISSION FACILITY THAT OPERATES AT A DS1 RATE (1.5444 MHz). A T1 LINE PROVIDES TWENTY-FOUR, 64-kb/s CHANNELS. TWENTY-THREE OF THE 24 CHANNELS ARE DATA CHANNELS, WHILE THE 24TH CHANNEL CARRIES CHANNEL-ASSOCIATED SIGNALING FOR THE OTHER 22 CHANNELS.

NOTE 2: ONE DLTU CAN BE EQUIPPED WITH 10 DFIs. A MINIMUM OF 4 AND A MAXIMUM OF 20 DFIs ARE REQUIRED FOR NORMAL OPERATION OF AN RSM.

NOTE 3: MULTIPLEXER A OR B CAN RECEIVE DATA FROM A MAXIMUM OF 10 FIDBs. EACH PIDB TRANSMITS/RECEIVES 32 TIME SLOTS OF 16-BIT SERIAL DATA TO/FROM THE DFI DURING AN NCT FRAME.

NOTE 4: THE MULTIPLEXER WILL TRANSMIT AND RECEIVE DATA WORDS OVER 2 FOUR-WIRE BUSES IN FOUR SEQUENTIAL 4-BIT NIBBLES.

Fig. 22— 5A remote switching module.



DCTU – DIRECTLY CONNECTED TEST UNIT
DLTU – DIGITAL LINE TRUNK UNIT
FIU – FACILITIES INTERFACE UNIT
IMPU – IMPROVED MODULE PROCESSOR UNIT
LDSU – LOCAL DIGITAL SERVICE UNIT
LOCAL ALARM – REMOTE SWITCHING MODULE STATUS ALARM UNIT
LU – LINE UNIT
MMSU – MODULE METALLIC SERVICE UNIT
MMSUG – MODULE METALLIC SERVICE UNIT GROWTH
ORB – OFFICE REPEATER BAY
PDC – POWER DISTRIBUTION CABINET
TSIU – TIME-SLOT INTERCHANGE UNIT
TU – TRUNK UNIT

Fig. 23—5A remote switching module with 1024 line terminations.

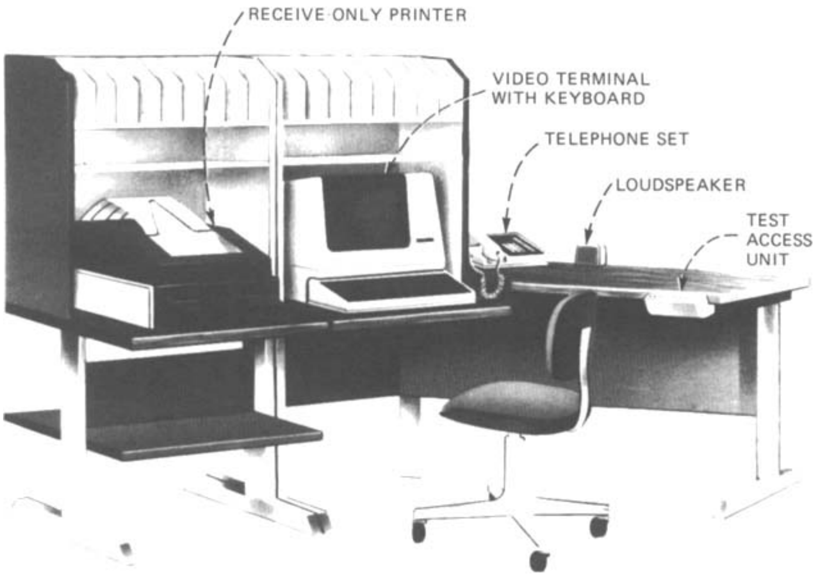


Fig. 24—MCC/TLWS console.

5.7.5 Other equipment

Other equipment includes an Office Repeater Bay (ORB), DSX-1 digital cross-connect facility, battery plant, distributing frame, etc. (see Fig. 23 for 1024 RSM equipment). The ORB supplies signal equalization, regeneration, and T1 line powering. The ORB is connected to a DSX-1 facility that provides test access to the T1 lines.

5.8 Master control center/trunk line work station

The MCC provides the interface capability for both administrative and maintenance tasks. The MCC is the primary communication link between maintenance personnel and the *5ESS* switch. The Master Control Center/Trunk Line Work Station (MCC/TLWS) console (see Fig. 24) and MCC/TLWS 6-foot cabinet (see Fig. 25) contain the following major components:

1. Video Display Terminal (VDT) with keyboard (color terminal option is also available)
2. Receive-Only Printer (ROP)
3. Multiline Telephone Set (MLTS) equipped with loudspeaker
4. Test Access Unit (TAU).

The video display terminal provides the means to communicate with the system during performance of a maintenance task. Maintenance requests are input through the keyboard, and the receive-only printer prints a hard copy of input and output messages for future reference.

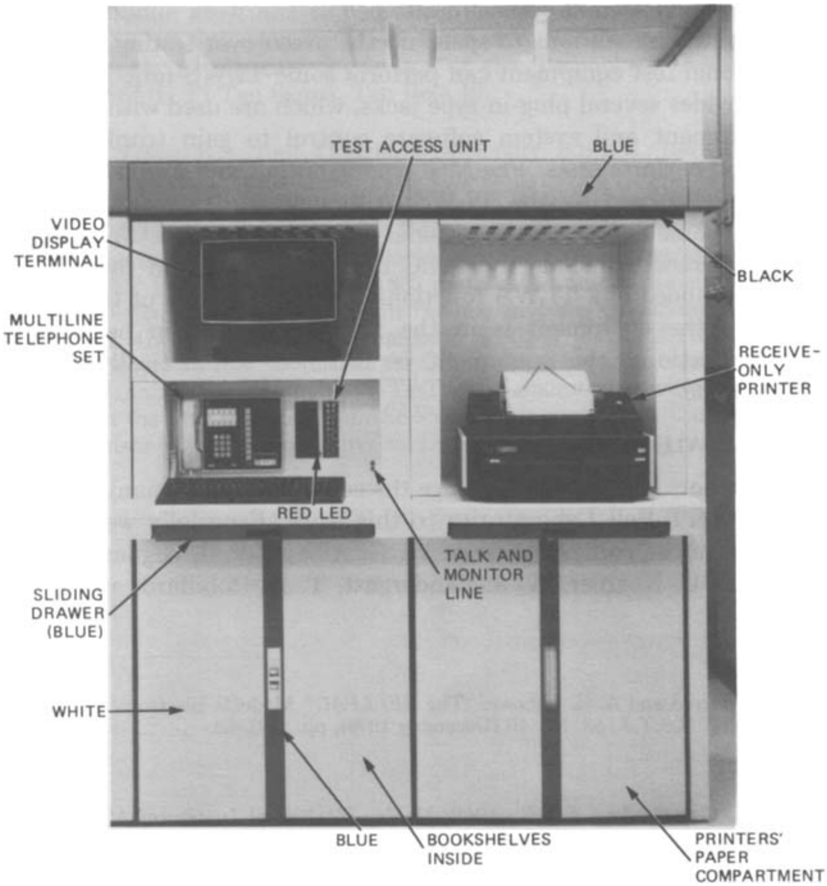


Fig. 25—MCC/TLWS/STLWS cabinet.

The MLTS is used to provide a general-purpose business line, and a TEL A Mon and TEL B Mon line, which is used to provide testing of the network. The MLTS can be used independently of the same central office, thereby ensuring outside communication during office outage. The MLTS is equipped with a loudspeaker to provide voice communication when maintenance personnel require hands-free operation.

The MCC/TLWS shares the same physical equipment as a fully equipped Supplementary Trunk Line Work Station (STLWS). The ROP, MLTS, and TAU are optional equipment for the STLWS only.

The STLWS enables a *5ESS* switch to be equipped with additional TLWSs (maximum of six) that are separate from the MCC. The operating company can then separate trunk and line testing activity from the MCC so that several crafts people can work simultaneously at different work stations to speed up the precutover testing.

Additional test equipment can perform some TLWS functions. The TAU provides several plug-in type jacks, which are used with portable test equipment and system software control to gain trunk or line access and perform tests. The MCC input/output and display conventions are also used by the TLWS. Although the TLWS and MCC share the same equipment, functional differences exist between them. These differences include the MCC functions mode and the TLWS functions mode. The TLWS functions are subfunctions of the MCC. Normally, the equipment is in the MCC mode. When performing TLWS functions, the equipment is switched automatically to the TLWS mode.

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