No. 1 ESS ADF:

System Organization and Objectives

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This article describes the system organization and objectives of the No. 1 Electronic Switching System Arranged with Data Features. The new hardware and software designs required to adapt a No. 1 ESS to a store and forward system are outlined with emphasis on the techniques used to get large system capacity, continuous reliable operation, and flexible service features. System operation, traffic capacity, and use of the new system are also discussed in this introduction to seven detailed articles.

I. INTRODUCTION

A new store and forward message switching system has been designed and is now serving a nationwide network for the Long Lines Department of the American Telephone and Telegraph Co. It handles administrative traffic, time and payroll reports, circuit order layout records, and plant service results records. The new system is called ADNet, for Administrative and Data Network.

This is the first of eight articles reporting on the new system, which uses single and multistation lines for transmitting teletypewriter and data messages. The lines are supervised by an electronic message switcher which polls the stations, receives their messages and queues them for delivery to one or more destinations. The switcher is designed around the No. 1 ESS processor[1] supplemented by new peripheral units for assembling, storing, and transferring data characters. It is called No. 1 ESS — Arranged with Data Features: No. 1 ESS ADF. Its capacity and reliability exceed that of other known electronic message switchers.

In today's business world there is a growing need for rapid and economical delivery of data and printed copy, for simultaneous transmittal to several destinations, and assurance of delivery. Store and forward techniques allow messages for a given destination to be queued and lines to be engineered on the basis of traffic delay. For customers who can tolerate the delay in delivery of information, this method allows more efficient use of lines than line switching arrangements. Thus, economies are realized by use of narrow-band facilities, by serving several stations on a single line, and by queueing messages for contiguous delivery.

Although electromechanical systems of this type[2] have been provided by the Bell System since 1940, the advent of electronic processing and electronic station controllers has opened new opportunities for accommodating service features, speeding delivery and expanding traffic capacity. The system described here is currently used to provide internal Bell System communications.

II. SYSTEM OBJECTIVES

The prime objective of the new system is to provide a more efficient and economical means for handling teletypewriter and other data traffic on a private line basis by using the large switching capacity of No. 1 ESS.

2.1 *Service Features*

The new system has been designed to provide:

(*i*) Compatibility between computer and teletypewriter terminals.
(*ii*) Speed change: 60, 75, 100, and 150 words per minute.
(*iii*) Code change: Baudot and American Standard Code for Information Interchange (ASCII).
(*iv*) Parity error detection.
(*v*) Mnemonic addresses and group codes for routing.
(*vi*) Multiple address message delivery.
(*vii*) Time and date insertion in message heading.
(*viii*) Sequential message numbering.
(*ix*) Message retrieval by identification of message number, time, and date.
(*x*) Privacy.

The Appendix lists and describes these and other service features.

2.2 *Maintenance and Administration*

The system has been designed to give 24-hour service with reliability comparable to that of telephone switching systems. Individual station and loop problems are quickly revealed by regular polling and troubleshooting. Discrete call-in codes alert only specific stations on a line and, with proper answerback, guarantee delivery to the proper station. Mutilated messages are recognized by character parity and the message retrieval function will often permit recovery of lost or mutilated messages.

By following No. 1 ESS maintenance philosophy, maintenance effort and the hazard of an outage are greatly reduced. This involves dual processors with automatic identification and location of faults.

Administrative effort has also been minimized. Traffic reports are available by line and by station to head off temporary congestion and allow long term traffic balance. Upon instructions from a control location, traffic destined to specific stations can be diverted. Other instructions permit suspension of message pickup from specified stations. Simple means are provided for adding group codes, changing addresses, or adding new stations.

2.3 *Flexibility*

The system can grow in a modular fashion, allowing economy for either small or large offices. The basic repertoire of service features allows a wide range of choice for individual stations or communities of users. The addition of new service features may require hardware as well as program changes. In either case such changes are possible without disrupting office operation.

2.4 *Capacity*

The new message switching system is designed to handle at least 1,000 lines. The system can efficiently accommodate a wide variety of message lengths up to many pages. It will handle messages occurring concurrently on many lines, initiating delivery to an idle line within 10 seconds after receipt of a full message. Polling codes can deal with 20 stations on a line. Multiaddress codes allow a single message to be directed to 300 or more stations.

III. NETWORK CONFIGURATION

The network which No. 1 ESS ADF controls is indicated in Fig. 1, which shows the relationship among stations, controllers, lines, and No. 1 ESS ADF. Each station has an associated electronic controller.[3] The stations may be computer ports or teletypewriters of the send only, receive only, or automatic send and receive type. The controller responds to polling signals from the No. 1 ESS ADF and registers

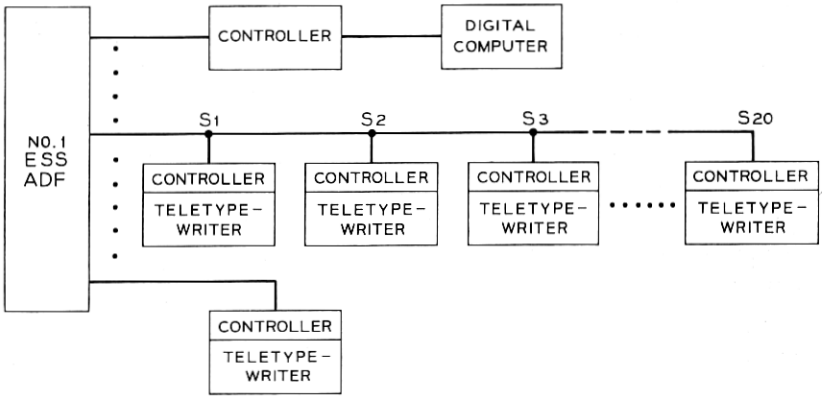

Fig. 1—Connection of terminals to No. 1 ESS ADF.

service requests when the customer has a message for delivery. Figure 1 shows several stations on one line. Contention for service is avoided by No. 1 ESS ADF which determines which station may receive a message or deliver a message at any time.

On half duplex lines, messages may be originated and terminated, but not simultaneously. Full duplex lines operate on a more complicated algorithm which allows supervisory interruptions without interference with message delivery. Full duplex lines may handle originating and terminating messages simultaneously. Mixing full and half duplex stations on one line is not permitted. Neither may different speeds or codes be mixed.

The traffic load on each line is the sum of the loads for the individual stations. The load is totalled separately for each direction of transmission. Traffic tables have been prepared which show the load which can be carried for given queue delays for half and full duplex lines. The physical routing of each line is carefully configured to interconnect the greatest number of stations not exceeding the prescribed load with minimal cost facilities linking them.

The stations are connected by private-line facilities operating up to 150 words per minute. The facilities are derived in a conventional manner using a full cable pair per station where distances are short and narrowband frequency division carrier channels where distances are long. These facilities are maintained through existing private-line-serving test centers which are capable of sectionalizing facilities and making measurements on them.

No. 1 ESS ADF has been programmed to quickly detect a difficulty in a controller or on a line by failure to receive proper acknowledgment from messages or polling. Reports are automatically printed on a teletypewriter at the serving test center closest to the No. 1 ESS ADF. This enables many problems to be identified and corrected before personnel at the affected stations are aware that they exist.

Stations transmit binary signals by means of frequency shift keying at 1175 ± 100 Hz. They receive at 2125 ± 100 Hz. An ac hub arrangement is used to join facilities at branch points in a line.

In addition to reports on station and line failures, the No. 1 ESS ADF provides reports periodically, or on request, on queue lengths and stations out of service to a number of specially designated teletypewriters at network management centers.

IV. SWITCHING CENTER DESCRIPTION

4.1 *General Design Plan*

The design of No. 1 ESS ADF is based on No. 1 ESS technology to minimize design effort and to take advantage of the lower costs of apparatus in large production.[1] (Sixty per cent of the frames in No. 1 ESS ADF are No. 1 ESS production items.) As Fig. 2 shows, the program-controlled central processor from No. 1 ESS has been used without change; additional special units have been designed to gain access to data lines and to provide the mass storage needed for store and forward operation. The hardware and software design principles developed for No. 1 ESS have been used and extended to store and forward data. Bell System switching reliability has been incorporated in all new designs.

The bus structure shown in Fig. 2 is designed to make modular growth possible by adding line terminal units and memory units as required for increased message handling capability.

Early in the development of No. 1 ESS ADF, simulation and analytical studies were used to aid in the development of hardware and software designs to provide maximum traffic handling capacity. These studies led to a system organization which provides traffic handling capacity for at least 1,000 low-speed lines by means of overlapping operation within the 5.5 microsecond central processor and concurrent processing within a new wired-logic arrangement called buffer control. Repetitive operations such as serial-to-parallel and parallel-to-serial conversion of data characters, special character recognition, assembly

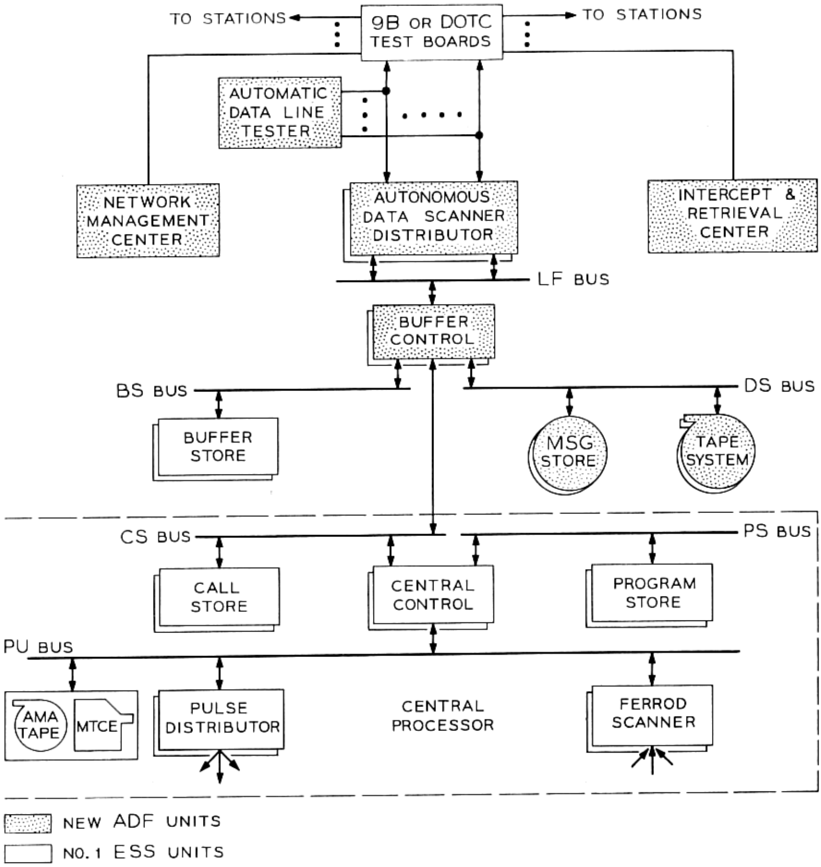

Fig. 2—No. 1 ESS ADF switching center block diagram.

of characters into computer words, error detection, and so on, are accomplished by wired logic in the buffer control and in other peripheral units.

The less repetitive and more complex functions such as station polling, heading analysis, address translation, routing, and traffic statistics, are handled by the stored program processor. This system organization minimizes the load on the central processor and bus structure so that very high traffic handling capacity can be obtained with economical computing units operating at a 5.5 microsecond cycle time.

The switching system hardware, as shown in Fig. 2, can be divided into five main subsystems: autonomous data scanner distributor, buffer control, message store, tape system, and the central processor.

4.2 *Autonomous Data Scanner Distributor*

As shown in Fig. 2, the low-speed lines (up to 150 words per minute) are directly connected to an autonomous data scanner distributor.[4] The unit can terminate 512 half or full duplex lines operating with the Baudot code at 60, 75, and 100 words per minute and the American Standard Code for Information Interchange (ASCII) at 100 and 150 words per minute. This unit is a time-division multiplex system with 1,024 time slots—an input and an output slot for each of 512 lines. The common control of the data scanner distributor samples each line 1,650 times a second and stores the sample taken at the center of each data bit. This sampling frequency permits sending characters with a maximum of 1 percent distortion and accepting characters with up to 45 percent telegraphic distortion at 150 words per minute.

The data scanner distributor uses the memory capability of aluminum strip ultrasonic delay lines to address lines, to sample the data being received in serial form from those lines, to store each bit in a memory time slot until the entire data character is received, and to pass on the character bits in parallel to the buffer control. The data scanner distributor also uses delay lines to store control information that assists in servicing user's lines. This unit works as an independent subsystem and can handle the input and output from 512 lines in real time. A maximum of five data scanner distributors can be connected to the system.

The duplicated common control of the data scanner distributor operates in a matched mode. Matching and internal parity checks are used to protect data during the assembly and disassembly process. The processing system monitors the data scanner distributor; and when fault sensing circuits indicate trouble, the system calls in automatic fault recognition and diagnostic programs. For example, if one common control fails, wired logic fault sensing circuits switch out the faulty unit at microsecond speed. Maintenance programs then diagnose the failure when spare processing time is available.

4.3 *Buffer Control*

The purpose of the buffer control is to relieve the No. 1 ESS central processor of a large number of repetitive tasks and to provide buffering and timing compatibility between the central processor normal cycle time and various rates of other peripheral units. The buffer control performs the following major functions.

(*i*) Receives data characters from the data scanner distributor and assembles characters into computer words.

(*ii*) Recognizes and flags special control characters.

(*iii*) Performs error control operations on the data.

(*iv*) Acts as a buffer in controlling the transfer of messages to and from the message store and the tape system.

(*v*) Interleaves the operation of the data scanner distributor, message store, tape, and central processor subsystems to permit concurrent operation of these asynchronous units.

The buffer control is a wired-logic, fully duplicated unit operating in a matched mode. All data transfers are matched and checked for parity. Buffer control administers the transfer of data between the buffer store and peripheral units (message store, tape, data scanner distributor), as well as the central processor, by providing queued access to the buffer store. Access to the buffer store is sufficiently often to meet the requirements of each peripheral unit.

The buffer control also operates as a maintenance coordination center and monitors all bus transmissions to and from connecting units. The buffer control, in conjunction with maintenance programs, uses match and parity circuits as the primary means for detecting and diagnosing troubles.

4.4 *Message Store*

The message store is a duplicated, sequential access (block oriented) memory unit which provides in-transit storage for all messages passing through the system.[5] Storage is accomplished in a disk file consisting of four double-faced rotating disks with a capacity of approximately 60 million bits. Duplicated disk files are synchronized by a digital servo system which controls the frequency of the motor drives so that identical data can be transferred to or from both files in one bus cycle time. The message store performs the following main functions:

(*i*) Retains each originated message until satisfactory delivery has been made to all addresses.

(*ii*) Stores a cross-reference file consisting of tape search numbers as a function of message numbers for retrieval of messages from the tape system.

(*iii*) Stores various types of registers, queues, and data blocks associated with the operational program.

Data are stored in fixed record length blocks on the disk with each block containing thirty-two 24-bit words. Data are stored in a block interlaced format at approximately 1,000 bits per inch. The disks are each divided into 16 sectors; queues are set up in buffer control call store so that in each revolution sixteen blocks of data can be written on or read from the disk system. Since the rotation interval of the disk system is 40 milliseconds, the average access time for a block of data can approach 2.5 milliseconds when a large number of blocks are being handled.

The switching system is designed to handle two duplicated disk systems providing a total of 120,000,000 bits of storage. The maximum traffic handling capacity of the disk system is approximately 38,400 characters per second.

4.5 *Tape System*

The tape system consists of two tape unit controls and up to 16 tape units per switching center.[6] Each tape unit control translates the tape instructions received from the buffer control into detailed logic sequences necessary to execute the tape operation. The tape unit control also assembles, disassembles, and buffers data transferred to or from the tape unit. Tape unit controls operate concurrently and can work with any tape unit for journal file, permanent file, and message retrieval functions.

The tape transports are nine-track units recording 800 bits per inch at a speed of 56.8 inches per second. The tape transport can read both forward and reverse, and data integrity is obtained by the use of parity and read-after-write check circuitry. The operation of the tape units has been designed to be almost entirely controlled by computer. Traffic attendants are required only to replace tape reels when indicated by the computer.

4.6 *Central Processor*

The central control, call stores, program stores, control circuits, and maintenance center are all standard No. 1 ESS units.[1] Both the call store and the program store are modular and can grow very large, as required.

The call store (ferrite sheet) units can be added in increments of 4,096 words. A maximum ADF system can have 192,472 words of call store. The program store is the semi-permanent twistor memory with removable aluminum cards containing magnetized bit patterns. Program stores can be added in increments of 65,536 forty-four-bit words for the storage of the call processing programs, maintenance programs, and for translation tables for customer lines, stations, features, group codes, and directory numbers. A maximum ADF system can have 393,216 words of program store.

4.7 *Summary of System Design*

The system organization and detailed design of subsystems provide:

(*i*) High processing power by concurrent operation of four asynchronous subsystems and use of wired logic for repetitive functions.

(*ii*) Modular growth with the flexibility to add high-speed lines and trunks as required for multiple switching center applications.

(*iii*) Economies associated with standardization of circuit design based on present No. 1 ESS production.

V. STATION AND TRANSMISSION DESIGN

A new family of electronic controllers and associated data sets have been developed for Bell System 4-row ASCII teletypewriters stations.[3] These electronic controllers are designed to provide improved message control, lower maintenance, and silent teletypewriter operation when not in use. The following features are built in to improve the integrity of message transmission:

(*i*) Roll call after transmission of each message.
(*ii*) Teletypewriter motor control.
(*iii*) Error detection.
(*iv*) Station power failure detection.
(*v*) Out-of-paper and paper jam alarm.
(*vi*) Regeneration of incoming and outgoing signals.

The performance of data transmission lines has also been improved by the use of new data sets. Maintenance has been improved by distortion monitoring provided by test boards and by the automatic distortion measurement capability of the No. 1 ESS switching center.

VI. OPERATIONAL AND MAINTENANCE PROGRAMS

6.1 *General*

The instruction format used in No. 1 ESS ADF is the same as that used in No. 1 ESS.[1] The program organization is similar to No. 1 ESS but has been influenced by the real-time requirements of handling many messages simultaneously by store and forward. Defensive techniques have been employed to guarantee the integrity of each message accepted by the system, since unlike conventional voice switching systems, the originator does not directly contact the terminator.

Therefore, the system is designed to guarantee the delivery of all messages accepted.

The program has been organized to respond quickly to errors detected by the internal hardware and software trouble detectors to assure dependable operation continuously. The program has been designed so that the system can recover from hardware and software troubles without losing or mutilating messages.

6.2 *Service Features*

A comprehensive set of service features has been incorporated into No. 1 ESS ADF to meet new requirements. The complete set of features includes those commonly found in single-user private line computer switchers. Other features have arisen from the ability of the machine to handle a number of different users with varying requirements. In addition to those features mentioned in the introduction, the system provides flexible heading formats, four levels of precedence, directory number addressing, interception of undeliverable traffic, journal file of messages, traffic statistics and status printouts to improve system administration and maintenance. All service features are listed and described in the Appendix.

Emphasis has been placed on developing message formats that are easy to read and easy to use. The system is designed so that all control characters are deleted; clear English copy appears on all printers. A message consists of two functional parts, heading and text. The heading contains message number, time, date, precedence, address (or group code), and personal address information. The text is the actual information conveyed by the originator and is delivered unaltered by the No. 1 ESS ADF. Although the heading is flexible in content, the format must be strictly adhered to. Format violations are detected and a service message is sent advising the originator of the type of error made. A typical message format is:

ORIGINATOR'S COPY	
S102 04/26 1340 EST	(ADF inserts message number, date, time)
CHGO123 BOS12 [Mr. H. Jones]	(terminal addresses supplied by originator)
"TEXT"	

DELIVERED COPY	
CHGO123	(Station address)
R506 04/26 1345 EST	(ADF inserts terminal message number, date, time)
CHGO123 BOS12 [Mr. H. Jones]	
"TEXT"	

Three features—privacy, action requests, and service messages—deserve specific emphasis because of their importance to overall system operation.

6.2.1 *Privacy*

Special steps have been taken to prevent the unauthorized delivery of messages. System programs have been designed so that messages cannot be delivered between stations of different users unless specified in the No. 1 ESS ADF translation tables for the originating and receiving stations.

6.2.2 *Action Requests*

Stations may originate various action requests which notify the switching center of certain desired changes. These changes may involve putting a station out of service (skip) or obtaining certain specific information, such as retrieving a message. Some 40 types of requests may be originated by the user and the maintenance center.

6.2.3 *Service Messages*

In response either to an action request or to some reportable occurrence, No. 1 ESS ADF originates certain messages to user or maintenance stations. There are 65 different messages which cover a variety of requests and conditions.

The entire system program has been designed so that user features are flexible and can be selected for each user or each station. Lines, stations, and features can be added or deleted from a user's set by a "recent change" procedure which can be done rapidly on-line without recompiling programs.

6.3 *Operational Programs*

The operational programs have been designed to handle a large variety of teletypewriter station terminals using the Baudot and ASCII codes at a variety of data rates.

Features mentioned earlier are implemented in 75 programs consisting of 100,000 computer words of code. The details of the operational programs can be found in Ref. 7.

The program system handles a typical message from a data terminal in the following manner. A message is prepared on a teletypewriter and then is placed on the machine with a "bid" for message pickup. All stations in the system are periodically polled by the switching center. When the service request is recognized by the processor, the translation tables are consulted to obtain a description of the data machine and the features selected by the user for that machine. Message number, time, and date are then sent to the originator, and transmission of the message into the system is started.

The message passes through the test board where line distortion and performance can be monitored. The data scanner distributor samples the incoming bit stream and converts the serial character stream to parallel characters. The parallel, multiplexed characters per line are received by the buffer control where they are assembled into 24-bit computer words and stored in the buffer store. Also in this process, the buffer control recognizes and flags special characters and detects and flags parity errors.

The computer length words associated with each active line are transferred to the processor and assembled into 32-word blocks in the call store. The processor extracts enough data from the heading of each message to put an entry into a queue for each terminator. Blocks containing heading and text are transferred via the buffer store to the message store.

As each message is delivered, the message is retrieved from the message store and is disassembled to the outgoing line by reversing the input process. After messages have been sent to all terminals, the data identifying each transaction, the heading and the text, are transferred from the message store to the tape system for permanent file and journal file recording.

6.4 *Maintenance Programs*

In a message switching system, operation without interruption is very important because there is a continuous flow of data through the entire system for the duration of each message. It is imperative that messages not be garbled, lost, or misdirected.

Reliability in the No. 1 ESS ADF system is accomplished by:

(*i*) Duplication of all units and buses.

(*ii*) Matching and parity checks on all data transfers.

(*iii*) Fault recognition programs which control micro-second reconfiguration of units to maintain a working system.

(*iv*) Comprehensive set of automatic diagnostic programs.

(*v*) Comprehensive safeguards against a variety of anticipated user errors.

(*vi*) Automatic overload control.

(*vii*) Automatic recovery program in case of memory multilation.

(*viii*) Comprehensive set of user and maintenance service messages.

The system is designed to operate without interruption for long periods of time. Experience with No. 1 ESS switching centers over the last three years has shown that a well debugged system can operate for years without a single interruption of service.[8] The programs for ADF are designed so that if a duplex failure does occur, all messages stored on disks can be recovered and delivered automatically after the system restarts. A record will also be found on disks of all messages being originated. After restart, originators of incomplete messages will automatically be sent a service message requesting that the message be originated again.

The maintenance programs for fault recognition, automatic diagnosis, and exercise are covered by 100 programs amounting to 150,000 words of code. The programs consist of modified No. 1 ESS programs for No. 1 ESS units and new programs for the new No. 1 ESS ADF units. New hardware and software techniques have been developed for handling autonomous wired logic and memory units such as the data scanner distributor, message store, and tape system. These programs are described in detail in Ref. 9.

Maintenance dictionaries and raw data printouts have also been developed for the new No. 1 ESS ADF equipment to permit rapid repair of hardware failures. This involved the insertion of 200,000 faults to develop the necessary data for dictionary preparation.

VII. CAPACITY

A store and forward system of this type can best be characterized by its thruput, that is, the maximum number of ten-bit characters transferred per unit of time at the interface between the data lines and the data scanner distributor. The thruput of a store and forward system is a function of message length, the complexity of the message heading, the multiple address factor, and the amount of intraline traffic.

The thruput of No. 1 ESS ADF was measured by using a programmed computer load test facility. The results are given in detail in Ref. 10. The results show that No. 1 ESS ADF can handle 6,800 characters per second at a message length of 1,200 characters. This is equivalent to 19,000 messages in the busy hour. For this configuration 600 simultaneous message transmissions (input plus output) can be handled. If the multistation teletypewriter lines are loaded to 0.6 erlang the system can handle 1,150 lines.

By using the load testing facility, the system was driven into real-time overload and it was demonstrated that the system could continue to operate without aborting, mutilating, or losing messages.

VIII. OPERATIONAL EXPERIENCE

The No. 1 ESS ADF system replaces an existing multicenter electromechanical system used for coordination of the Long Lines Department work operation. The revised nationwide network called Administrative-Data Network (ADNet) which went into service February 3, 1969, connects some 720 Long Lines, Telephone Operating Company, and Western Electric Company locations to the switching center with 400 circuits and 1,250 four-row ASCII teletypewriter machines. Connection is also made to computers at two Long Lines data processing centers so that computer-generated data can be sent or field data can be received and processed.

The system is being used to send administrative messages, traffic orders, commercial service orders, payroll, plant service results, circuit layout information and budget analysis reports. Daily originated plus terminated traffic is now averaging 38,000 messages consisting of 50,000,000 characters.

The system has given very satisfactory operation since February 3, 1969. System down time is averaging two minutes per month without loss of messages. A more detailed account of operational experience is given in Ref. 10.

IX. ACKNOWLEDGMENTS

Many people contributed to the development of this system from many areas of Bell Telephone Laboratories, American Telephone and Telegraph Company, and Western Electric Company. Significant contributions were made by Bell Laboratories people from the Data Systems Engineering Center and the Device, Telegraph Station, Electronic Switching, and Data Switching Development Laboratories. Overall guidance on the application aspects was given by the Engineering, Marketing, and Long Lines Departments of the American Telephone and Telegraph Company.

APPENDIX

Service Features

A.1 *Mnemonic Addresses*

Mnemonic address codes (a combination of letters and numbers such as an abbreviation or contraction of the destination name) are used to route messages to the proper destinations. The user may select a number of different codes, each of which may include up to seven characters. In addition, a given destination may be assigned more than one code.

A.2 *Group Code Addresses*

Group codes are mnemonic codes which address a specific combination of stations. A group code is selected by the user and may consist of up to seven characters.

A.3 *Multiple Addressing*

The ADF system can handle originated messages with up to 379 destination addresses. The destination address may be one or more mnemonic address codes, group codes, or call-directing codes (for five-level half-duplex stations only).

A.4 *Precedence*

The ADF system queues messages for delivery to terminating stations and will rank messages for delivery according to the following descending levels of precedence:

Precedence Level	*Code*
URGENT	1
RUSH	2
NORMAL	3
DEFERRED	4

The 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.

A.5 *Personal Address Information*

For originators using the ASCII format, up to 31 characters of personal address information may be used with each mnemonic address code or group code in each message heading.

A.6 *Message Identification*

The user may elect to identify each message with a sequence of from one to seven characters within the message heading. The use of message identification is available only for five-level full duplex stations.

A.7 *Message Numbering*

A message numbering service is available at the originating machine and at the terminating machine. Originating message numbering is optional for each station for both eight-level and five-level stations. Terminating message numbering is required for all stations.

A.8 *Date and Time Services*

Originating and terminating date and time service is optional. When used, the date and time are provided as a group following the message number. Time is indicated on a 24-hour clock with the user specifying the time zone.

A.9 *Delivery of Originator Nontext Information*

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, the relevant address (mnemonic or group code, precedence designation and personal address information), and the user message identification. Options vary for five- and eight-level stations and, also, for half-duplex and full-duplex per-line or per-station configurations.

A.10 *Tabbing*

An appropriate time interval after transmitting tabbing or form-feed characters allows the receiving terminal to perform the mechanical functions with a minimum delay. This option applies only to 8-level stations.

A.11 *Automatic Station Operation*

A message prepared for transmission is automatically picked up by the system without occupying the attendant at the sending station; message reception is automatic at unattended receiving stations.

A.12 *Multiline Hunting Groups*

The switching center can distribute message deliveries over a group of stations at a location with a rotary terminal hunting process. Messages addressed to the group are delivered to an idle station within the group. Messages may also be addressed and delivered to a specific station of the group.

A.13 *Station Service Arrangements*

The user may select half-duplex or full-duplex stations for originate only, terminate only, or automatic send and receive service. Three-row

Baudot and four-row ASCII teletypewriters can be specified. Arrangements are also provided for IBM 360 computers.

A.14 *Network Management Arrangements*

A user may select stations (within the user set) to perform control functions, to receive control and status information, and to receive messages undeliverable to their destination. A station may be assigned more than one of the above functions; only the supervisory position function requires transmission capability.

A.15 *Status Printouts and Traffic Statistics*

The No. 1 ESS ADF system compiles and sends status reports and traffic statistics to the status printout station. Status reports may be delivered periodically (as a summary), on request, or on occurrence. Traffic statistics are delivered daily and monthly.

A.16 *Treatment of Undeliverable Traffic*

A message becomes "undeliverable" when the message has been accepted by the system (origination was valid), but cannot be delivered to the intended destination. When a message becomes undeliverable, it will be rerouted to a suitable alternate station and a service message will be appended which indicates (if known) the addressee to whom the message could not be delivered.

A.17 *Skip in Polling Sequence*

A station is "on skip" when the ADF system is not picking up traffic according to the polling list. The No. 1 ESS ADF system will place any normally polled station on skip and will also take the station off skip and resume normal operation upon request from user or maintenance control position.

A.18 *Hold*

A station will be placed on or off hold at the request of the affected station user control station or maintenance 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 "hold." For high precedence message, an action copy will also be sent to a suitable station such as a control station.

A.19 *Alternate Delivery*

At the request of the affected station, all messages addressed to one station will be rerouted to a different specified user station. The station precluded by alternate delivery will be returned to normal message reception at the request of the user.

A.20 *Permanent Message File*

All message traffic is stored on a magnetic tape file for specified periods of time to accommodate message retrieval.

A.21 *Message Retrieval*

Retrieval of messages (or groups of messages) sent or received by users within a specified time interval is entirely automatic. Messages not on active tapes can be retrieved by manually inserting an off-line tape on a tape drive. A service message accompanies each retrieved message. The service message identifies the copy as a retrieval and includes the message number used in the retrieval request and the pertinent station identity.

A.22 *Directory Numbers*

Every station has a ten-digit directory number unique within the system plan. The No. 1 ESS ADF system accepts messages addressed with directory numbers from maintenance stations and routes these messages to proper stations.

A.23 *Intercept of Undeliverable Traffic*

When a message is undeliverable to a given address, it will be delivered to a designated interception position which may be the originator, user control, or maintenance position.

A.24 *Charge Recording*

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

REFERENCES

1. "No. 1 Electronic Switching System," B.S.T.J., *43,* No. 5, Pts. I and II (September 1964), pp. 1831–2609.
2. Bacon, W. M. and Locke, G. A., "A Full Automatic Private Line Switching System," AIEE Trans., *70,* Pt. 1, (1951), pp. 473–480.
3. Carney, A. C., Fitch, S. M., and Parker, G., "No. 1 ESS ADF: Teletypewriter Stations and Transmission Facilities," B.S.T.J., this issue, pp. 2941–2973.
4. Corbin, J. E., Lehman, H., and Townley, R. C., "No. 1 ESS ADF: Autonomous Data Scanner and Distributor," B.S.T.J., this issue, pp. 2857–2885.
5. Aitcheson, E. J., Ault, C. F., and Spencer, R. G., "No. 1 ESS ADF: Message Store—A Disk Memory System," B.S.T.J., this issue, pp. 2887–2913.
6. Potter, J. L., Strebendt, Mrs. F. E., and Williams, J. R., "No. 1 ESS ADF: Magnetic Tape Subsystem," B.S.T.J., this issue, pp. 2915–2940.

7. Kienzle, H. G., Nicodemus, K. L., Smith, M. T., Jr., Weber, E. W., and Zydney, H. M., "No. 1 ESS ADF: Message Processing Program Organization," B.S.T.J., this issue, pp. 2753–2830.
8. Haugk, G., "Early No. 7 ESS Field Experience I—Two-Wire Systems for Commercial Applications," IEEE Trans. Commun. Technology, *Com-15* No. 6 (December 1967), pp. 744–750.
9. Aitcheson, E. J., and Cook, R. F., "No. 1 ESS ADF: Maintenance Plan," B.S.T.J., this issue, pp. 2831–2856.
10. Barney, D. R., Giloth, P. K., and Kienzle, H. G., "No. 1 ESS ADF: System Testing and Early Field Operation Experience," B.S.T.J., this issue, pp. 2975–3004.