

**NO. 1 ELECTRONIC SWITCHING SYSTEM
ARRANGED WITH DATA FEATURES
GENERAL DESCRIPTION**

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1. GENERAL

1.01 The purpose of this section is to describe, in brief and general terms, the No. 1 Electronic Switching System Arranged with Data Features (No. 1 ESS-ADF).

PURPOSE

1.02 The ADF system is a store-and-forward message-switching data system which is an extension of the original No. 1 ESS. The block diagram of Fig. 1 presents the relationship of the ADF data handling system to No. 1 ESS. The ADF system is designed to provide flexible, efficient, dependable, and maintainable service for handling data traffic.

SYSTEM CHARACTERISTICS

A. Access to System

1.03 The customer gains access to the ADF system via hard-wired teletypewriter (TTY) links. Data sets within the customer premises are connected to data sets in the central office via the control

serving test center (CSTC). The function of the CSTC is similar to that of the toll testboard in voice communications since the CSTC provides a method of monitoring the service quality. The block diagram of Fig. 2 shows the relationship of the CSTC to the customer and the central office.

B. Capacity

1.04 Each ADF central office will accommodate nominally 3000 full-duplex lines, including high-speed trunks. The input-out subsystem will handle asynchronous (start-stop) codes at rates up to and including 150 words per minute (wpm) and synchronous trunk transmissions at 2400 bps. The following rate/code combinations are available to the customer:

- 100 wpm 5-level
- 100 wpm ASCII (American Standard Code for Information Interchange)
- 150 wpm ASCII (10-bit code, 8 information plus start and stop)

1.05 All message traffic through the ADF system is routed through an in-process storage unit called the primary message store with a capacity of approximately 60 million bits.

C. Service Features

1.06 Many service features are provided on an optional basis since service features are directly related to customer needs. The available features are those which meet the basic TTY requirements of Bell System customers. Access lines terminate directly on the No. 1 ESS-ADF (Type I access). The offices are fully interconnected by high-speed data trunks shared by all customers on a common usage basis. Customer privacy is provided through programming.

Customer Service Features

Station Service Arrangements

1.07 For each station the customer may select originate-only, originate-terminate, or terminate-only service.

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Automatic Station Operation

1.08 The ADF system will automatically pick up a message prepared for transmission without attendant attention at the sending station, as well as automatically provide for message reception at unattended receiving stations.

Multiline Hunting Groups

1.09 The ADF system has the capability of delivering messages to any one of a group of stations (each of which is served on a single station line) by using a terminal hunting process. Messages addressed to the group as a whole will be delivered to an idle station within the group, whereas a message with a particular station address will be delivered to the addressed station.

Code Conversion

1.10 The ADF system will accept traffic from and deliver traffic to stations operating in either ASCII (8-level with the eighth level being a parity bit) or Bell System 5-level data codes. The ADF system will also provide code conversion between ASCII and Baudot codes.

Speed Change

1.11 Any one of the input data rates as listed in 1.04 can be handled by the ADF system. The system will provide rate conversion among stations operating at these different speeds.

Privacy

1.12 Privacy prevents delivery of any message to an unauthorized customer. The customer must designate the station(s) eligible to receive messages of a private nature.

Error Control

1.13 For stations using the ASCII format, the ADF system will use parity checks as a

method of error control for the customer. When an error in transmission is detected, an error-indicating character will be printed out at the receiving station.

Mnemonic Addresses

1.14 Mnemonic (arbitrary combination of letters and numbers) address codes will be recognized by the ADF system and will be used to route messages to the proper destinations. The customer may select a number of different codes, each of which may include up to seven characters. In addition, a given destination may have more than one code assigned.

Call Directing Codes

1.15 The ADF system will recognize call directing codes (CDCs) on messages from 5-level half-duplex stations. For these stations, a given destination location may have more than one CDC assigned; however, any CDC must designate a single destination station. The CDCs are assigned by the customer.

Group Code Addresses

1.16 Group codes are mnemonic codes which address a specific combination of stations. Group codes will be recognized by the ADF system and will be used to route messages to the destinations indicated by the group code. The group code is selected by the customer and may consist of up to seven characters.

Multiple Addressing

1.17 The ADF system will handle originated messages with essentially an unlimited number of destination addresses. The destination address may be a mnemonic address code, a group code, or a CDC (for 5-level half-duplex stations only).

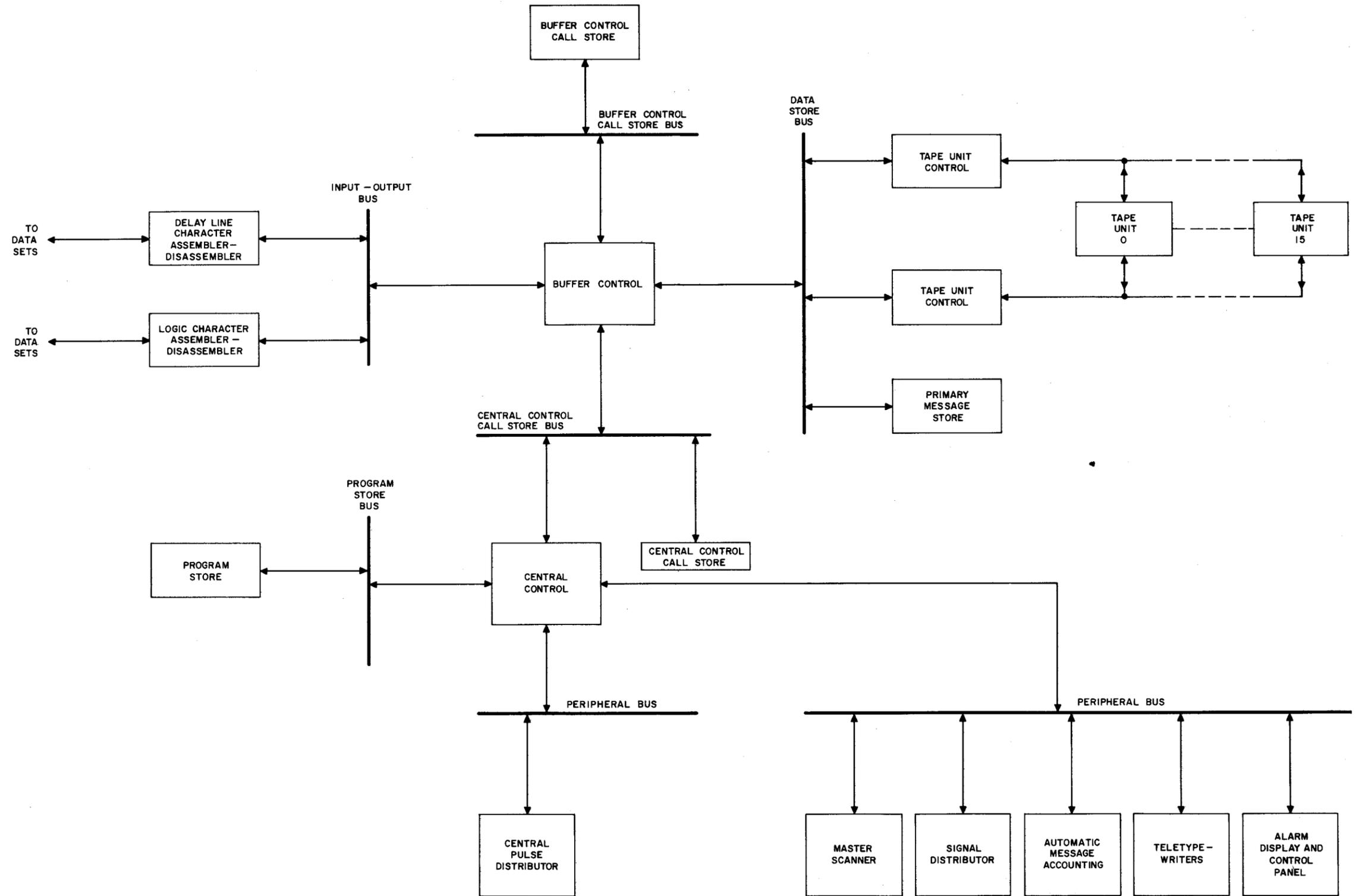


Fig. 1—No. 1 ESS-ADF Functional Block Diagram

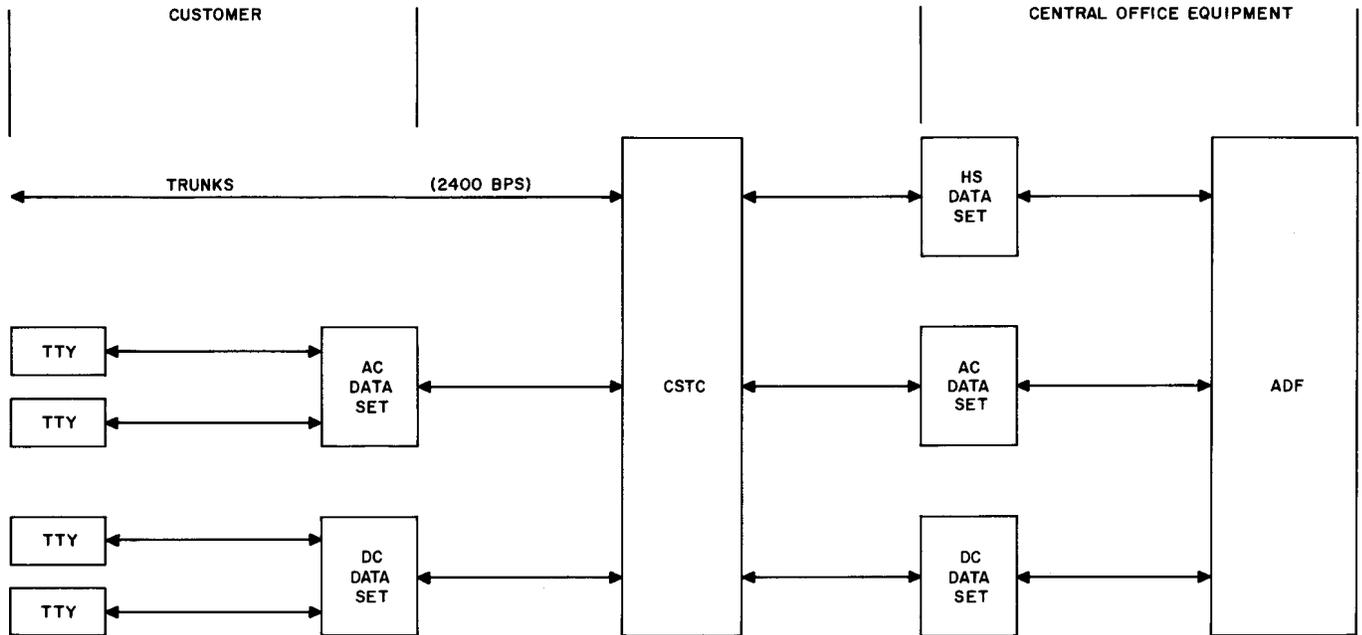


Fig. 2—Control Serving Test Center and Data Set Interfaces

Precedence

1.18 The ADF system will queue (form a waiting list in temporary storage) messages for delivery to terminating stations and will rank messages for delivery according to the following levels of precedence:

PRECEDENCE LEVEL	NUMERIC DESIGNATOR
URGENT	1
RUSH	2
NORMAL	3
DEFERRED	4

The numeric precedence assigned by the message originator to each mnemonic code of the message heading affects only the delivery of the message to that address by the terminating ADF office.

Personal Address Information

1.19 For stations using the ASCII format, the customer may supply up to 31 characters of personal address information for each mnemonic address code or group code in each message heading. Personal address information is supplied

by a message originator for use only at a destination location.

Customer Message Identification

1.20 The customer may elect to include a sequence of from one to seven characters within the message heading for the purpose of message identification. The use of customer message identification is possible for both 8-level and 5-level full-duplex stations.

Message Numbering

1.21 The ADF system provides a message numbering service on an originating machine basis and on a terminating machine basis. Originating message numbering is optional on a per-station basis for both 8-level and 5-level full-duplex stations. Terminating message numbering is required for all stations.

Date and Time Services

1.22 The ADF system provides as an option an originating and terminating date and time service. When used, the date and time will be provided as a group and will follow the message number (if provided). Time will be indicated on a

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24-hour clock with the customer specifying the time zone desired.

Delivery of Originator Nontext Information

1.23 The delivery (or optional selective deletion) of message originator nontext information to terminating stations is governed by both originating and terminating options. Normally, the information units that may be delivered (as nontext information) will consist of the originating message heading, relevant address (mnemonic or group code, precedence designator, and personal address information), and customer message identification. Options vary for 5-level and 8-level stations and also for half-duplex and full-duplex per-line or per-station configurations.

Tabbing

1.24 The ADF system will provide an appropriate time interval after transmitting tabbing or form-feed characters such that the receiving terminal may perform the mechanical functions with a minimum of delay. This option applies to 8-level stations.

Customer Control Locations

1.25 A customer may select stations (within the customer set) to perform customer control functions, to receive control and status information, and to receive undeliverable messages. The three types of control stations will be designated as the customer supervisory position, status printout position, or customer completion position. A station may be assigned more than one of the above functions; only the customer supervisory position function requires transmitting capability.

Status Printouts and Traffic Statistics

1.26 The ADF system will compile and send status reports and traffic statistics to the status printout position. Status reports may be delivered periodically (as a summary), on request, or on occurrence. Traffic statistics are delivered daily or monthly. Contents of these reports vary with options.

Treatment of Undeliverable Traffic

1.27 A message becomes "undeliverable" when the message has been accepted by the ADF

system (origination was valid) but which cannot be delivered to the intended destination. When a message becomes undeliverable to the intended station, the ADF system will reroute the message to a suitable alternate and will add on a service message which indicates (if known) the addressee to whom the message could not be delivered.

Skip in Polling Sequence

1.28 The ADF system will place any normally polled station on "skip" and will also take the station off skip and resume normal traffic upon TELCO request, CSTC request, or customer control position request. A station is on skip when ADF system is not picking up traffic according to the polling list.

Intercept

1.29 The ADF system will place any station on or off intercept at the request of the affected station, CSTC, TELCO, or the customer control station. When, temporarily, no attempt is being made to send messages to a given station and instead these messages are being stored, the station is on "intercept." All messages destined for a station while it is on intercept will be stored. For high precedence messages, an action copy will also be sent to the appropriate control station.

Alternate Delivery

1.30 At the request of the customer, the ADF system will intentionally reroute all messages addressed to one station to a different specified CSTC, TELCO, or customer station. The station precluded (by alternate delivery) will be returned to normal message reception at the request of the customer.

Permanent Message File

1.31 The ADF system will store message traffic for specified periods of time in a magnetic tape file which accommodates message retrieval.

Message Retrieval

1.32 The ADF system will provide for retrieval of messages (or groups of messages) sent or received by customers within a specified time interval. A service message will accompany each retrieved message. The service message will

identify the copy of a retrieval and will include the message number used in the retrieval request and the pertinent station identify.

Telephone Company Service Features

Directory Numbers

1.33 Every station will have a 10-digit directory number unique within the system plan. The ADF system will accept messages addressed with directory numbers from TELCO stations and will route these messages to proper stations.

Journal File

1.34 The ADF office will retain a file of all message-switched transactions including incompletions attempted at that office. The files will contain such information (which can be retrieved by a TELCO position) as originating and terminating identity, date and time of origination and termination, message numbers, final disposition, message length, and any other information necessary to facilitate message tracing.

Permanent Message File

1.35 The ADF system will store messages in a file accessible to the TELCO attendant for message retrieval.

Message Retrieval

1.36 The ADF system will provide message retrieval at the request of the TELCO position.

Traffic Statistics

1.37 The ADF system will provide compiled traffic statistics and equipment usage statistics for message-switching studies periodically and at the TELCO request.

Status Printouts

1.38 The TELCO position may request any status information obtainable by any customer station.

Service Observing

1.39 The ADF system will produce and record service observing data with respect to traffic handled in order to provide an indication of grade of service.

Intercept of undeliverable Traffic

1.40 When a message is undeliverable to a given address, it will be delivered to a designated ADF intercept position which may be the originator, customer control, or TELCO position.

Charge Recording

1.41 Service and feature usage (by the customer) is automatically recorded for charging purposes.

D. System Concepts

Stored Program Control

1.42 The ADF system functions are controlled by programs which consist of appropriate combinations of instructions. The program instructions, suitably encoded, are stored in a memory unit from which they are read out one at a time into the control circuitry for execution. Consequently, system operation can be altered considerably by program changes without any circuit modification.

Functional Concentration

1.43 The ADF system equipment, in addition to the modified No. 1 ESS equipment, is concentrated into a number of highly efficient units, each of which is categorized into a broad system function such as input-output, control, memory, and storage. The net result is a total system organization which, in concept, is relatively simple.

Time-Shared Control

1.44 The operation of all system units is controlled by programs and wired logic. The use of ESS devices allows the system to operate at speeds much higher than the rate at which events associated with a single message can occur. This permits the control equipment to be time shared by all the messages which the system handles. Time sharing is accomplished by subdividing the work required to process a message into small segments which are interwoven with segments associated with

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other messages in process. In addition, certain operations are performed concurrently on behalf of a number of messages.

Modular Design

1.45 A modular block concept is used for traffic-dependent units so that growth can be accommodated economically and conveniently.

Plug-in Equipment Units

1.46 In a major portion of the ADF system, circuit packs are used. The use of these circuit packs, which have components mounted on printed wiring boards that plug into the equipment, facilitates maintenance and replacement of faulty units.

Duplication and Automatic Maintenance

1.47 The primary purpose of duplication in the ADF system is to provide reliable, continuing service. Under normal conditions both units of a duplicate pair operate side-by-side in response to the same input information but only one of two is operating on active status. By continuously comparing the outputs of duplicate units and by other means such as error detecting codes and system monitor checks, it is possible to detect the existence of a system malfunction. The unit at fault is automatically identified by appropriate programs and is taken out of service. While the system continues to provide data handling service, an appropriate diagnostic program submits the faulty unit to a thorough sequence of tests. Test results are printed out by a system TTY. A trouble locating manual translates the diagnostic printout into the identity of the plug-in unit(s) at fault.

2. SYSTEM DESCRIPTION

GENERAL

2.01 The organization of the system is given in functional lines in the block diagram of Fig. 1. The individual functions of the units will be described in the order in which data progresses through the system so far as is practical for discussion purposes. A unit description is given prior to a discussion of data flow through the system.

2.02 The number of equipment units is traffic dependent except for the buffer control, central control, and the master control center. Duplication and traffic dependence are two entirely distinct considerations. The buffer control, for example, is not traffic dependent but is fully duplicated. A single buffer control is sufficient for all office sizes but a duplicate is provided for reliability. A brief functional and physical description for each unit is given in this part.

UNIT DESCRIPTION

A. Data Sets

2.03 The data sets used between the control serving test center and the ADF office are low current, balanced to ground, constant-impedance type pulsers. These data sets perform the conversions between the line signals and the augmented (higher voltage level) low-level logic signals used by the line facility subassembly. Most local loops are connected by dc data sets; longer distances require the use of ac data sets. High-speed data sets (Fig. 3) are provided for interoffice trunks. The block diagram of Fig. 2 illustrates the data set interfaces.

B. Line Facility Subsystem

2.04 The purpose of the line facility subsystem is to accept and generate data streams passed between subscribers and switching centers. The line facility units convert serial data into parallel characters suitable for storage and processing in the digital system and reconvert the parallel characters into serial form for transmission.

2.05 There are two types of character assembler-disassembler (CAD) units used in the line facility subsystem. The delay line character assembler-disassembler (DCAD) provides the input-output interface between customers and the switching centers. The logic character assembler-disassembler (LCAD) provides the input-output interface between switching centers and trunks.

2.06 Both the DCAD and LCAD have duplicated control logic and unduplicated per-line terminals. Both units are match circuits (within the control logic) for maintenance purposes and for error control. In addition, each type has its own temporary data storage which provides time buffering for the input-output interface. The

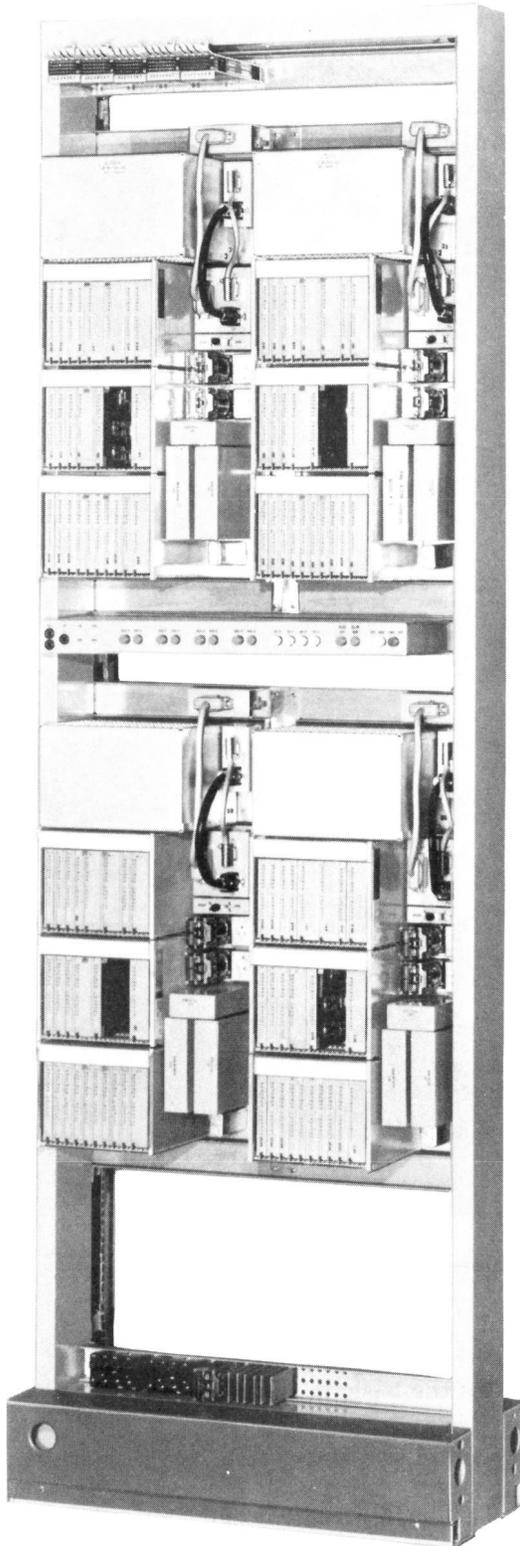


Fig. 3—High-Speed Data Set Bay

number of particular CAD units used in any one office depends on traffic requirements and the maximum data handling capability for that office.

Delay Line Character Assembler-Disassembler

2.07 The DCAD handles low-speed transmissions and uses aluminum strip ultrasonic delay lines for in-process data storage (Fig. 4). The DCAD consists of five bays of equipment. Three bays are occupied by control circuitry and each of the two remaining bays accommodates 256 full-duplex lines from data sets for a total capacity of 512 lines. A maximum capacity ADF office can handle up to five DCAD units. The basic DCAD is shown in the block diagram of Fig. 5.

Logic Character Assembler-Disassembler

2.08 The LCAD is used to handle high-speed trunk transmissions and uses low-level logic for processing and storing data (Fig 6). The LCAD consists of six bays of equipment. Two bays contain the common control logic and each of the remaining bays provides termination for four intercenter trunks which gives a total of 16 full-duplex trunks for each LCAD. A maximum capacity ADF office can handle up to eight LCAD units. The block diagram of the LCAD is shown in Fig. 7.

C. Buffer Control Community

Buffer Control

2.09 The purpose of the buffer control (BC) is to relieve central control of a large number of repetitious routine tasks and to provide buffering and timing compatibility between the central control normal cycle time and various rates of other units. The BC performs the following major functions:

- (a) Receives TTY and data characters from the line facilities and assembles them into computer words.
- (b) Monitors the data for special characters and control words.
- (c) Performs error control operations on the data.
- (d) Acts as a buffer in controlling the transfer of messages to and from the primary message store and the tape subsystem. These units

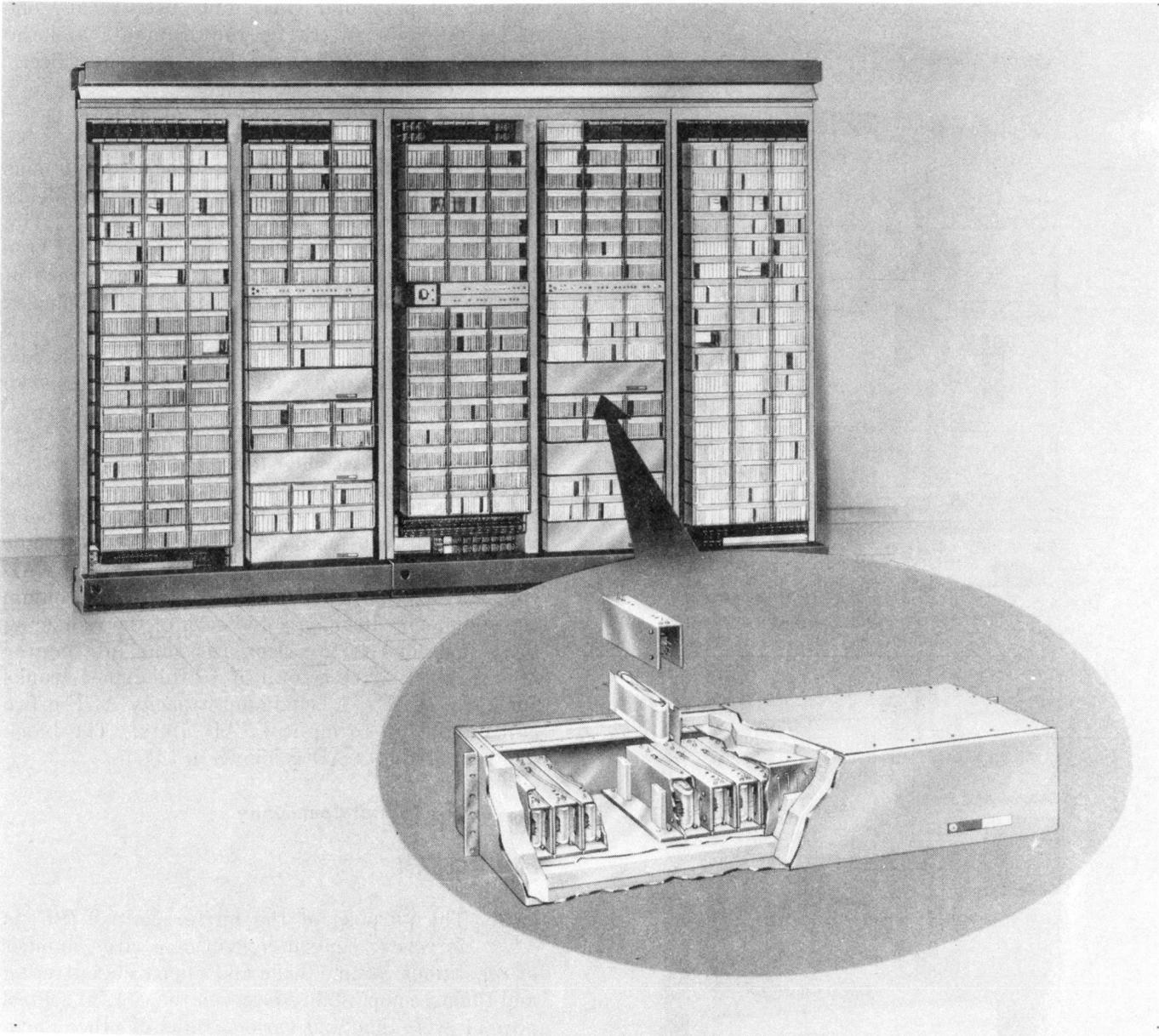


Fig. 4—Delay Line Character Assembler-Disassembler

require that the data be transferred at a rate and time dictated by the rotation of the primary message store disc or the speed of the magnetic tape.

(e) Acts as the principal interface between the No. 1 ESS central control and the remaining ADF equipment for operational and error status information transfer.

2.10 The BC is a wired logic, fully duplicated unit. Each BC consists of two double bay

frames (Fig. 8). The block diagram of Fig. 9 illustrates the basic interfaces of the BC.

Buffer Control Call Store

2.11 The buffer control call store (BC CS) is a magnetic memory unit which uses multi-aperture ferrite sheets for storage of information on a temporary basis (Fig. 10). The prime function of a BC CS is to provide temporary storage for all the message-related information processed by ADF; however, other common system storage involving

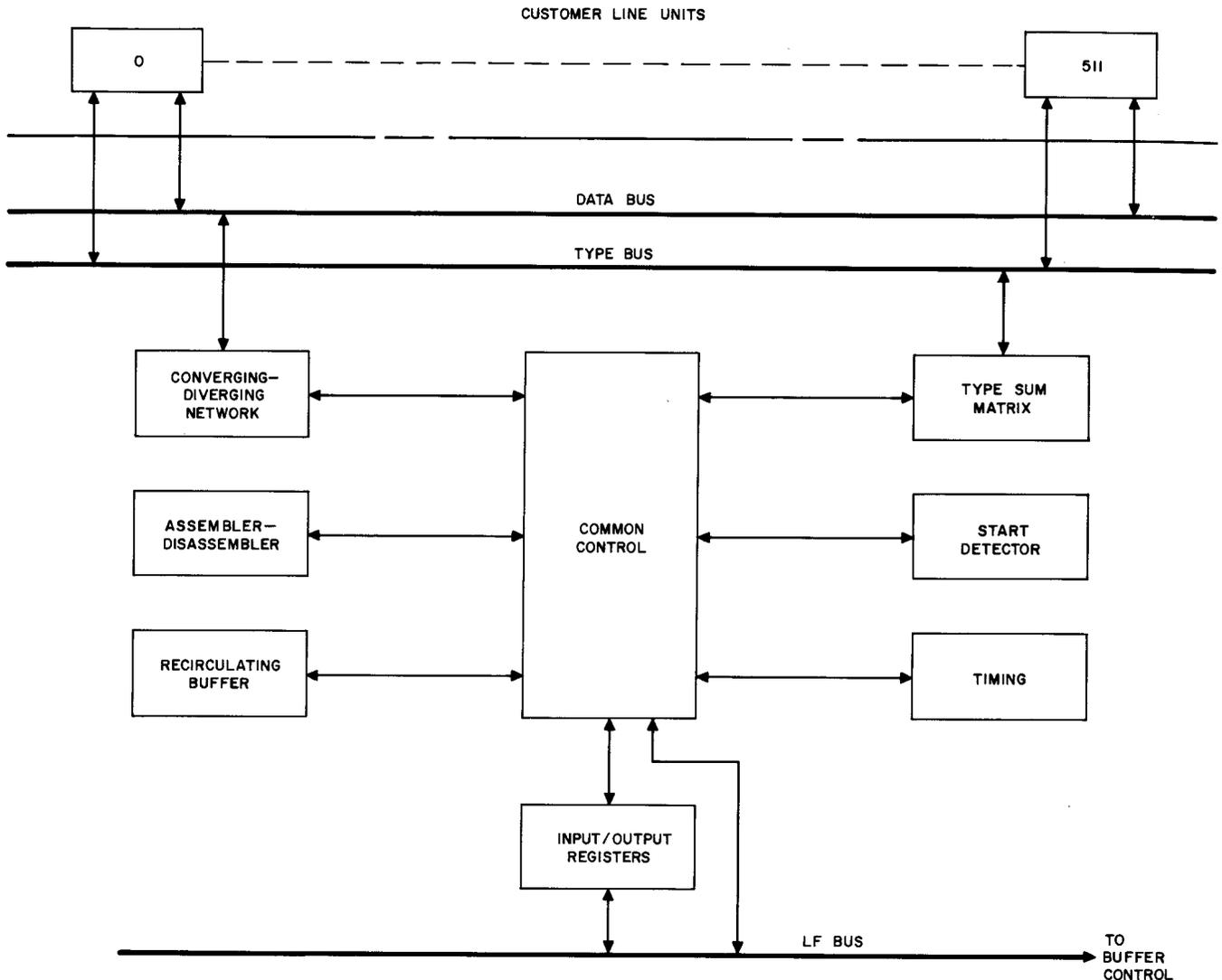


Fig. 5—Delay Line Character Assembler-Disassembler Block Diagram

administration and maintenance of the line facility community and storage communities is assigned to the BC CS. The memory area of each BC CS is split for duplication and each half-store area is addressed and manipulated separately by the program. The BC CS is a traffic dependent unit and no more than eight BC CSs may be used in one office. Each BC CS occupies one equipment bay.

Primary Message Store

2.12 The primary message store (PMS) is a duplicated, sequential access (block-oriented) memory unit which provides in-transit storage capability for the store-and-forward process of

handling messages (Fig. 11). Storage is accomplished in a disc file which consists of four double-faced rotating discs with a total capacity of approximately 60 million bits. The duplicated disc files are synchronized by a frequency-controlled servo system. The PMS performs the following functions under directions from BC:

- (a) Retains each originated message until a satisfactory delivery has been made to all addresses.
- (b) Retains all incoming traffic under emergency conditions while line load control is being initiated.

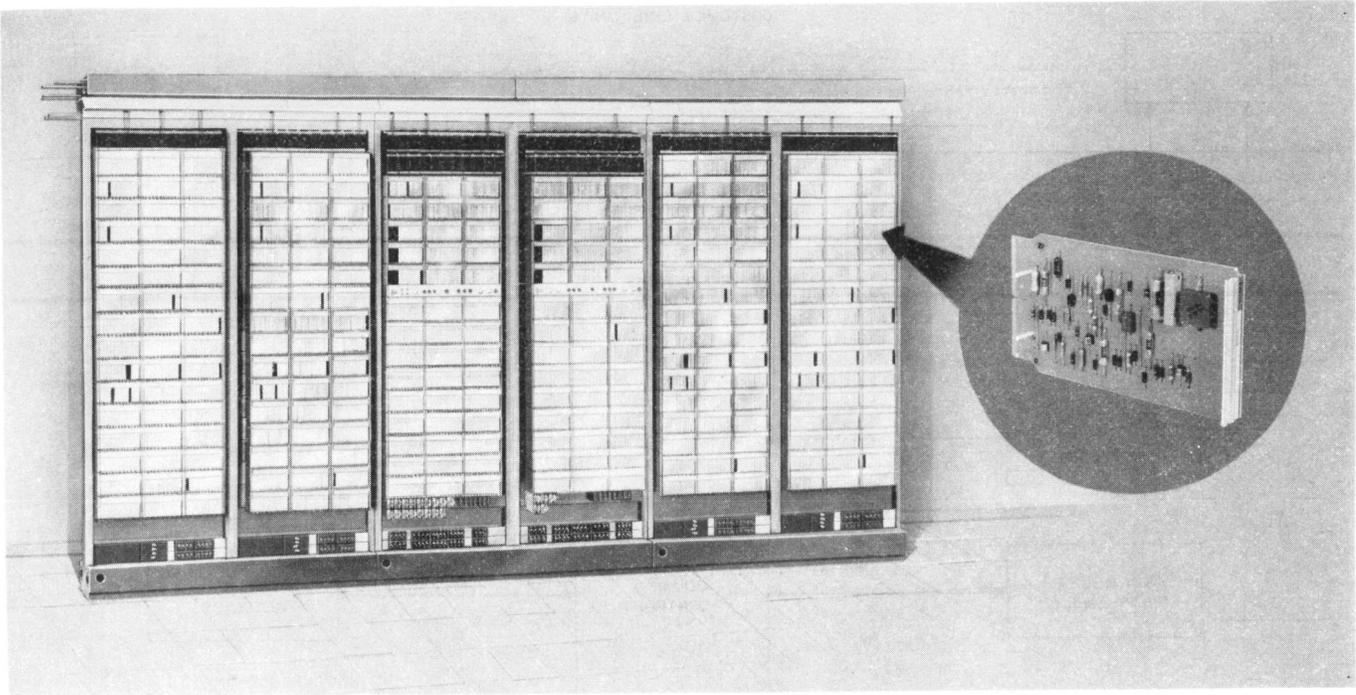


Fig. 6—Logic Character Assembler-Disassembler

(c) Retains system administration information.

2.13 Each PMS is fully duplicated and consists of three major sections:

- Memory module (KS-19672 memory disc)
- Special double bay frame with memory module enclosure, power converter, servo control logic, and associated control functions
- Standard single bay frame containing the control, read-write, and maintenance circuitry

Tape Subsystem

2.14 The tape subsystem consists of tape control units and magnetic tape recorders. The purpose of the tape subsystem is to provide a permanent message file and a journal file for messages handled by each ADF office. The function of the permanent message file is to provide high volume storage of data for an indefinite period when rapid access is not required. The journal file serves as a message log which references all messages handled by the office as well as the disposition of each message. The journal file stores message administration information and may be used

to locate messages stored in the permanent message file.

2.15 The tape subsystem has the following capabilities:

- (a) Records at a density of 800 tape characters per inch.
- (b) Uses standard 9-track ASCII format.
- (c) Records or searches at a tape speed of 56.8 inches per second (ips).
- (d) Provides high-speed rewind at a rate of 225 ips.
- (e) Utilizes magnetic tape which is one-half inch wide and is supplied in 2400-foot reels.

2.16 There are two tape unit controls supplied in each office and the maximum number of tape units which may be handled by a single control is 16 (Fig. 12). The tape unit controls operate independently; however, either control may handle the full tape unit complement. Each tape unit control occupies one equipment bay and each tape unit occupies one equipment bay. Tape units are

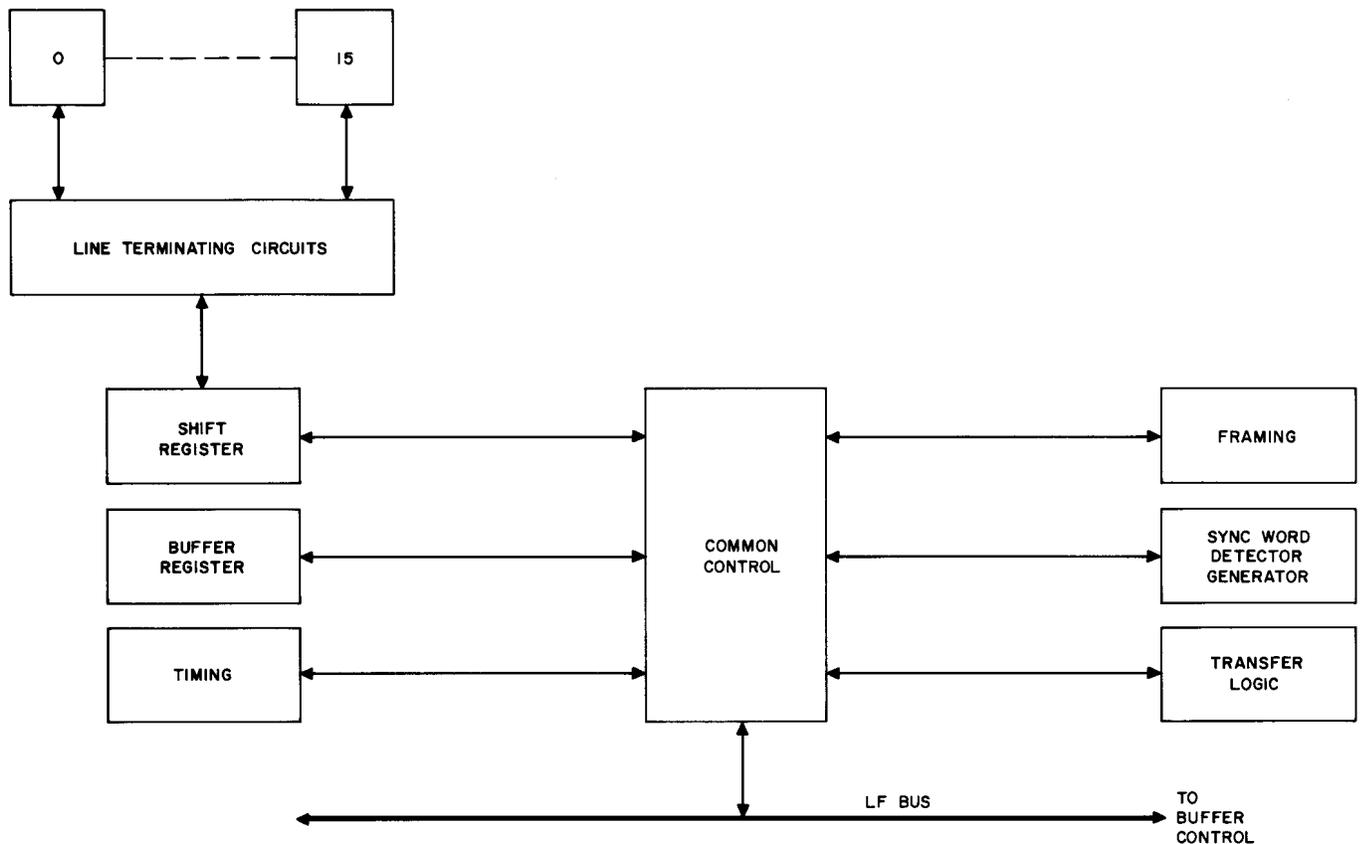


Fig. 7—Logic Character Assembler-Disassembler Block Diagram

designed for location remote from the switching center.

D. Central Control Community

Central Control

2.17 Central control (CC) is the primary information processing unit of the ADF system (Fig. 13). The CC executes instructions which are taken from the program store during a 5.5-micro-second cycle (normally). These instructions, which are presented to CC as binary words of 44 bits each, institute actions which may be either internal or external to the CC. All addresses and commands originate from the CC and all answers return to the CC; however, the CC can only execute instructions contained in the stored program. The block diagram of Fig. 14 illustrates the basic interfaces of the CC.

2.18 Two identical CCs are provided in each ADF office and each CC comprises four bays of logic circuitry. Both CCs operate continuously, one on active service with the other checking the operation. The standby unit takes control if trouble develops in the active unit.

Central Control Call Store

2.19 The CC call stores (CC CSs) provide temporary memory (by means of ferrite sheet modules) for the CC just as the BC CS provides temporary memory for the BC. These CSs are identical to those used for BC (Fig. 10). A maximum capacity ADF office can handle up to 39 CC CSs.

Program Store

2.20 The program store contains random access semipermanent program control and translation information (Fig. 15). The information consists of the programs and miscellaneous other data which

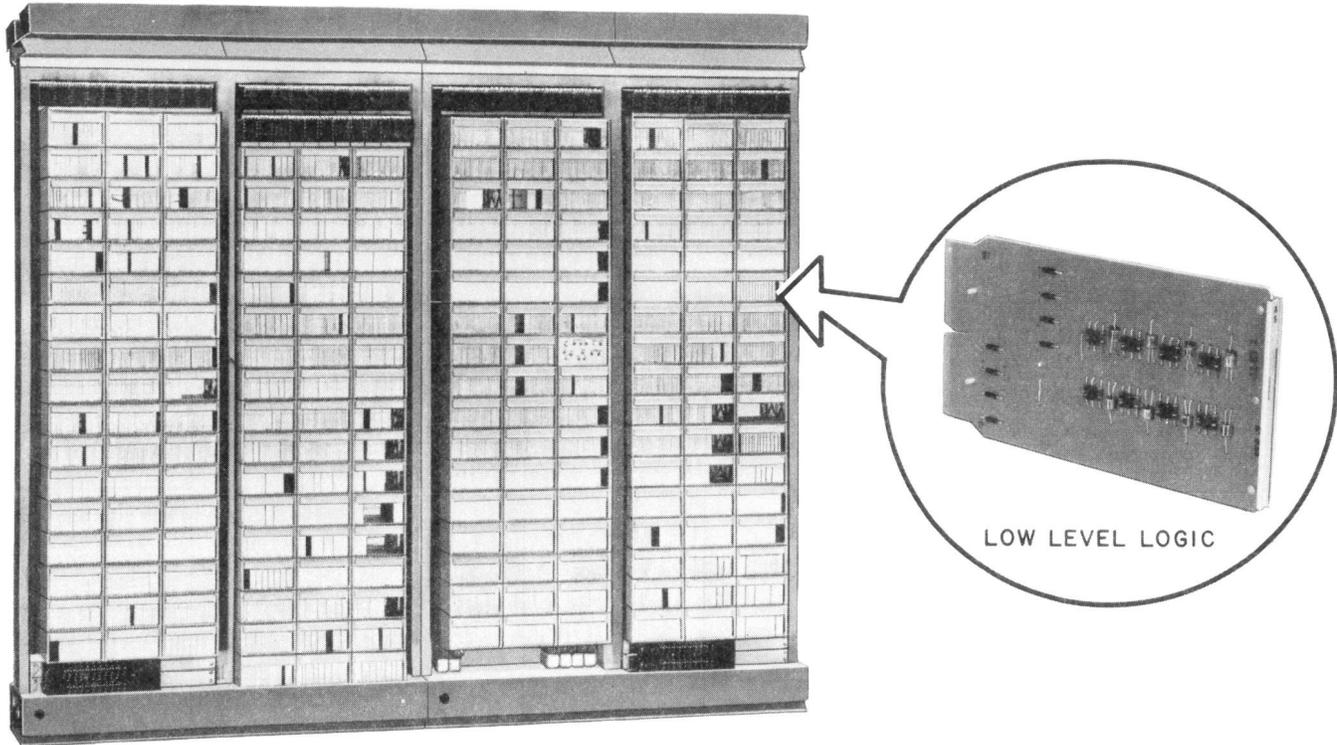


Fig. 8—Buffer Control

are used to process messages, translate line and trunk information, and to carry out diagnostic tests and maintenance procedures on the system. The program store, which is a read-out-only memory, uses twistor modules as the basic storage block. Stored information is in the form of a 44 by 64 array of bar magnets on removable cards. To change the information content, the card must be removed from the store and the new information recorded by means of a card writer. The memory area of each program store is divided into two information blocks to increase reliability by duplication. Each program store comprises five bays of equipment which includes the memory, access, control, and readout functions.

Central Pulse Distributor

2.21 The central pulse distributor (CPD) provides central control with microsecond access to many points within the system requiring high speed action signals (Fig. 16). Functionally, the CPD is a large decoder which uses diode-transformer gates as the decoding elements. Each CPD occupies one equipment bay, has a maximum capacity of 768

outputs, and is fully duplicated for reliability. A maximum of eight pairs of CPDs may be provided for each office. The units in each pair operate independently of one another.

Signal Distributor

2.22 The signal distributor provides central control with the capability to operate relays in circuits which do not require microsecond access. The supplementary signal distributor provides 1024 output terminals. In the signal distributors, the control circuits are duplicated such that either one of them can control all the outputs; however, each controller normally controls 512 outputs. The signal distributors are incorporated into standard frames (Fig. 17) and the number of signal distributors used is determined by the office size.

Master Scanner

2.23 The purpose of the master scanner is to monitor miscellaneous circuits and alarm points periodically and to detect any change in state of the ferrods from a previous scan (Fig.

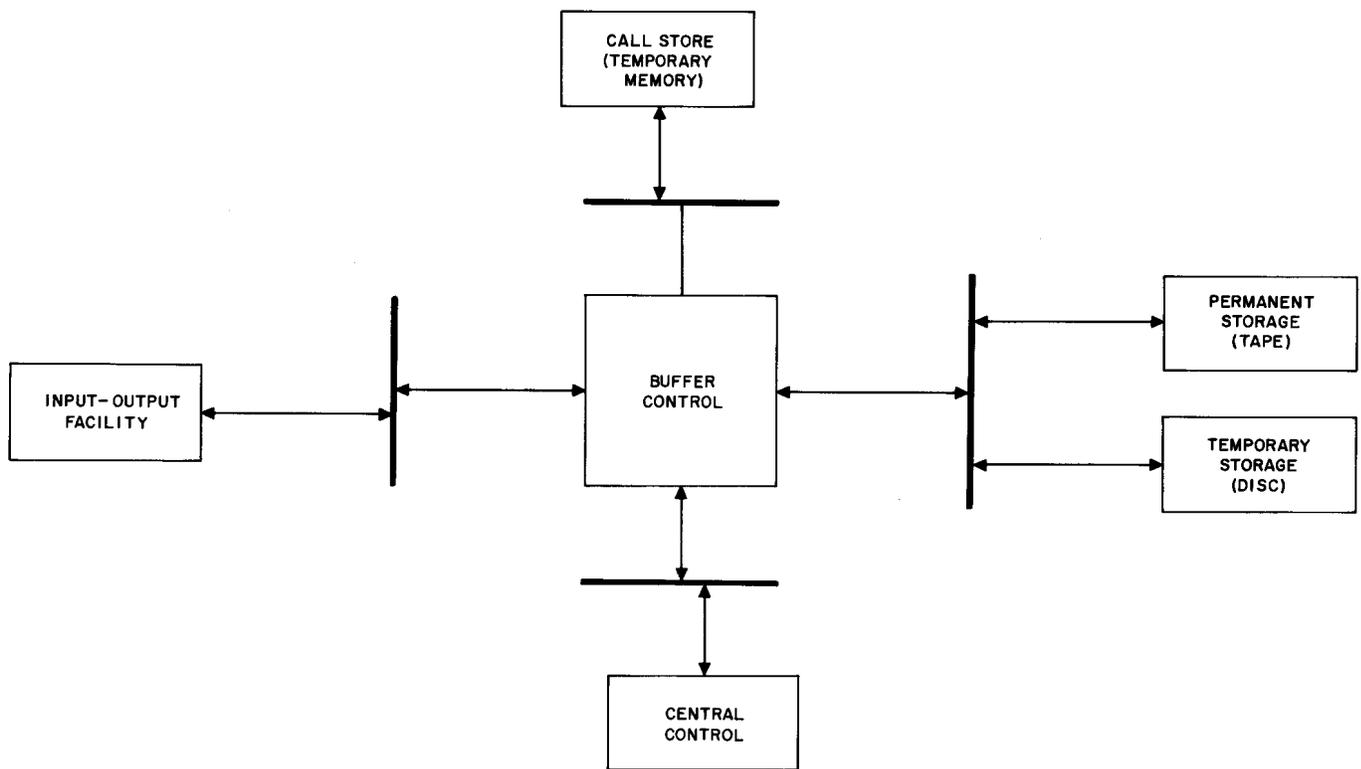


Fig. 9—Major Buffer Control Interfaces

18). The state of the ferroids will determine whether test, diagnostic, administrative, or other action responses are required.

2.24 The master scanner frame is composed of 64 rows of 16 ferroids each, which provides a capacity of 1024 scan points. The ferrod sensor is essentially a transformer with magnetic coupling between the interrogate, readout, and control windings (Fig. 19). The presence of an output is dependent upon the state of the control current. The basic inputs and outputs of the scanner are shown in Fig. 20. Two master scanner frames are always provided in each switching center, while the maximum number of scanners is traffic dependent.

E. Master Control Center

2.25 Communication between the system and its maintenance personnel is accomplished by using:

- (a) Conventional office alarm system.

- (b) Local alarm circuits, display lamps, and power control switches at individual system units.

- (c) Local and/or remote TTYs, visual displays, and manual controls at the master control center (MCC).

2.26 The MCC is the administration and maintenance center of the office and consists of the following functional sections of equipment as shown in Fig. 21.

- Control, display, and test panel
- Teletypewriter
- Automatic message accounting

Control, Display, and Test Panel

2.27 This control panel (Fig. 22) serves as the centralized control point for the system. In addition to rotary selector switches, the panel

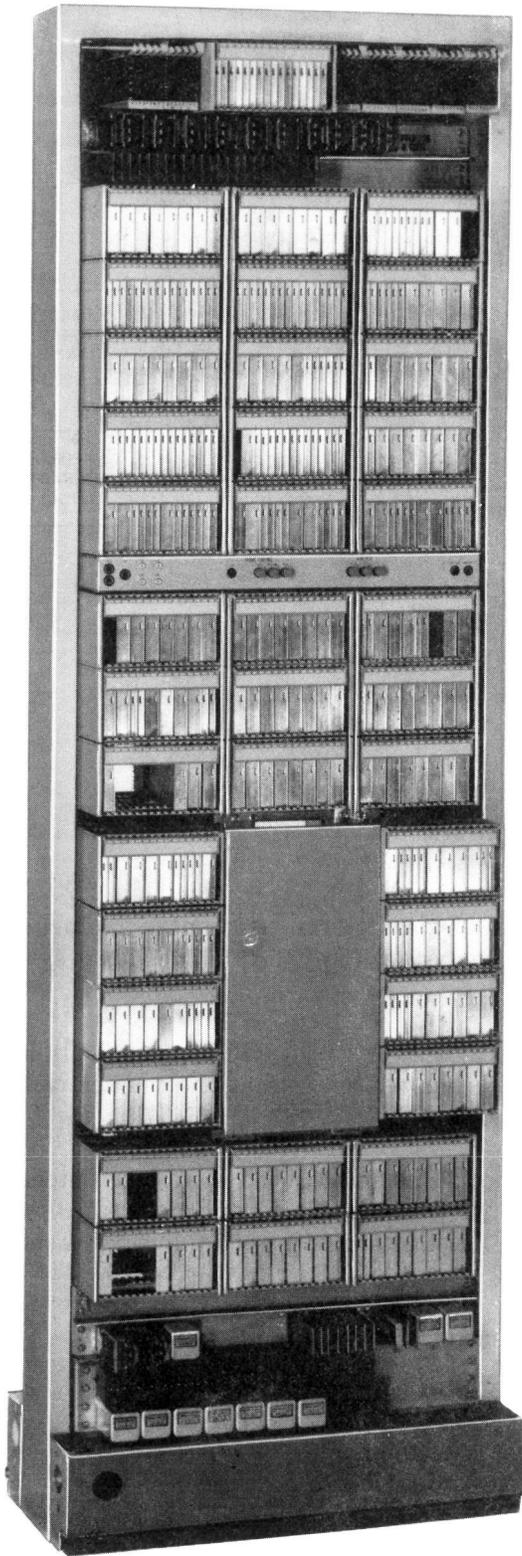


Fig. 10—Call Store

contains lamps and keys which are functionally illuminated for control purposes.

Teletypewriter

2.28 The TTYs are the primary means of communication between the system and maintenance personnel. Specific system actions are initiated by TTYs and the system reports on these actions or on various internal conditions by the same means. There is always one TTY mounted as part of the MCC. A complete description of the TTY intraoffice communication facilities is given in 2.45 through 2.53.

Automatic Message Accounting

2.29 The automatic message accounting (AMA) recorder is used to store customer charging information on magnetic tape. A duplicate AMA unit is provided for reliability and continuity of recording. Each tape transport with its associated controller (which comprise one recorder) is mounted in a standard frame (Fig. 23).

2.30 Charging data is stored temporarily in a tape buffer area in a call store. When the tape buffer area is filled (capacity of 100 words), the data is transferred to the AMA recorder. The total time required for a 100-word transfer to tape is about 950 milliseconds, including tape start and stop time.

F. Miscellaneous Units

Memory Card Writer

2.31 Because special action is required to insert new information into the program store, a portion of a call store is designated as the recent change memory area and serves to store new or changed program instructions and translation information. When enough entries have accumulated to fill the recent change memory, the card writer is used to prepare a new set of program store cards that incorporate the changes.

2.32 All 128 cards of one program store module are handled as a group by the card loader. The entire group is inserted into, or withdrawn from a program store memory module by a motor-driven magazine or loader (Fig. 24). This loader also serves as the handling and transport medium for the cards. The cards are placed in

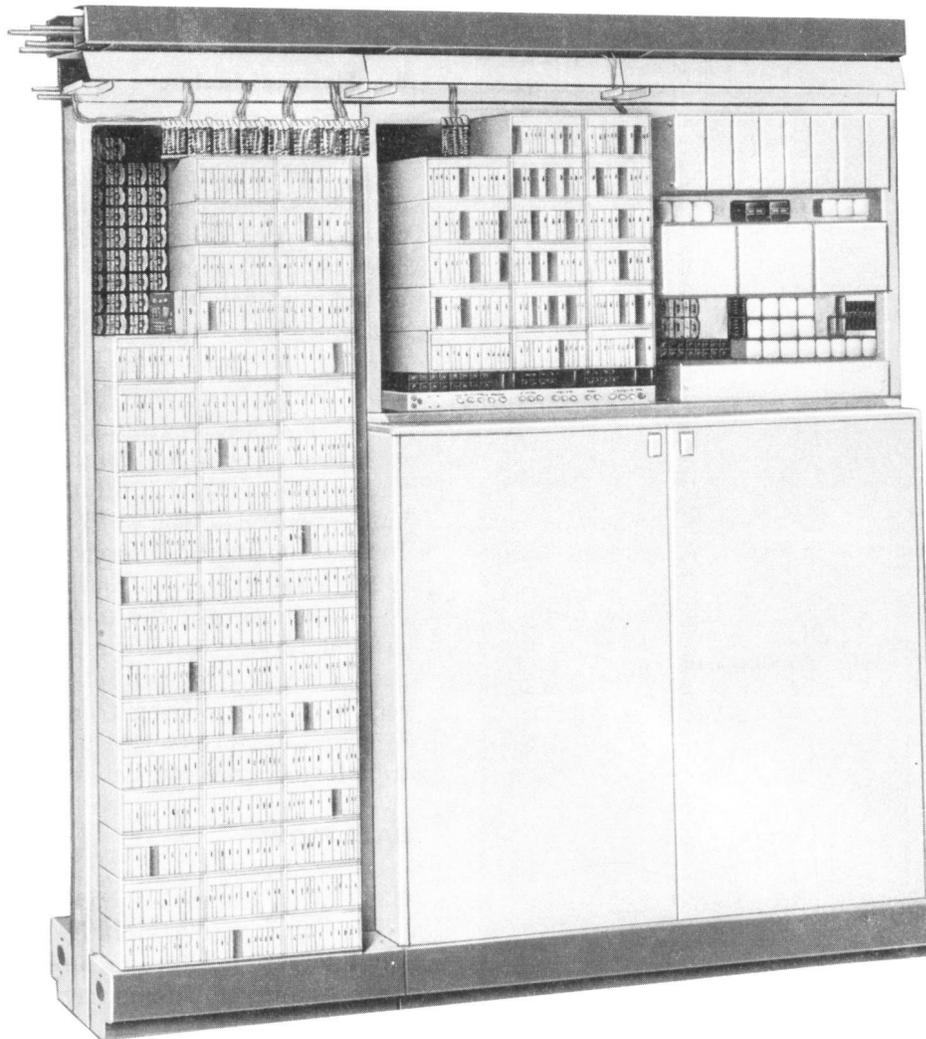


Fig. 11—Primary Message Store

the loader in two groups: 64 right-hand and 64 left-hand, alternately, with the magnet sides facing each other. The card loader is then attached to the memory card writer where each group of 64 cards is processed in sequence. Thus, two passes are required, one for each group of the cards, and the loader must be manually inverted for the second pass. The card writer withdraws one card at a time from the loader, writes the information, and reinserts the card (Fig. 25). The time required for one pass of all right-hand or left-hand cards is about 4.5 minutes.

INTERCONNECTIONS

2.33 The system units are linked by means of duplicated interconnections. Differences in function, speed, and number of units account for certain differences in the interconnection methods used for the equipment.

2.34 Information is exchanged over buses, providing common links which serve a multiplicity of units. A gating arrangement allows access to the different units using the bus. This arrangement

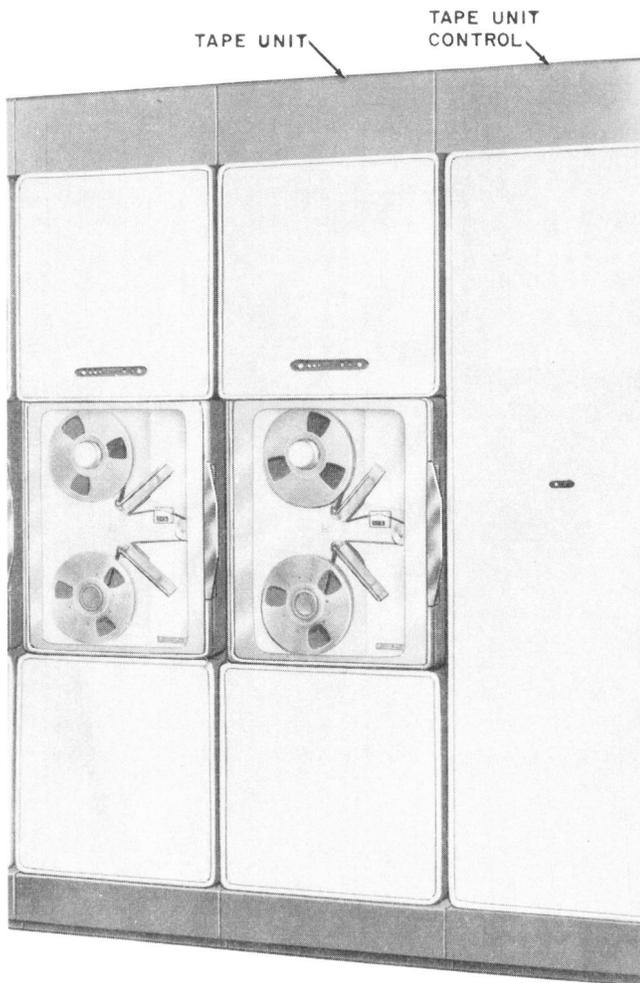


Fig. 12—Tape Unit and Tape Unit Control

eliminates the need for many individual unit-to-unit interconnections. With very few exceptions, the flow of information on any particular bus lead is always in the same direction.

A. Bus Systems

2.35 There are four major bus systems which allow buffer control to communicate with

- Line facility units
- Central controls
- Buffer control call stores

- Tape units, tape unit controls, and primary message store

B. Electrical Features

2.36 Signals are transmitted over the buses as 200-milliampere pulses of approximately 0.5-microsecond duration which may be applied as often as once every 5.5 microseconds. The buses are able to transmit high-frequency signals while being relatively insensitive to ambient electrical noise.

2.37 A separate pair of twisted 26-gauge wire (balanced-to-ground) is provided for each bit in a bus. The block diagram of Fig. 26 shows a transmitting bus pair for an address bit from the buffer control to the buffer control call stores. A 100-ohm noninductive resistor terminates the ends to minimize reflections and a center-tapped inductor is bridged across the pair to provide a path to ground for unwanted longitudinal signals. Each pair is transformer-coupled to cable drivers and receivers. The driving transformers are connected in parallel across the pair and the receiving transformers are connected in series.

DATA FLOW

2.38 The process of handling data through an ADF office includes message reception, administration, storage, and transmission. The inprocess storage (temporary) will be discussed as it is used (Fig. 27).

A. Receiving Messages

2.39 The ADF system periodically interrogates customer terminations for evidence of message origination.

2.40 As shown in Fig. 27, the incoming data is received by one of the character assembler-disassembler units. This data is converted from serial form (as received) to parallel form for processing in the ADF office. Data, assembled from the serial bit stream into parallel characters, is transferred one character at a time through the buffer control into the "input buffer word" portion of the buffer control call store. The characters are accumulated into 3-character call store words, and stored temporarily in the "input" character hopper" for access by the central control.

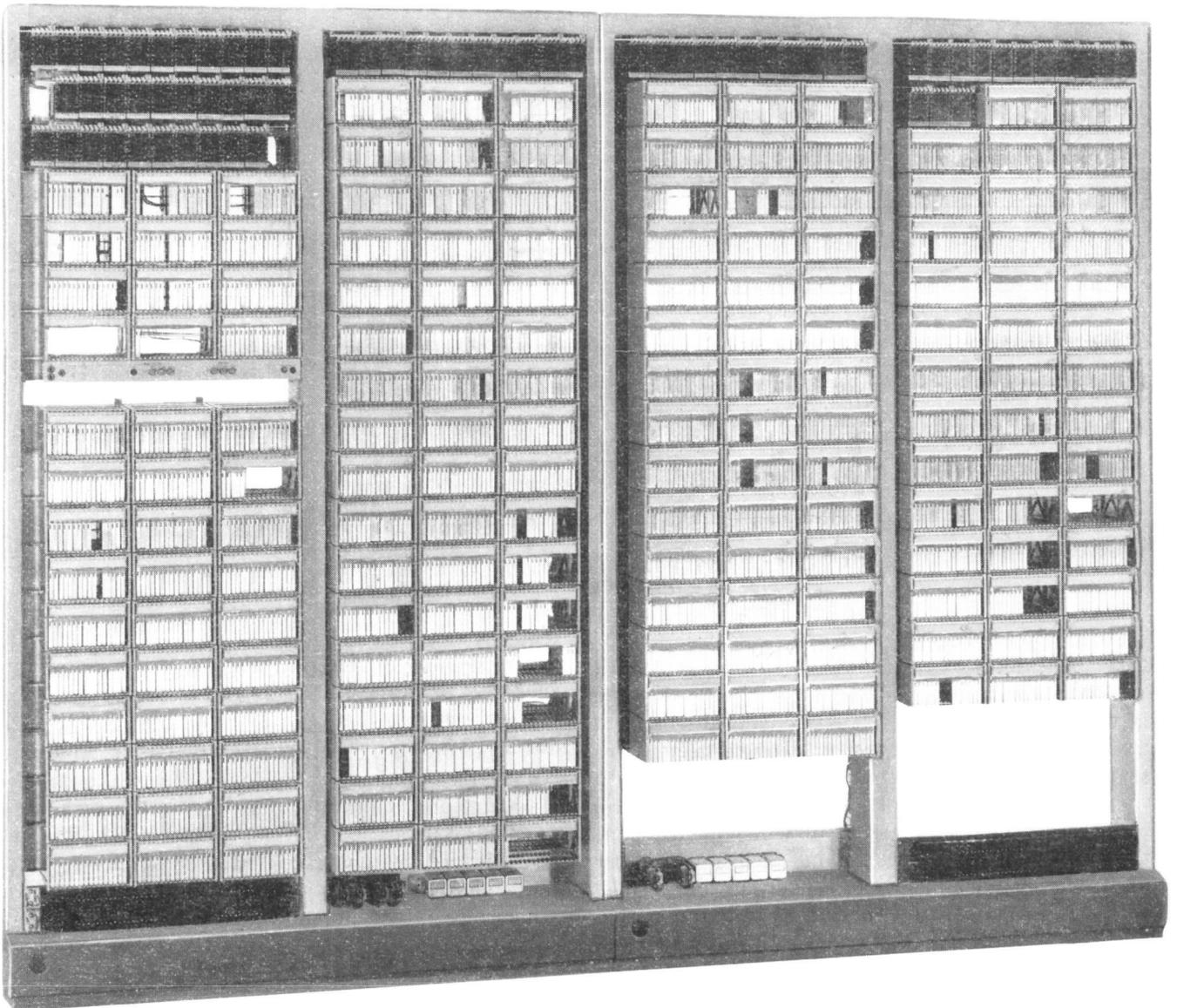


Fig. 13—Central Control

2.41 Central control reads the "input character hopper" to examine the characters and determine the line equipment number. During this process, the characters from each customer message are formed into blocks and are stored temporarily in the central control call store. After storage in the central control call store, the blocks are transferred back to the buffer control call store. From here, the blocks are transferred to the primary message store where they are placed on the disc memory for later transmission.

B. Transmitting Messages

2.42 Once the data blocks are stored in the primary message store, the central control will verify that the designated addressee is ready to receive. The blocks are now read one at a time from the primary message store and placed in the buffer control call store to remain until transferred to the central control call store for disassembly.

SECTION 8

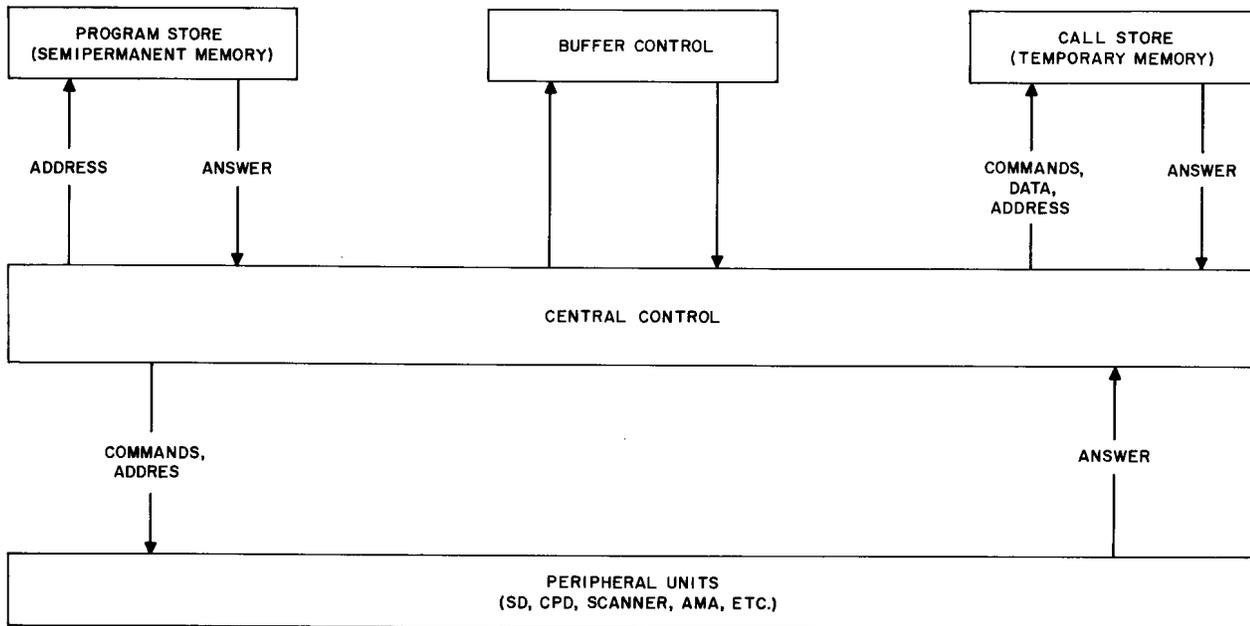


Fig. 14—Major Central Control Interface

2.43 The blocks are disassembled by the central control and are placed in temporary storage in the area of the buffer control call store known as the character output buffer. The characters are transferred from the character output buffer to the "transmit word" portion of the buffer control call store. The buffer control will now transmit the characters to the proper line facility (character assembler-disassembler) to be converted from parallel to serial format as the characters are transmitted to the addressee. If trunk traffic is being processed, buffer control disassembles blocks directly from the buffer control call store.

C. Message Storage

2.44 After central control has verified that the message has been delivered to all addresses, it directs that the message blocks be assembled in the buffer control call store. Buffer control then transfers the blocks to the tape subsystem where they are stored on magnetic tape. The tape record provides complete message storage for an indefinite period of time, as well as a journal file for all messages in storage.

INTRAOFFICE COMMUNICATIONS

2.45 The internal communications facilities provided for No. 1 ESS-ADF consist of both data and voice communication channels. Maintenance, traffic, and operational information is exchanged among four areas of primary importance: the MCC within the switching center, the switching center, the control serving test center (CSTC), and the message intercept and retrieval bureau (MIRB). The relationships among these areas are shown in Fig. 28.

2.46 Data communications are accomplished using two methods. The first method, which uses the peripheral order bus, provides for communications between the functional TTYs and the central control. The second method, which uses normal line input terminals, provides for communications that are handled in the same manner as regular customer traffic.

2.47 Voice communication is provided through the use of a modified No. 1A2 Key Telephone System similar to that used in No. 1 ESS offices. This key system provides the features necessary for effective voice communication in the areas needed and remains fully compatible with connected and adjacent ESS circuits.

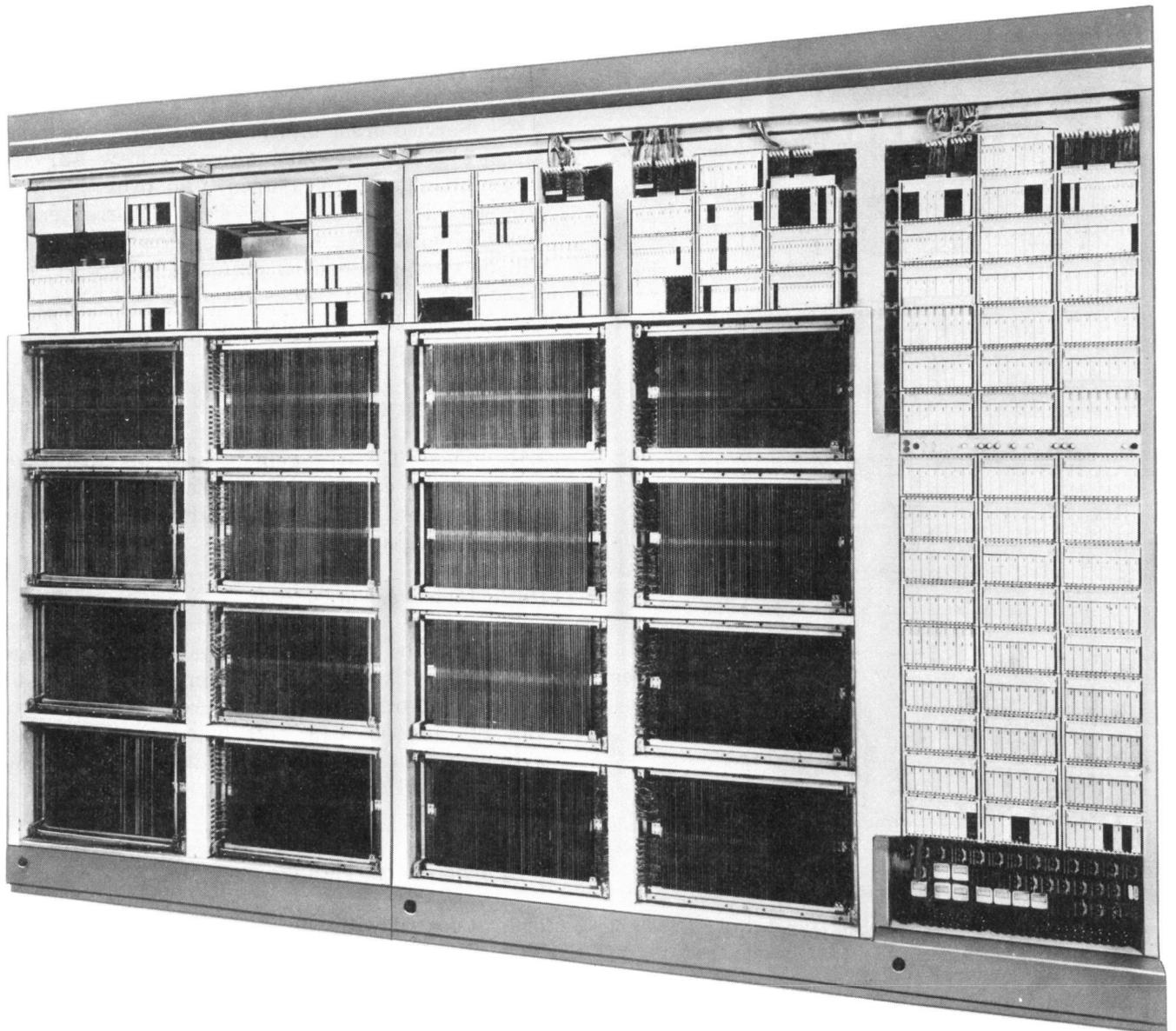


Fig. 15—Program Store

A. Peripheral Order Bus Communications

2.48 Initially, there are six communication functions provided for use with TTYs on the peripheral order bus. The first three of these functions are provided in the No. 1 ESS. The remaining three functions are required for the No. 1 ESS-ADF operation (in addition to the first three).

Maintenance Function

2.49 Two TTYs provide maintenance functions for the MCC. One TTY serves as the basic communication channel between the central processor and maintenance personnel and is permanently located as part of the MCC. The second TTY may be located either near the MCC or in a remote maintenance center. If the switching center operates

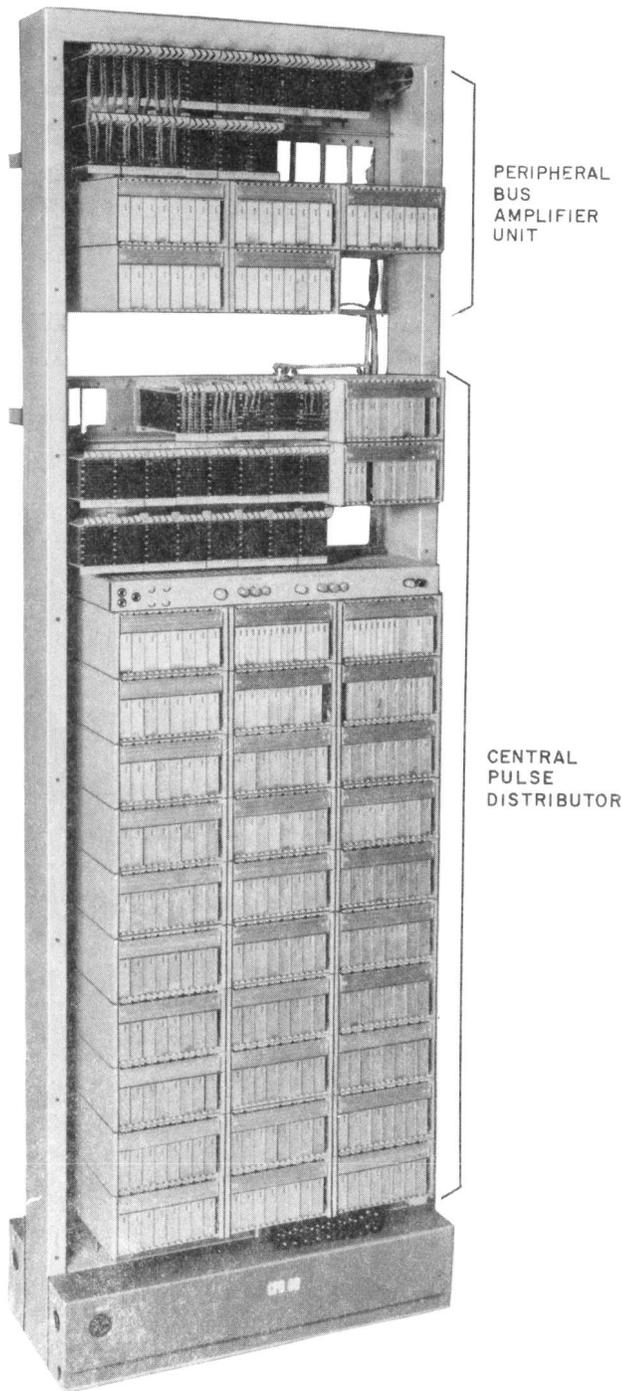


Fig. 16—Central Pulse Distributor

unattended at any time, this second TTY must be located at some remote attended point.

Service Order Function

2.50 Service order information (such as customer class of service change, new service information, new features, and other related provisions) is handled by a peripheral bus arrangement. A switching center which may operate unattended will be equipped with a remotely-located service order TTY. This provides for the input of service order information from the remote attended location into the system.

Traffic Usage Function

2.51 This TTY arrangement provides a printout of the contents of traffic usage registers (amount of traffic handled). Both local and remote TTY locations are provided.

Traffic Measurement Function

2.52 Initially, this TTY replaces the traffic usage TTY discussed in 2.51 in providing input and output of traffic service measurement information. This TTY (one used for both functions) is equipped with the same alarm capabilities as the tape supervision TTY.

Tape Supervisory Function

2.53 Located with the system tape units in the MIRB this TTY provides input and output information regarding operational and maintenance tape manipulation. At each TTY, a minor alarm is activated each time a message is directed to the tape TTY and a major alarm is activated each time a message is received which requires immediate attention.

CSTC Monitoring Function

2.54 This TTY is used to notify the central processor of office overload conditions and equipment failures as determined at the CSTC. The TTY is equipped with only minor alarm capability.

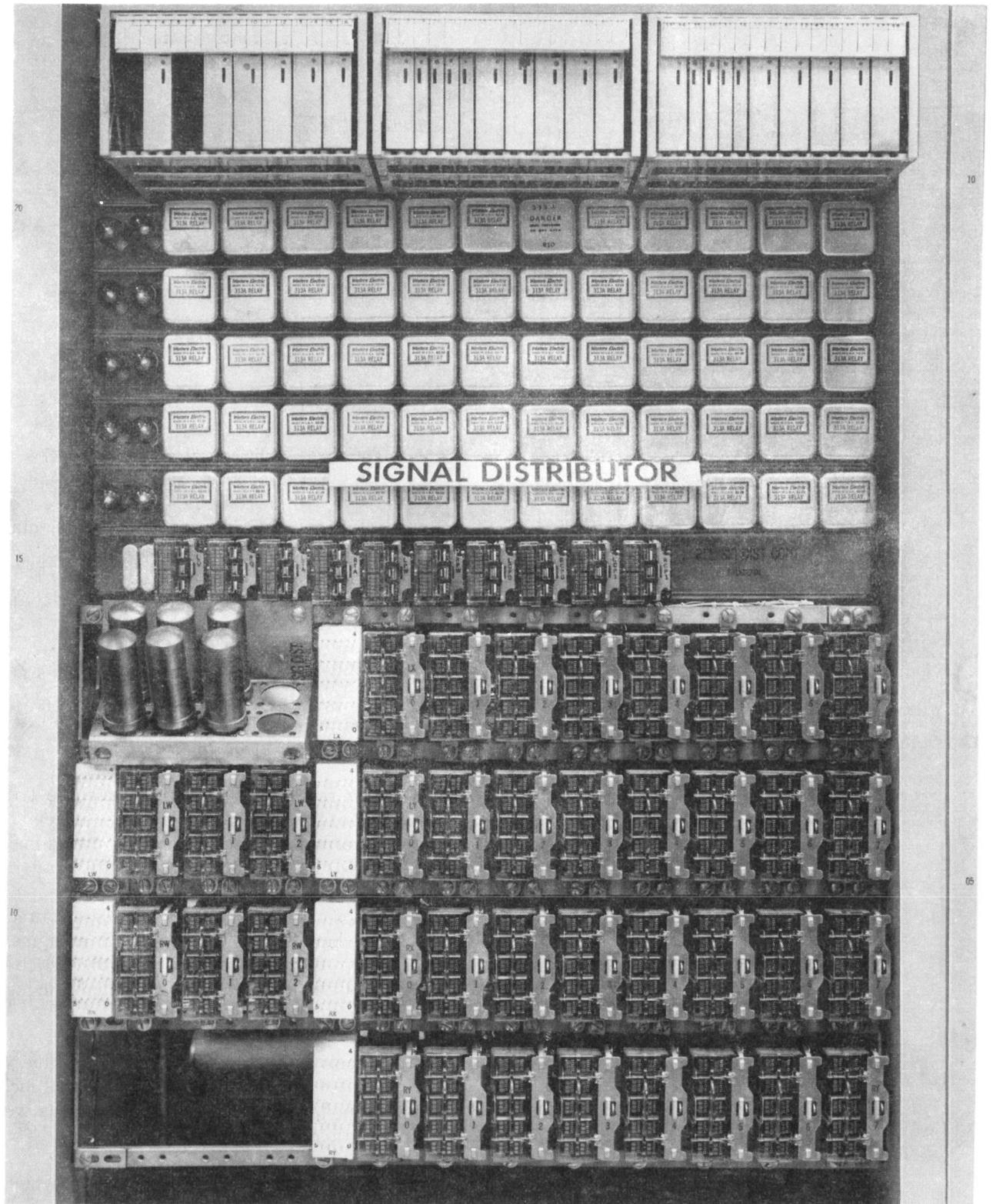


Fig. 17—Signal Distributor

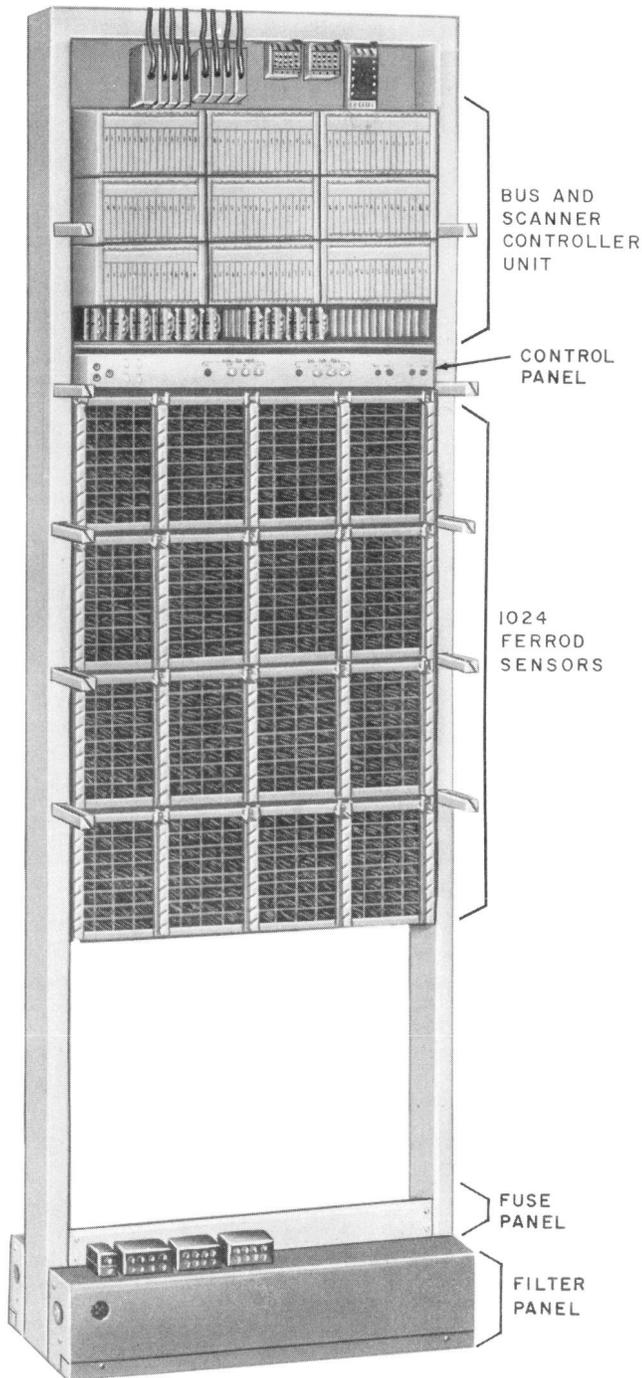


Fig. 18—Master Scanner

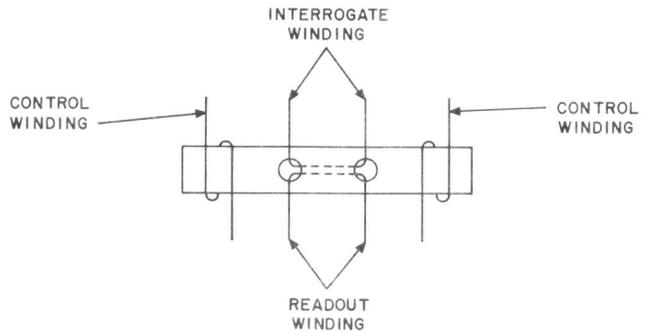


Fig. 19—Ferrod Sensor

B. Normal Access Route Communications

2.55 The CSTC and the MIRB are the two major communication areas served by normal access terminals in No. 1 ESS-ADF. The three normal access classes of CSTC stations which may be found in the No. 1 ESS-ADF office are

- (a) One or more high-speed (greater than 150 bps) receive-only stations
- (b) One or more low-speed receive-only stations
- (c) One or more originate-terminate stations with action request privileges.

2.56 The receive-only stations receive trouble reports generated by the office. The originate-terminate stations provide communication with the No. 1 ESS-ADF and other stations.

2.57 The message retrieval and intercept functions are handled by common TTY equipment in the MIRB. Communications with the MIRB take place through normal access terminals, using the following equipment:

- (a) Receive-only equipment to produce page printed copy plus a punched tape that includes all the nonprinting control characters as well as the printing characters.
- (b) Message preparation equipment (which the attendant uses to prepare and proofread service messages and retrieval instructions off-line) plus sending equipment to transmit these messages to the switching center. The number and type of TTYs for this application are traffic dependent.

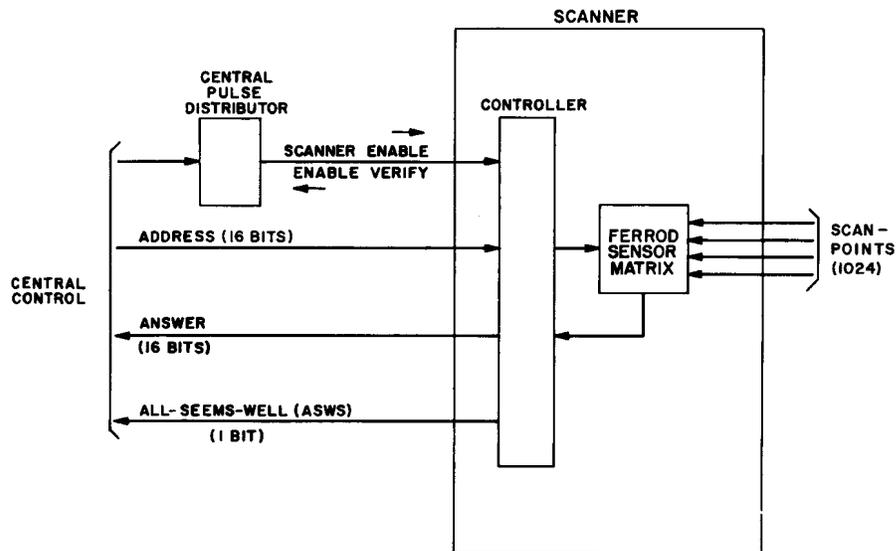


Fig. 20—Scanner Inputs and Outputs

C. Office Voice Communications

2.58 Voice communications are accomplished within No. 1 ESS-ADF using a modified No. 1A2 Key Telephone System. This key system with other associated circuits provides the following features which may be selected in various combinations for voice communication applications:

- (a) Signaling subscriber stations on a maximum of 13 central office or PBX lines.
- (b) Holding these lines.
- (c) Indicating by means of visual signals whenever these lines are called, held, or busy.
- (d) Indicating by means of audible signals whenever these lines are called.
- (e) Originating and holding outgoing calls.
- (f) Accessing a maximum of 12 manual intercom lines between subscriber stations.
- (g) Furnishing interrupted voltages necessary for lamp flashing or winking.
- (h) Providing interrupter connections for interrupted ringing.

- (i) Providing time-out of locked-in signals after incoming calls are abandoned.
- (j) Furnishing steady and flashing lamp voltages to external circuits from the interrupter of the key system unit.

3. APPARATUS ELEMENTS

3.01 The characteristics of the apparatus elements are vital in providing the message-switching capability and storage capacity which the ADF system offers. Physical size, capacity, speeds, method of operation, and material characteristics determine the major differences in apparatus elements and how they are used.

FERRITE SHEET CALL STORE MEMORY

3.02 The 6A ferrite sheet memory is used in the call store for temporary, electrically-changeable information (Fig. 29). An individual sheet has 256 holes of 0.025-inch diameter arranged in a 16 by 16 array. The material surrounding each hole acts as a small two-state magnetic core to store one information bit.

3.03 A memory module has 192 active ferrite sheets plus 12 spare sheets. A module has a capacity of 49,152 bits which are organized by the wiring pattern into 2048 words of 24 bits each. One call store is composed of four memory modules.

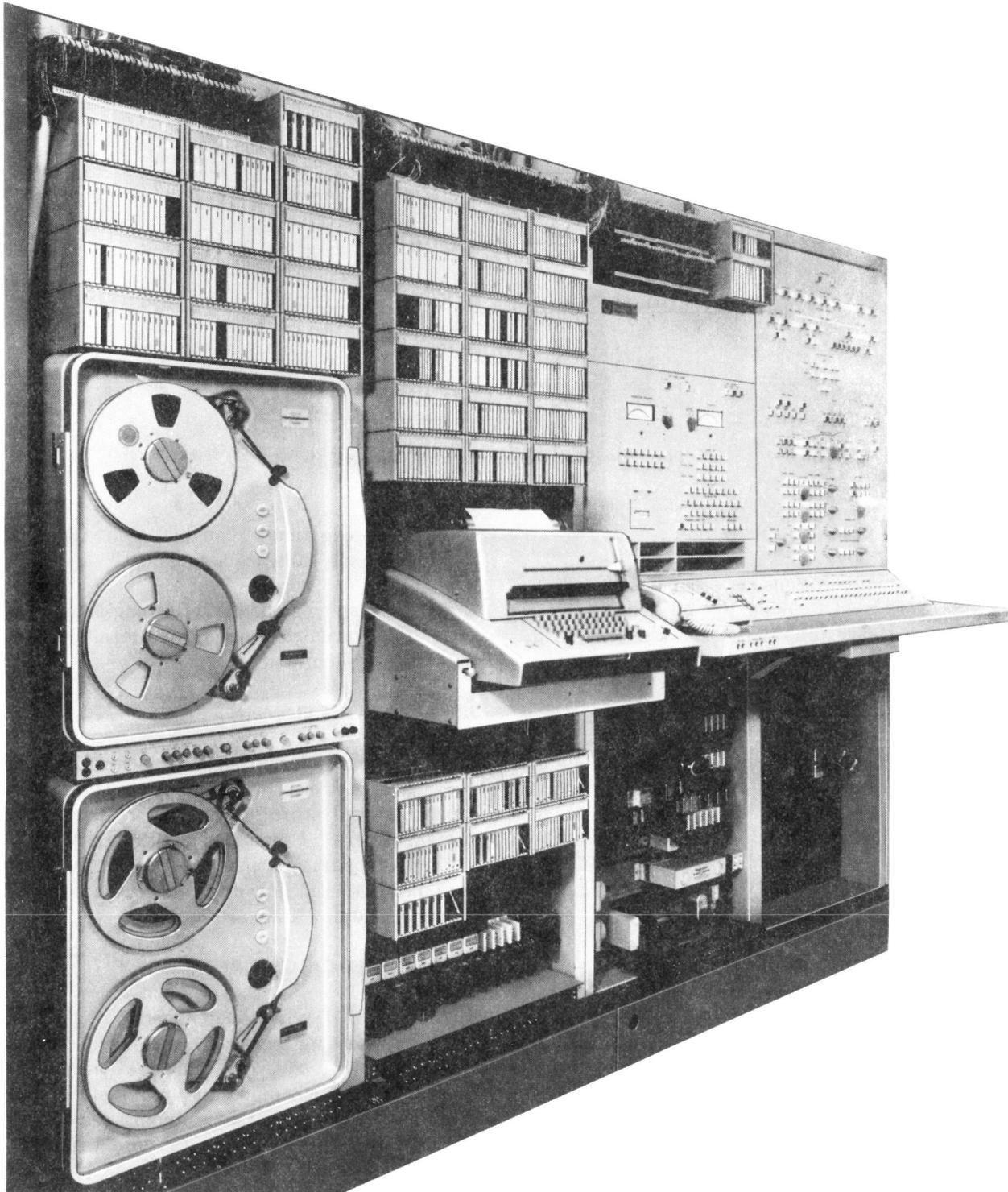
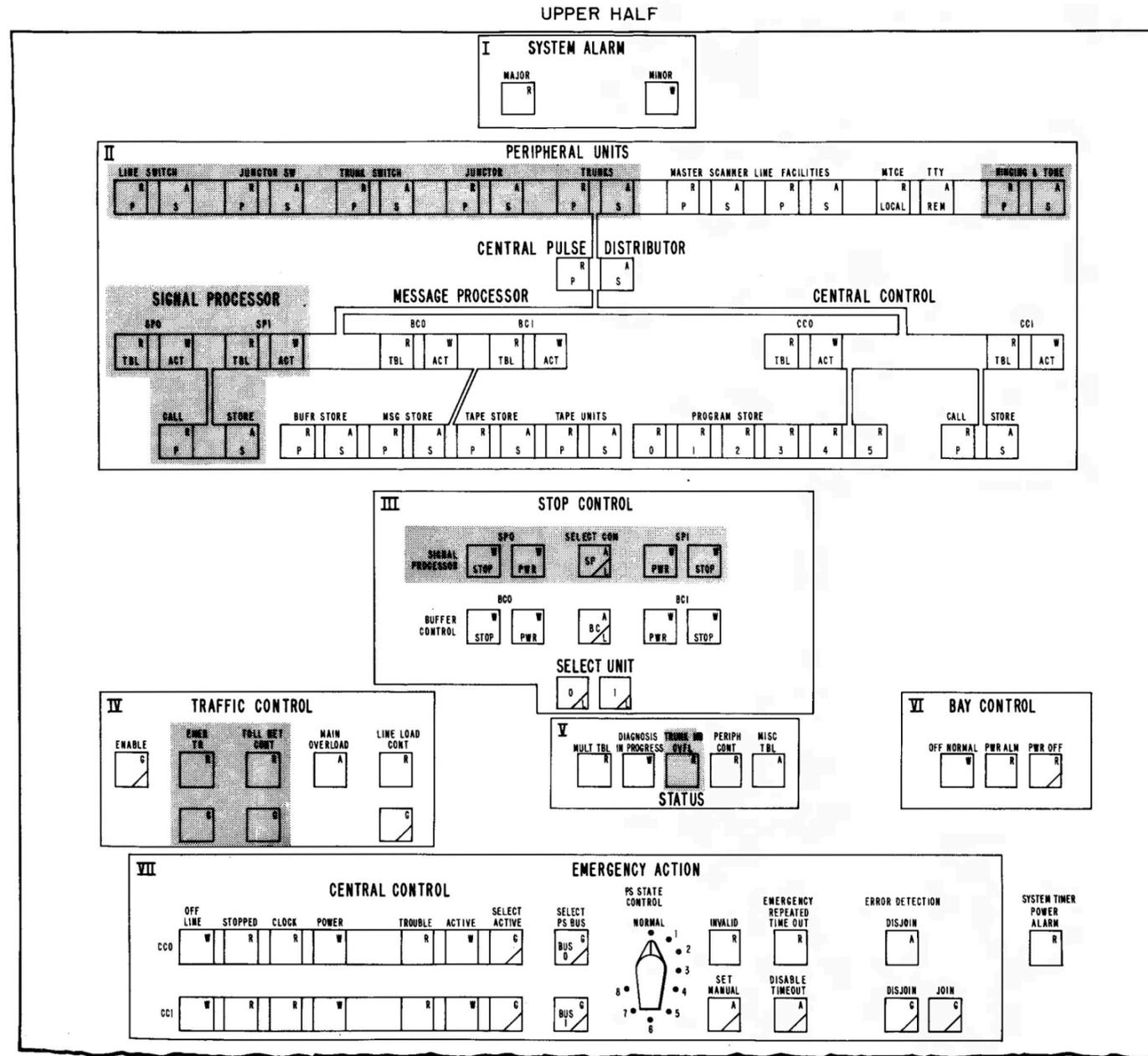


Fig. 21—Master Control Center



NOTE:
THE SHADED KEYS AND LAMPS ARE NOT
USED IN A NO. 1 ESS-ADF OFFICE.

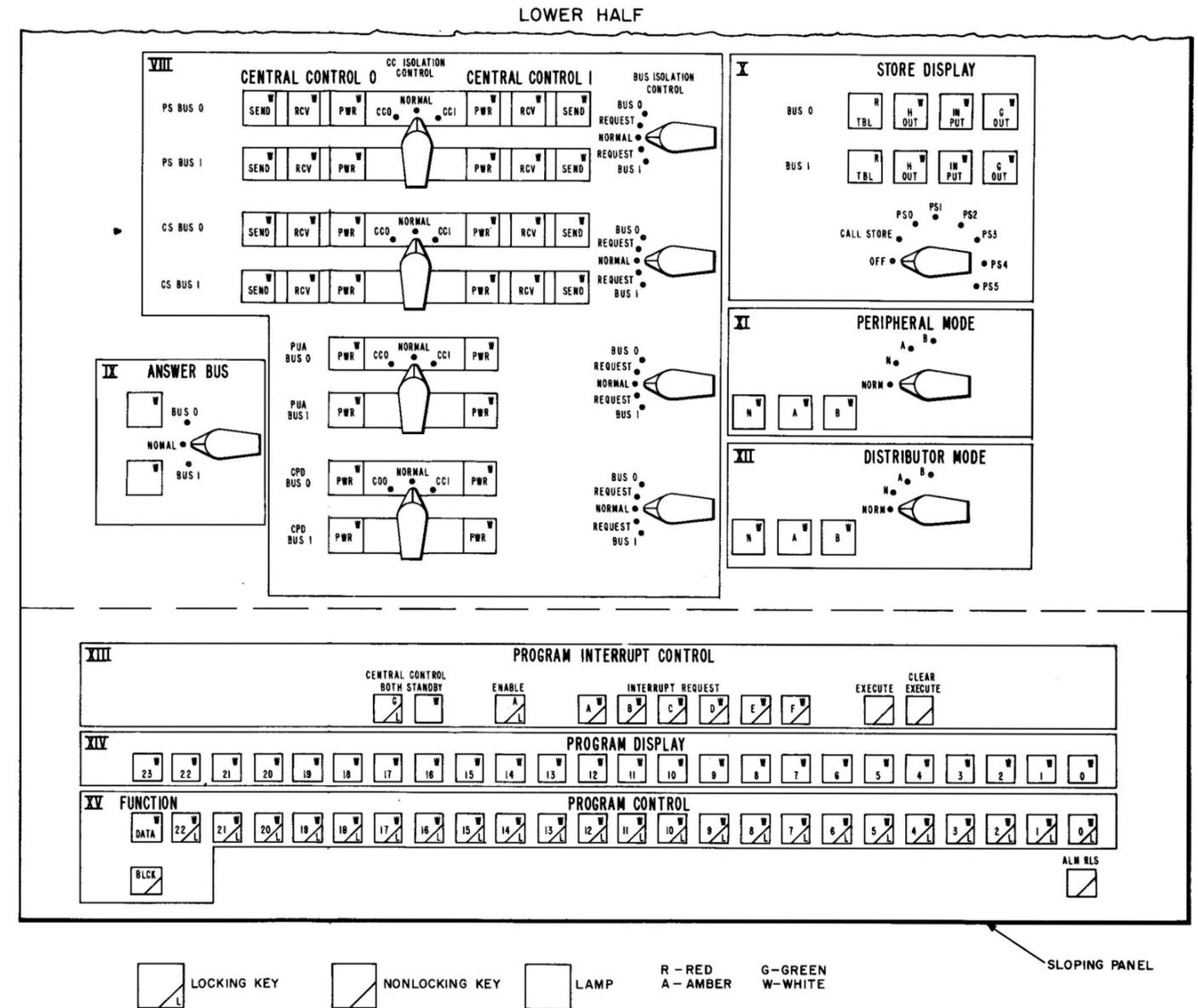


Fig. 22—Control, Display, and Test Panel

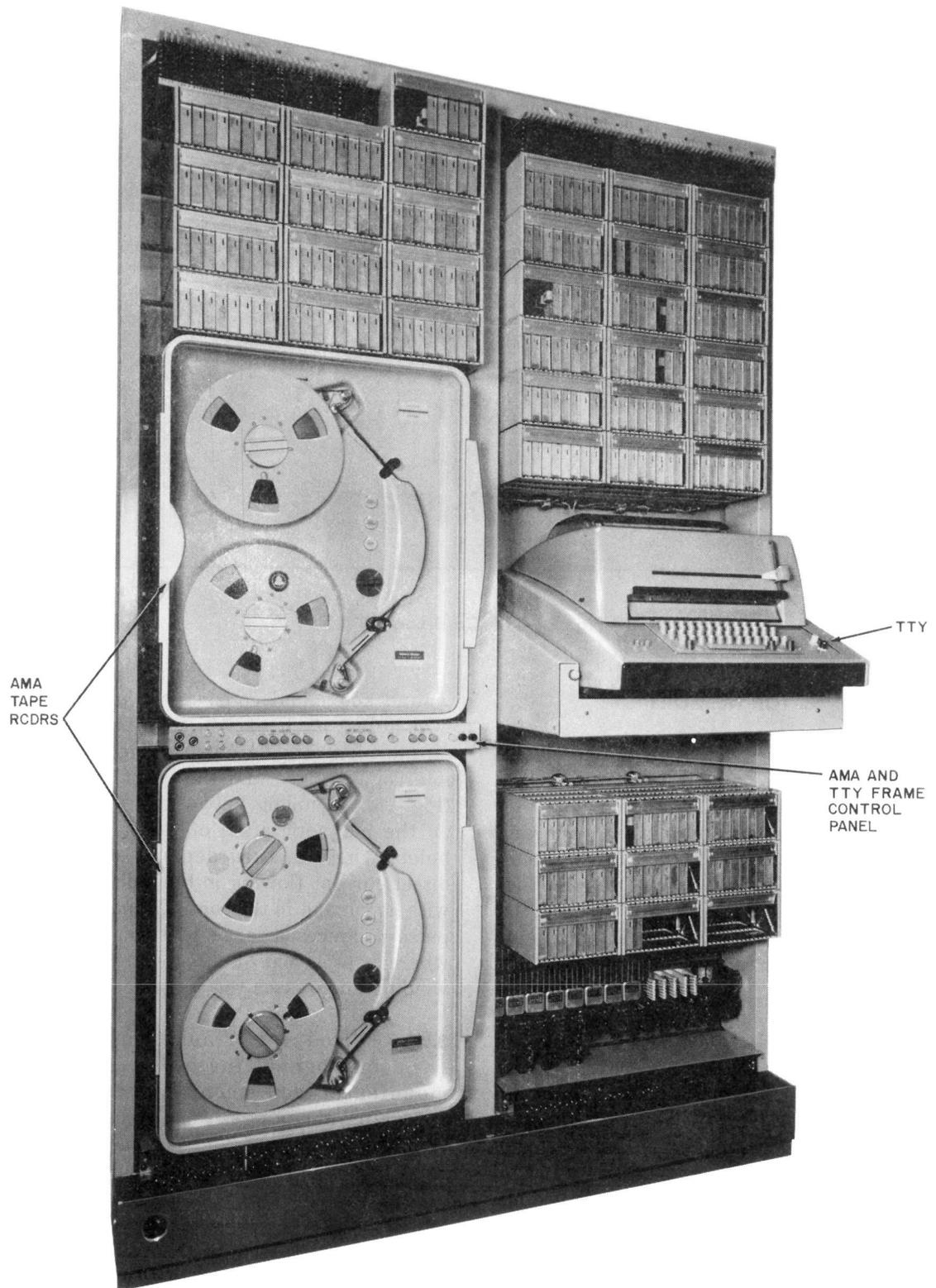


Fig. 23—Automatic Message Accounting and Teletypewriter Frame

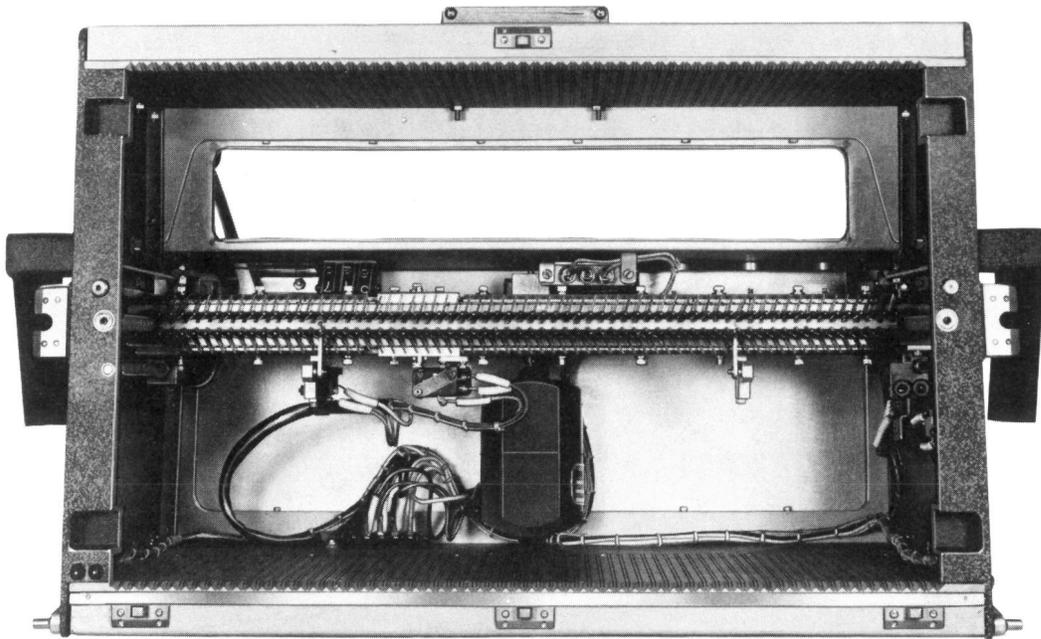


Fig. 24—1A Card Loader

PROGRAM STORE TWISTOR MEMORY

3.04 The 1A twistor memory used in the No. 1 ESS-ADF program store is identical to that used in the No. 1 ESS. This memory module provides storage for the semipermanent program and translation information. Stored information (data bits) is in the form of magnetized or demagnetized magnets mounted on removable aluminum cards. Each card contains sixty-four 44-bit words, one bit per magnet, as recorded by the card writer (2.31).

3.05 One memory module is composed of 64 pairs of cards, with a readout solenoid plane between each pair; access being obtained by pulsing the desired solenoid. Twistor wire pairs, arranged between the cards and solenoids, respond to the solenoid currents according to the binary information stored in the magnets; each twistor pair providing the readout for one bit (Fig. 30).

FERROD SENSORS

3.06 The ferrod sensor, a current-sensing device, has been developed as the building block for all No. 1 ESS scanners. It consists of a ferrite rod located on the centerline of a pair of identically

wound solenoidal coils. The ferrite rod contains two holes, each of which is threaded with two single-turn loops of wire; one loop carries the interrogate pulse and the other the readout pulse (Fig. 19). Coupling between the two loops depends on the magnetic state of the material around the holes, which in turn depends on the amount of direct current flowing in the solenoidal coils. Thus, with no current in the control winding, an interrogate pulse produces a large pulse in the readout loop, whereas presence of direct current in the control winding suppresses this pulse.

3.07 Ferrod sensor units contain two ferrods, one behind the other. These units are mounted on equipment frames in matrix type apparatus mountings, each accommodating 128 of these dual units or 256 ferrod sensors. The mounting serves as a physical support and also as an array of magnetic shields to prevent interference between adjacent sensors.

3.08 Interrogate pulses for the ferrod sensor are generated in the master scanner. The control winding(s) connects to the circuit in which a current is to be sensed. The readout winding gives the information as to whether a current is or is not flowing in the control winding. This information

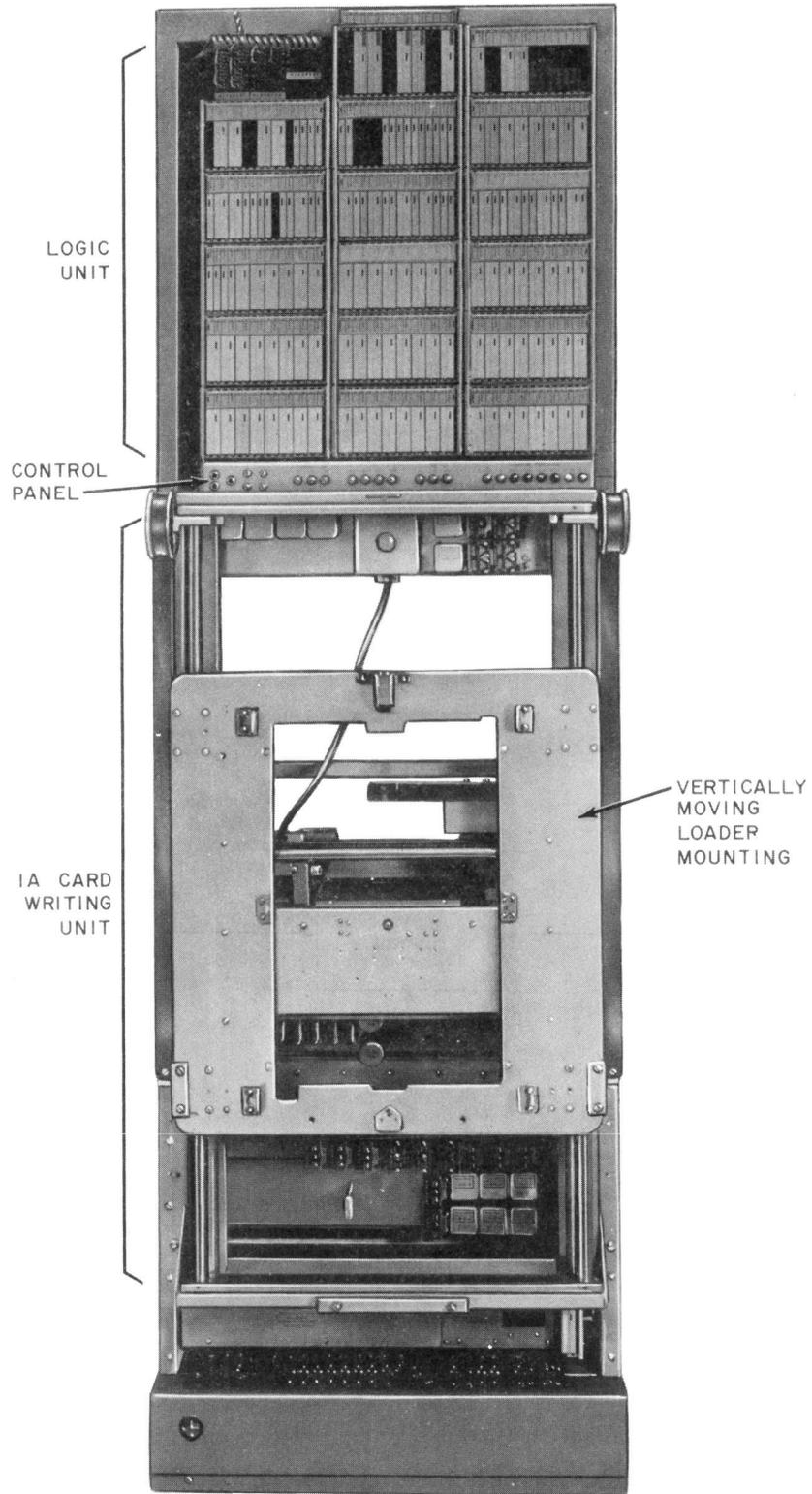


Fig. 25—Memory Card Writer Frame

SECTION 8

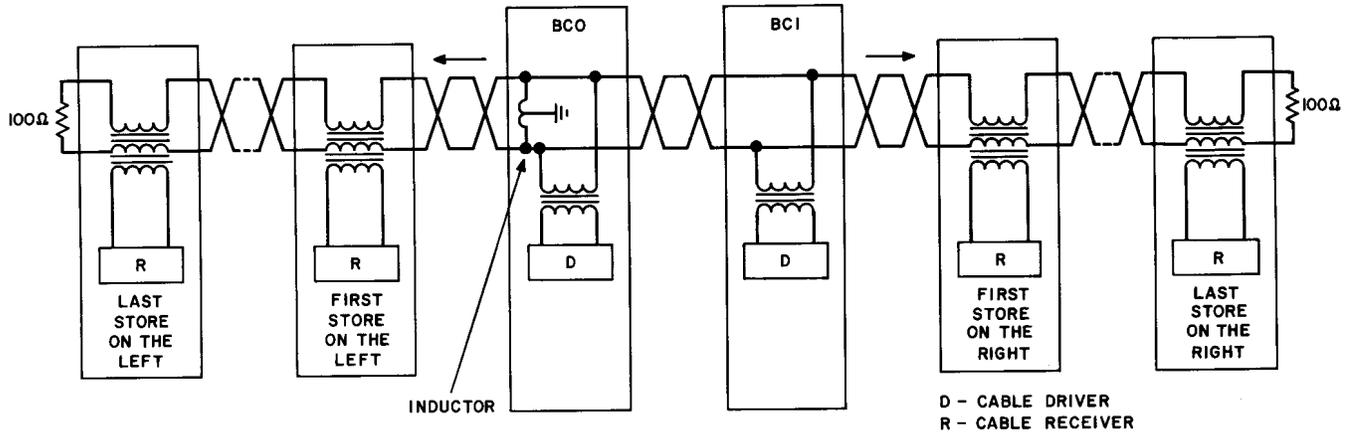


Fig. 26—Typical Bus Pair

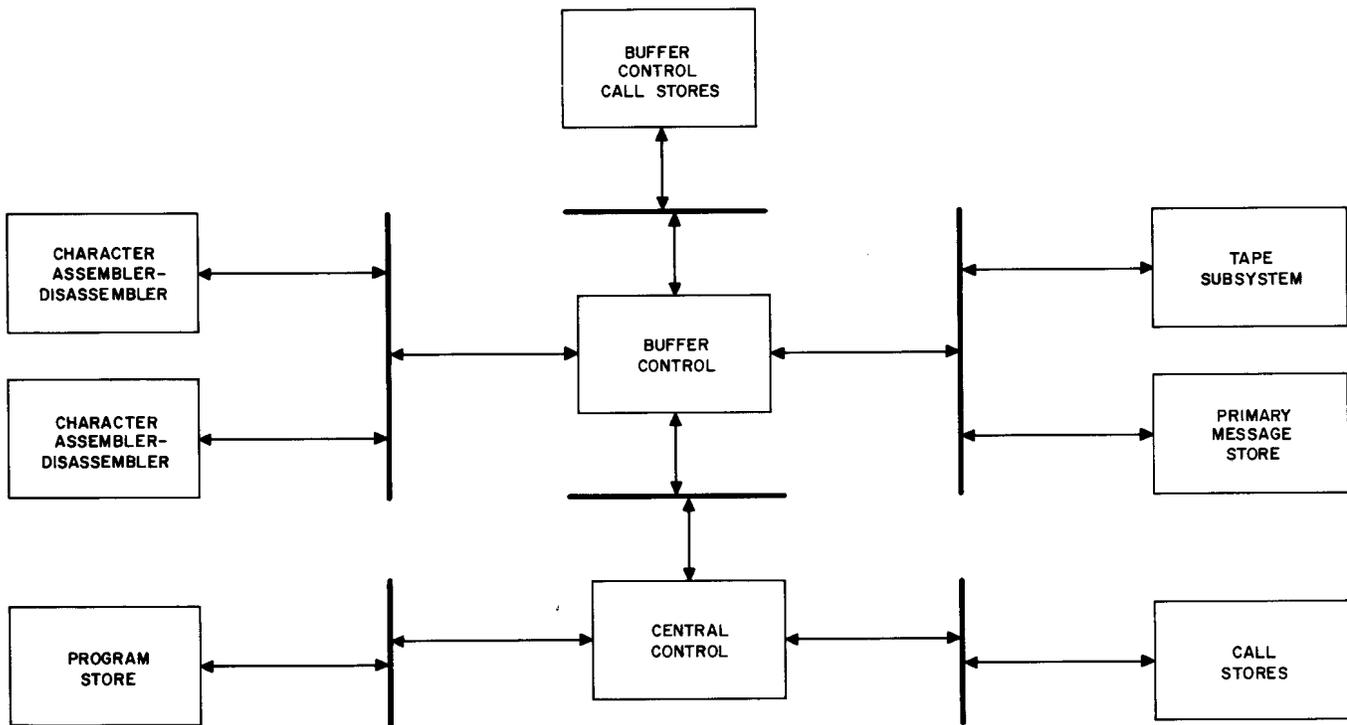


Fig. 27—Simplified Block Diagram

is sent to central control and is used to decide which of two alternate actions to take.

ULTRASONIC DELAY LINES

3.09 Each ultrasonic delay line unit consists of 20 aluminum strip delay lines (inset, Fig.

4). Each strip has a normal delay of 606 microseconds and a capacity of 1024 bits. The strips are used in the delay line character assembler-disassembler as storage devices.

3.10 The basic concept of a delay line memory consists of inserting information into a path

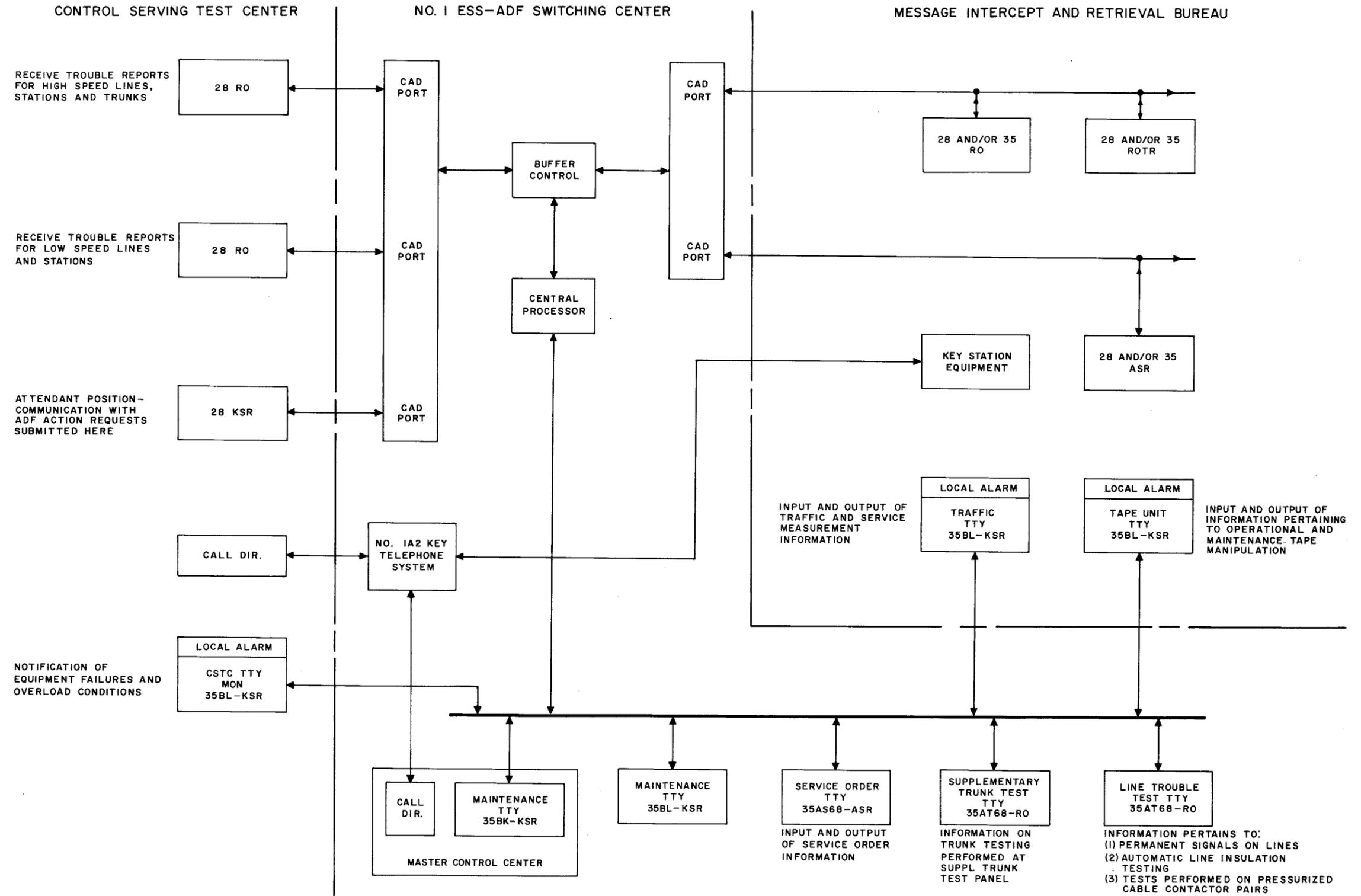


Fig. 28—Intraoffice Communications Channels

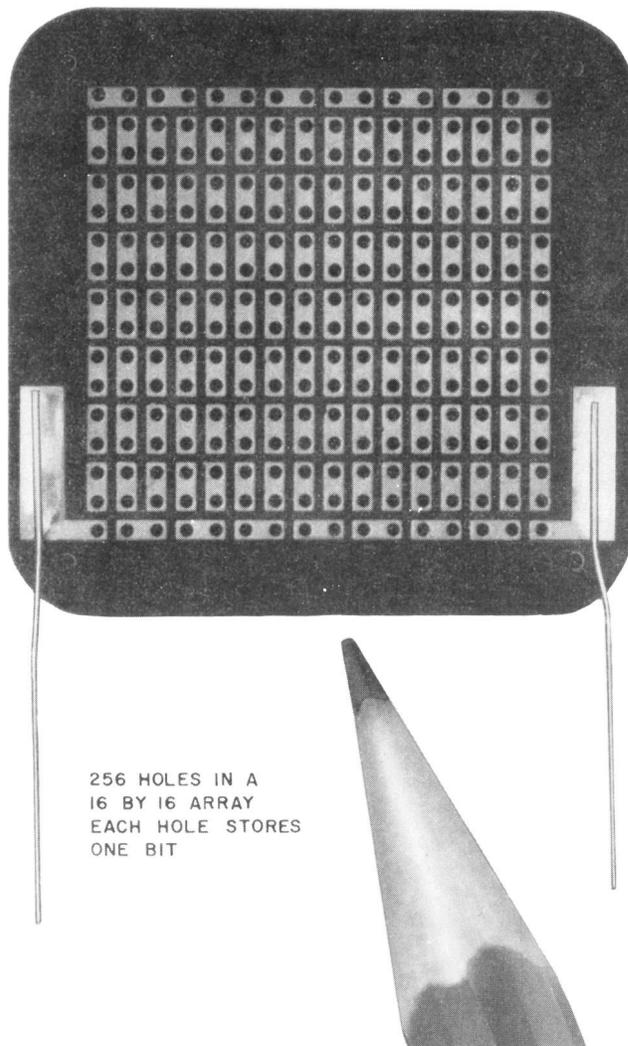


Fig. 29—Ferrite Sheet

which contains delay. If the end of the delay path is connected back to the beginning through amplifying and timing circuits, a closed loop is formed which allows for recirculation of the information.

3.11 A simple acoustic delay line consists of a length of aluminum with transducers at each end. A piezoelectric transducer on the transmitting end converts an electric pulse into mechanical energy. The velocity of propagation of the mechanical wave is such that the signal arrives at the receiving end of the line with a few hundred microseconds delay. At the receiving end of the aluminum strip, another piezoelectric transducer converts the mechanical signal back into an electrical signal, which is then amplified to its original strength

and put back into the delay line. Continuous recirculation of the pulses causes the represented data to be retained indefinitely.

3.12 Each bit of information is available to external circuitry on an output lead as the pulse passes through the amplifier. Included in the circuitry are means to read in, read out, or to erase data bits from the delay line. Since the delay time of these lines varies if the temperature changes, they are housed in an oven maintaining a nominal temperature of 140°F (60°C).

DISC FILE

3.13 The disc file is the memory module of the primary message store (Fig. 31). Each disc file consists of four discs rotating at 1460 rpm mounted in a controlled environment enclosure. The discs are brass, coated with a nickle-cobalt magnetic film, and are 26.5 inches in diameter and 1/8 inch thick. Each disc face is divided into three 50-track zones, each with a fixed clock frequency chosen so that the packing density of the innermost track of each zone is approximately 1000 bits per inch.

3.14 Air-bearing magnetic head assemblies, containing 13 head cores (12 are active) comprise the basic read-write transducers; one head core is provided per track. When the discs are not rotating, the head assemblies are held retracted from the disc surface by head mounting springs. As the rotating discs attain operating speed, a pneumatic system overrides the springs and forces the heads toward the disc surface until the heads "fly" on the laminar flow of air produced by the rotating discs.

3.15 The four discs provide eight recording faces for a storage capability of approximately 60 million bits. Information is stored on the discs in fixed record lengths. Recorded information remains on the discs indefinitely until replaced by new data. The disc file is duplicated for reliability and both units operate continuously, record simultaneously, and are shut down (individually) only when a malfunction occurs.

TAPE UNITS

3.16 The tape units (Fig. 12) are used by the ADF office to provide a means for recording on magnetic tape the messages and administrative

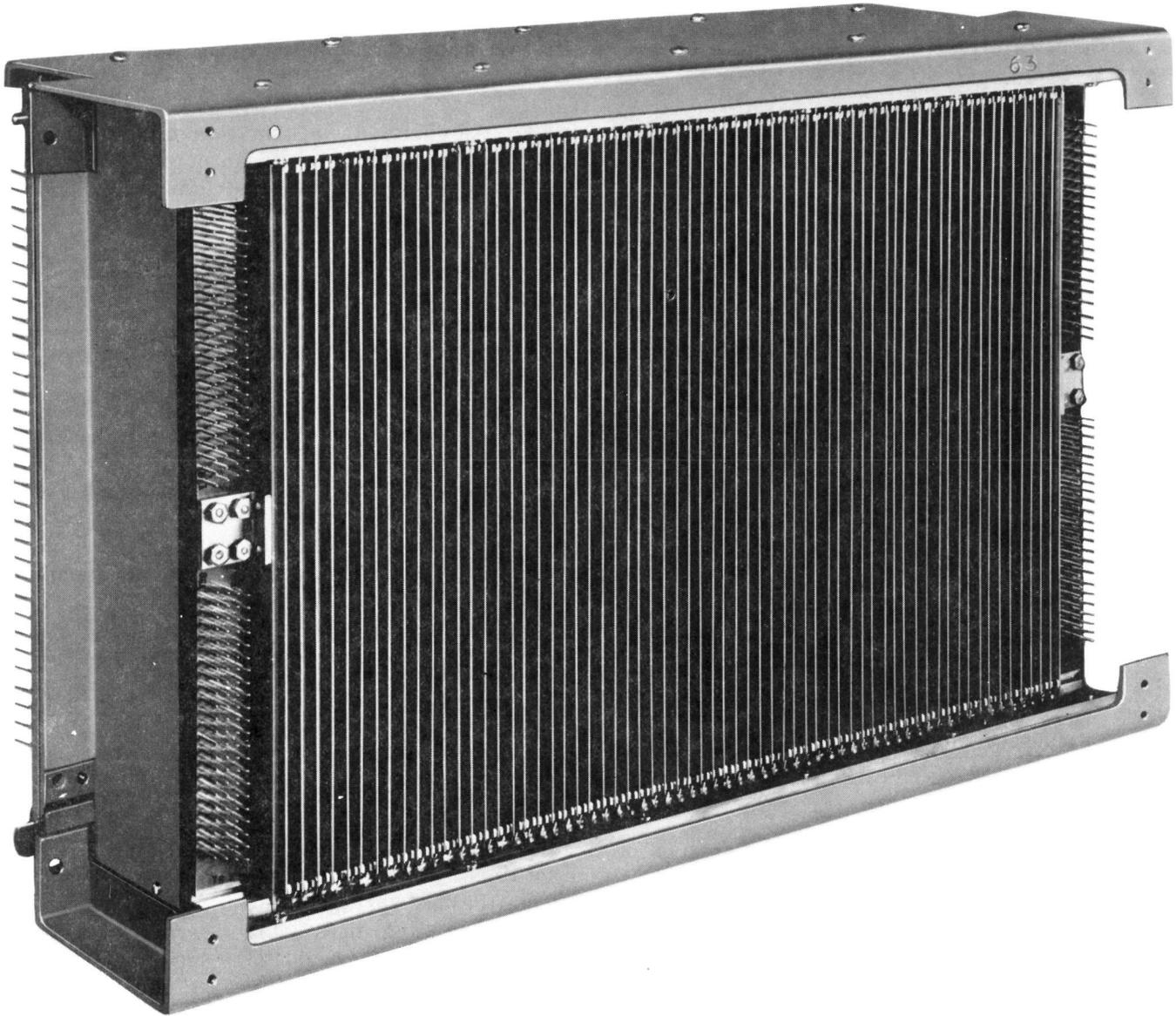


Fig. 30—Twistor Memory Module

information handled by that office. The capabilities of the tape units are discussed in 2.14, 2.15, and 2.16.

3.17 The tape unit provides a nine-track read-after-write head assembly for digital recording of data. An erase head precedes the write head to remove residual noise accumulation. The tape unit uses vacuum chambers with photocell control to provide the required tape tension during record, read, and rewind operations. Individual servo systems control the supply and take-up reel

motors. A third servo loop controls capstan acceleration, deceleration, and steady-state speed.

3.18 A low inertia printed circuit motor enables the capstan to accelerate and decelerate rapidly enough to perform as many as 30 start-stop commands per second.

4. OPERATIONAL PROGRAM

4.01 The major objectives of the program are to handle large numbers of messages rapidly

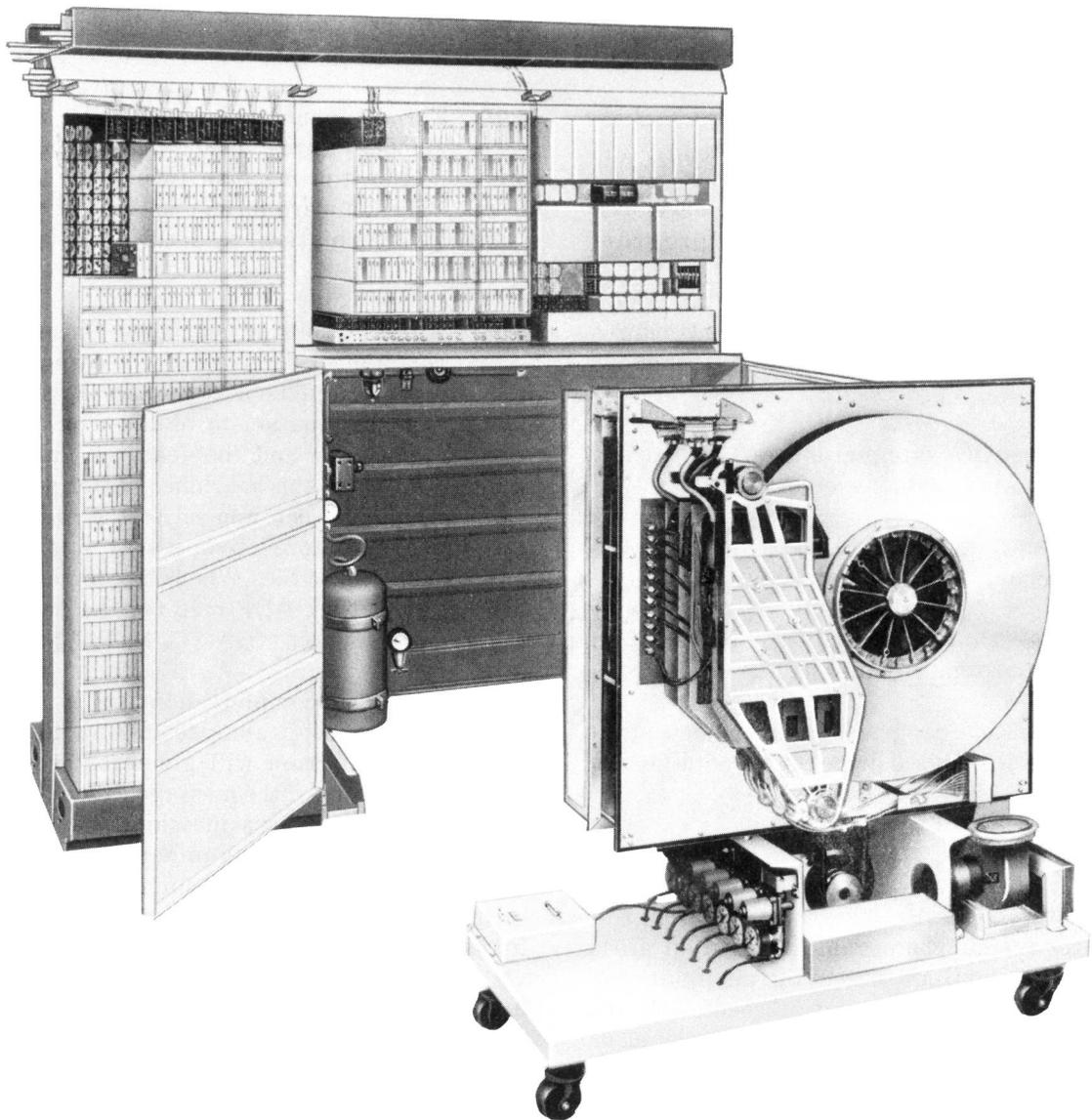


Fig. 31—Disc File

and to provide flexibility for growth and new service features.

4.02 The overall program can be divided into functional blocks, each being devoted to a particular system category of functions. The following are some of the general categories of nonmaintenance functional blocks:

(a) ***Input-output programs***—collect input information to be processed, or transmit to

peripheral units information which results from processing.

(b) ***Message-handling programs***—apply to processing information pertinent to each message and the associated customer features.

(c) ***Service routine programs***—supply on request special information services to each client.

SECTION 8

- (d) **Executive control program**—provides the control by scheduling for the input-output and message-handling programs.

PROGRAMMING REQUIREMENTS

4.03 The ADF operational program is developed around the following general program requirements:

- (a) Appropriate start-up and restore procedures to offset any irregularities or interruptions in normal message processing.
- (b) Comprehensive safeguards against a variety of anticipated customer errors.
- (c) Service messages to assist and direct customers in correcting erroneous procedures.
- (d) Accurate timing and control to assist in meeting customer requirements.
- (e) When possible, programs shall be independent of office size and distribution of data lines.

GENERAL PROGRAM SEQUENCING

4.04 The sequence of searching for work (an input stimulus) consists of an ordered procedure for scanning program input-output areas called work lists. Upon detecting an input, the program initiates the action and proceeds with the process until the processing task is completed or until a condition is encountered which requires a response from an input-output unit. In either case, the input scanning process continues the search for other input stimuli.

4.05 A priority structure is used within the search logic since certain types of inputs may be more critical than others and consequently the inputs are not necessarily processed in time order. The executive control program directs this ordered search for work.

MESSAGE HANDLING

A. Message Origination

4.06 An interrogation scheme called polling is used for recognition of customer service requests. This requires the ADF processor to poll

each customer periodically for detection of service requests.

4.07 The customer will prepare the message in standard format, load it into the data machine, and condition the machine to indicate that it has traffic. The standard format consists of the heading (routing information) and the text (content of message).

4.08 As ADF polls all machines, those which are conditioned for traffic will respond. When the program detects a response, it consults its translation information to obtain a description of the data machine and the features purchased by the customer for this machine. After all pertinent information has been applied to the message, it is assembled and stored temporarily in the primary message store disc file. When the complete message has been received, ADF restores the data machine to the idle condition.

4.09 Once the complete heading is stored, the program will analyze it. As the analysis occurs, the program will generate a centralized descriptive record of the message called the message processing block. This message processing block contains the directory number of the originator and a list of the directory numbers of all message recipients; consequently, it serves as a stimulus to initiate message deliveries.

B. Message Delivery

4.10 At some later time, the ADF system interrogates the machine at the delivery point. If the machine is available and functioning properly, the ADF system will deliver the message (consisting of heading and text). Once the message is completed to the customer, the ADF system will restore the receiving machine to the idle condition.

C. Tape Records

4.11 After the message has been delivered to all addresses, the program initiates three records called the permanent file, journal file, and the AMA record. The permanent file stores the message on tape and the journal file catalogs a record of the message processing block for each message. The AMA record stores all information necessary for customer billing purposes for each message, or a summary billing record per customer which is assembled in the call store.

D. Message Switching

4.12 All data machines will be connected directly to the ADF system initially; consequently, all data machines will communicate only with an ADF office. With this arrangement, the originator and terminator are never in direct contact.

INTERFACES, STORAGE, AND PROCESSING**A. Program Interface**

4.13 In the ADF system, a portion of the buffer control call store memory is used for organizing the processing tasks required for the input-output equipment and also is used to communicate with central control. Information destined for the central control is loaded into a predetermined area of this memory which is scanned and unloaded periodically by the program. Information destined for the input-output equipment is loaded by the program into another area of the memory which is scanned and unloaded periodically by the input-output equipment. Thus, the memory serves as the interface between the input-output equipment and the central control. The program communicates with three communities: data lines, magnetic discs (primary message store), and tape stores.

B. Interface Timing

4.14 The No. 1 ESS-ADF system operates on a real-time basis and since some of the devices used in the system are asynchronous, buffer control must serve these devices at the appropriate time. Examples of the demand for buffer control attention at specific times are explained as follows:

- (a) If buffer control does not read or write the tape unit at the proper times, the unit will abort and stop.
- (b) If buffer control does not serve the primary message store (disc file) when the disc has rotated to the proper position, the primary message store will mark a data block in error and proceed to the next data block.
- (c) If buffer control does not sample the line facility units at the proper time, a new character coming into the unit from a subscriber will overwrite the existing character.

4.15 In the case of delays to tape unit and message store service by buffer control, data is not destroyed but additional program time is required to repeat the operations within the system. In the case of delay in line facility scanning, data may be overwritten and destroyed which means that data retransmission is required.

C. Program Memory Areas

4.16 The ADF data processing program uses several types of memory areas. These may be generally classified as processing registers, memory work lists, and reference memory. Processing registers are used as temporary memory areas to retain the status of a data message in process since the message is handled in segments. Work lists are used to facilitate scanning and time-order arrangements in the program sequence. The reference memory employs a table lookup technique to provide needed information (desired output) relative to a specific message in process.

D. Input Processing

4.17 The following is a brief summary of the input data processing sequence for a typical message which will serve to indicate how the program is implemented.

4.18 The poll administration program will generate the polling code and will analyze the data machine response for indication of traffic origination. With a traffic response, control of the line will shift to a message reception control program which assigns the temporary memory areas to the incoming message and inserts originating information into the message processing block. The ADF system response to the data machine is controlled by the heading generation program which assigns time, date, and message number information (if required). The station then sends the heading followed by the text. Once the heading information is stored on the disc, the heading analysis program processes the heading and inserts terminating addressee information in the message processing block. With these actions complete, the message reception control program will guide the message progress until the end-of-message sequence is received.

4.19 At this point in the sequence, the message reception control program will divorce the data message from the line and transfer control of the message to the cross reference file program.

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After the cross reference file (for the originating machine) is updated, message control is shifted to the message queue insertion program. A delivery request is made up for every terminating directory number listed in the message processing block and these requests are added to the message queue. When this is completed and an AMA program billing entry is made, the message terminating program transfers the call store copy of the message processing block to the magnetic disc, releases the processing register, and finally releases the call store copy of the message processing block.

E. Output Processing

4.20 Message delivery is initiated by the scanning of the message queue by the message nomination program which delivers a copy of the message processing block into the call store. At the request of the message nominating program, the heading generation program will assemble the call-in code plus time, date, and message number information which is transmitted to the station. Now the answer response analysis program verifies a satisfactory response from the data machine and control of the message is transferred to the message transmission control program which sends the message. Once the end-of-message sequence is sent by the ADF system, the heading generation program will generate a code for verifying the operation of the data machine, and the answering response analysis program will again analyze the response from the data machine.

4.21 Once the message delivery is completed, the message transmission control program will restore the line to idle status and transfer message control to the cross reference file program. This program will update the cross reference file information for the receiving data machine and transfer message control to the message termination program. After billing information is recorded, the message terminating program either returns the message processing block to the disc or requests permanent filing.

4.22 When the last addressee has been serviced the message terminating program transfers control to the permanent file program and the tape record is made. The AMA billing records will now be updated and message control will be transferred to the journal file program. Here, the message processing block information is stored on tape to complete the processing of the data message.

5. MAINTENANCE

5.01 Maintenance is implemented using equipment and programs developed for the No. 1 ESS and, in addition, new equipment and techniques suitable for data handling requirements. In a message-switching system, an interrupt has more significance than in a conventional telephone office. For example, once a talking connection has been established, the central office in the No. 1 ESS performs only a supervisory function, that is, periodically scans for a disconnect. However, in a message-switching office, whenever a subscriber line becomes active there is a continuous flow of data through the central processor. This means that each active data subscriber requires the attention of the central processor throughout each message. Because of this continuous dependence on the central processor, a message-switching system is more vulnerable to the effects of interrupts. Should interrupts resulting from errors or faults be sufficiently long, the loss of subscriber data will be unavoidable and retransmission of the data will be necessary.

5.02 The system design is such that downtime should not exceed 2 hours over a 40-year life and is engineered for easy trouble location and repair.

DUPLICATION AND SWITCHING

5.03 The combined No. 1 ESS and No. 1 ESS-ADF systems are shown in Fig. 1. Normal data processing in the system requires a complete complement of these units; consequently, both systems combine to form a complex in which a failure in either system affects the other. Duplication for reliability is employed throughout the combined system, for example:

- (a) The buffer controls, central controls, and major buses are duplicated. Duplication is employed in the call stores, program store, tape subsystem, primary message store, line facility units, and peripheral units.
- (b) A tape unit control sends to buffer control on duplicate buses (but receives on one bus).
- (c) One primary message store (of the pair) is normally connected to each data bus.

- (d) Each line facility unit contains a duplicated common portion and a noncommon per-line portion which is not duplicated. The common portion is connected in duplicate to the duplicated line facility bus (each half is connected to one of the duplicated buses).
- (e) Each buffer control has an active or standby status, with the one on active status exerting preferred control over the buses.
- (f) The major data storage units (both temporary and permanent) are duplicated either in access or memory hardware or both. All line facilities have duplication in the common portions to enable access to groups of subscribers under fault conditions. With this arrangement, one-half of each duplicated subsystem may be out of service without traffic interruption.

MAINTENANCE CIRCUITS

5.04 The majority of trouble detection is accomplished by hardware. However, upon repeated failure, a maintenance program is called in. The maintenance program analyzes the trouble, determines an appropriate system reconfiguration, and restores processing capability. Circuit (hardware) solutions are used for the following purposes:

- (a) Detection of errors or faults.
- (b) Automatic retrials of buses.
- (c) Initiation of interrupts of the central processor.
- (d) Bus control for all buses.
- (e) Access for diagnosis.

A. Buffer Control

5.05 The buffer control operates as a maintenance coordination center and monitors all bus transmissions to and from connecting units. The buffer control uses match circuits as the primary means for detection and diagnosis of troubles. The match circuit operate in either a normal match mode or an off-normal mode. In the normal match mode the active buffer control executes an address match and the standby buffer control executes the data match. A match failure stops a portion of the buffer control and interrupts the central processor. In the normal mode, a mismatch

indicates trouble. When a mismatch occurs, the corresponding section in both buffer controls will stop and a maintenance interrupt will be sent to the central processor. In the off-normal mode, a matcher compares various internal points within the buffer control, which provides access to all internal registers. The buffer controls, in normal parallel operation, are in the normal match mode.

5.06 Each buffer control has three match circuits which are used to match internal data. These matchers are the buffer store matcher, line facility matcher, and data store matcher. In the normal mode, these circuits match address and data fields on transmissions to and from the buffer controls. In the off-normal mode, selected sequence points are also matched.

5.07 Additional circuits within the buffer controls which are used for maintenance purposes provide:

- (a) Automatic repeats for all three subsystem buses
- (b) Parity (error detecting code) protection for all bus transmissions
- (c) Capability for central control to read and write into all buffer control registers
- (d) Capability for central control to read and write into the major subsystems
- (e) Special control features directed by the central processor, such as active and standby status orders and sequencer resets.

B. Primary Message Stores

5.08 The primary message store checks the address field and data field parity and returns an all-seems-well (ASW) indication to buffer control if all checks pass. If an error is indicated, a counter in the buffer control will be incremented and the counter is read by the central processor. If a failure repeats, a central processor interrupt and a buffer control stop will result. In addition to special access points within the primary message stores through buffer control, the central processor has access to critical points within the stores by means of the scanners, and control by means of the central pulse distributors. The stores are connected to a monitor bus which connects groups

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of internal points to a group of scanner points. An automatic "shut-up" disconnects the store from the bus if a failure occurs which could cause the store to transmit erratically on the bus.

5.09 The primary message store, because of its large capacity, has a special update mode. When a duplicated pair of primary message stores are in the update mode, the store which is being updated will only receive from the buffer control. The store which is not being updated will both send and receive. This permits a form of on-line updating to bring a store (which has been shut down) up to the memory status of the duplicate store.

C. Line Facility Units

5.10 Communications between the buffer control and line facility units is similar to that described for the primary message stores, with one addition. When the address field parity is checked and if a line facility decodes the proper address but fails parity, an address error (ADE) signal is sent to the buffer control. The buffer control repeats the bus transmission if an ADE is received, and if a second ADE is returned an interrupt will be sent to the central processor.

D. Tape Unit Controls

5.11 The tape unit control operation is similar to that of the primary message stores, except that one tape control unit sends to the buffer controls on two buses and receives on one bus, and if a failure occurs, all bus transmissions are repeated automatically.

E. Alarms and Master Control Center

5.12 The No. 1 ESS-ADF uses the existing No. 1 ESS alarm system. The master control center is modified to include indications for the new equipment added for the message-switching community.

MAINTENANCE PROGRAMS

A. Operational Levels

5.13 Operational processing is divided into two levels of interrupt, the nondeferrable and the deferrable. To insure that the nondeferrable jobs will be executed on schedule, the central control

is provided with 5-millisecond interrupt capability. Every 5-milliseconds, central control generates a clock pulse that initiates an interrupt in the operational program being executed. Central control then stores the contents of its registers and transfers to the interrupt program. The maintenance program is executed according to priority and then central control returns to processing the program which was interrupted.

B. Maintenance Levels

5.14 The maintenance programs are similar to the operational processing programs and are classified on the same nondeferrable-deferrable basis.

Fault Recognition Programs

5.15 The function of the fault recognition program is to restore the message processing ability of the system in the event of an error or fault. Generally, this involves isolating the trouble to a subsystem and reconfiguring to obtain a workable system. When a trouble occurs, fault recognition programs are activated immediately by an interrupt level which overrides any operational program in process. The message processing ability of the system must be recovered and maintained so long as enough operating subsystems exist to form a functional system. To facilitate a return to message processing after an operational configuration is found, the isolation of the faulty subsystem and the analysis of errors are postponed and executed later as a base level program.

Diagnostic Programs

5.16 Diagnostic programs are low priority, demand type programs used to isolate faults to a small number of packages. When system traffic is light, these programs are executed frequently; however, when traffic is heavy, these programs are executed on a scheduled basis. Generally, fault recognition programs request the diagnostic programs when a fault is found. When a diagnosis is requested, the diagnostic program is executed and the results are printed out in a reduced form. Diagnostic programs may be requested by maintenance personnel via the system TTY. A diagnostic program is automatically executed when power is applied to a unit. Generally, while a unit is being repaired, power is removed. When the power is reapplied, the diagnostic program is automatically

requested. If the unit passes the tests it is returned to service. If the unit does not pass, it remains out of service and test results are printed out of the TTY.

Exercise Programs

5.17 Exercise programs are used to exercise infrequently used hardware, to verify trouble-detecting circuits. These programs may be requested automatically by the system on a periodic basis. They may also be requested on demand by other programs or by maintenance personnel. The exercise programs are low priority and are administered under control of the maintenance control programs.

C. Program Implementation

Buffer Control Fault Recognition Programs

5.18 Central control is available only at limited times for maintenance of the message-switching community. The No. 1 ESS-ADF uses both hardware and program for trouble detection, once detected, it depends completely on the central processor to solve the problem. Maintenance programs are initiated by a buffer control interrupt to central control when such troubles such as match failures and bus transmission failures occur. To facilitate identification of the failure location, buffer control contains dedicated error summary flip-flop indicators for troubles in various units and buses.

5.19 Match circuits are the primary means which buffer control uses to detect both internal and external troubles. When a buffer control mismatch occurs the buffer control fault recognition program is entered. The program must determine whether the failure occurred in either or both buffer controls or in some external subsystem. If an error caused the mismatch, the two buffer controls will be put back in step and restarted. If a fault caused the mismatch, the faulty unit is removed from service and a request for the appropriate diagnostic program is placed.

5.20 When troubles are detected on bus transmissions, the buffer control retains the failing information as an aid in determining which of the units is faulty. When faults are encountered within the buffer controls, the buffer control fault recognition program will attempt to reconstruct the fault using buffer control hardware to determine which buffer

control is at fault. If the trouble condition cannot be reproduced, it is classified as an error and both buffer controls are restarted. If the trouble can be reproduced, the faulty buffer control is removed from service.

5.21 The buffer control is a wired logic machine which cannot execute maintenance programs unassisted. Central control must load test words into buffer control, adjust the wired sequences, and start the buffer control. The tests are divided into routines which exercise specific hardware areas of buffer control, depending upon where the trouble is encountered. The tests consist of inserting a known test word, allowing buffer control to operate on this word, and then verifying the answer.

5.22 Since a complete exercise of the buffer controls would be lengthy, the buffer control fault recognition program is divided into a first-look program and a complete check program. A fault or an error produces an entrance to the first-look program, which exercises only those portions of buffer control that are directly related to the interrupt condition. If a fault is not found in the immediate hardware, an error analysis routine is called in. If the error rate is low, the buffer control returns to processing; however, if the error rate is high, a complete check program is called in. If the complete check program is executed a number of times with negative results, then diagnostics will be called in to check the standby buffer control.

Buffer Control Diagnostic Programs

5.23 Two principal testing methods are used for diagnostic programs. The on-line method is a technique whereby the two buffer controls are connected together and the matcher is used for each operation. In the off-line method, the stand-by buffer control is tested while the active buffer control is executing message processing operations. The off-line method is used whenever possible in order to prevent interfering with high-speed data processing. In on-line testing, the buffer controls are connected together and put in step. A particular match point is selected and a test word loaded. Match results are recorded and analyzed for trouble location.

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D. Routine Exercise Programs

5.24 The two basic groups of routine exercise programs serve to update memory and status items and to exercise hardware that is not normally used in system operation. The automatic exercise programs are composed of three classes:

- (a) Exercise programs rigorously scheduled at relatively high frequency such as one used to reset buffer control error counters.
- (b) Exercise programs rigorously scheduled at relatively low frequency (during low traffic).
- (c) Exercise programs scheduled to be executed in system spare time and on a preset cycle basis.

Generally, the automatic exercise programs can be called in on demand by maintenance personnel or programs.

TEST LOOP FEATURES

5.25 The system has various forms of loop-around facilities (or test messages) which are executed via the queues and instructions in the buffer control call stores. A test message may be executed through a primary message store or tape store by loading the queues with instructions to write a block. At a later time the queue may be loaded with instructions to read back the block. In this manner, routine exercise programs may write and read blocks through the primary message stores and tape stores.

5.26 All the line facility units have some form of loop-around feature. A test message may be loaded into the call store and processed through the buffer control to the output section of a line facility unit. The message is then looped around to the input section of the line facility unit where it will consequently be returned to buffer control and to the call store. By this method, various programs may request test message action on a demand or routine exercise basis.

6. GLOSSARY

6.01 The following terms and definitions apply to this general description.

Address A combination of bits which identifies a location in a storage device or other equipment unit.

Asynchronous A digital transmission which requires start and stop pulses to maintain character synchrony. This is the prevalent TTY method of operation. Also used to describe any system which is not in step with another.

Bit A binary digit or information unit. It is represented by one of two possible conditions, such as: the characters 0 or 1, on or off, high potential or low potential, conducting or not conducting, magnetized or demagnetized.

Bus A group of leads providing time-shared communication paths over which information is transmitted from any one of several sources to any of several destinations.

Central Processor The community of data processing equipment as opposed to input-output equipment.

Error A malfunction, the symptoms of which *cannot* be reproduced under program control.

Fault A malfunction, the symptoms of which *can* be reproduced under program control.

Full-Duplex An operational configuration which permits a subscriber to transmit and receive simultaneously.

Half-Duplex An operational configuration in which the subscriber may handle messages in only one direction at a time, either transmitting or receiving.

Parallel In digital transmission, the simultaneous transfer of all bits of a word or character. See Serial.

Parity Bit A bit associated with a word to make the total number of ones, including the parity bit, either odd or even.

Piezoelectric Transducer A device which performs electrical/mechanical transfer of energy by means of a crystal element.

Random Access The ability to gain access to any location (of a memory device) during a time

interval that is essentially independent of that location.

Redundancy The use of additional equipment or devices to maintain system integrity in the presence of troubles.

Register A data word repository.

Sequential Access A system by which access to a location is gained as the location appears in a preset equence or order.

Serial A digital transmission, the sequential transfer of the bits in a word or character. See Parallel.

Synchronous A digital transmission in which all code elements are of equal length and are bit-synchronous as opposed to character-synchronous. Also used to describe any system which is in step with another.

Trouble A malfunction or other condition that causes a deviation from normal system operation.