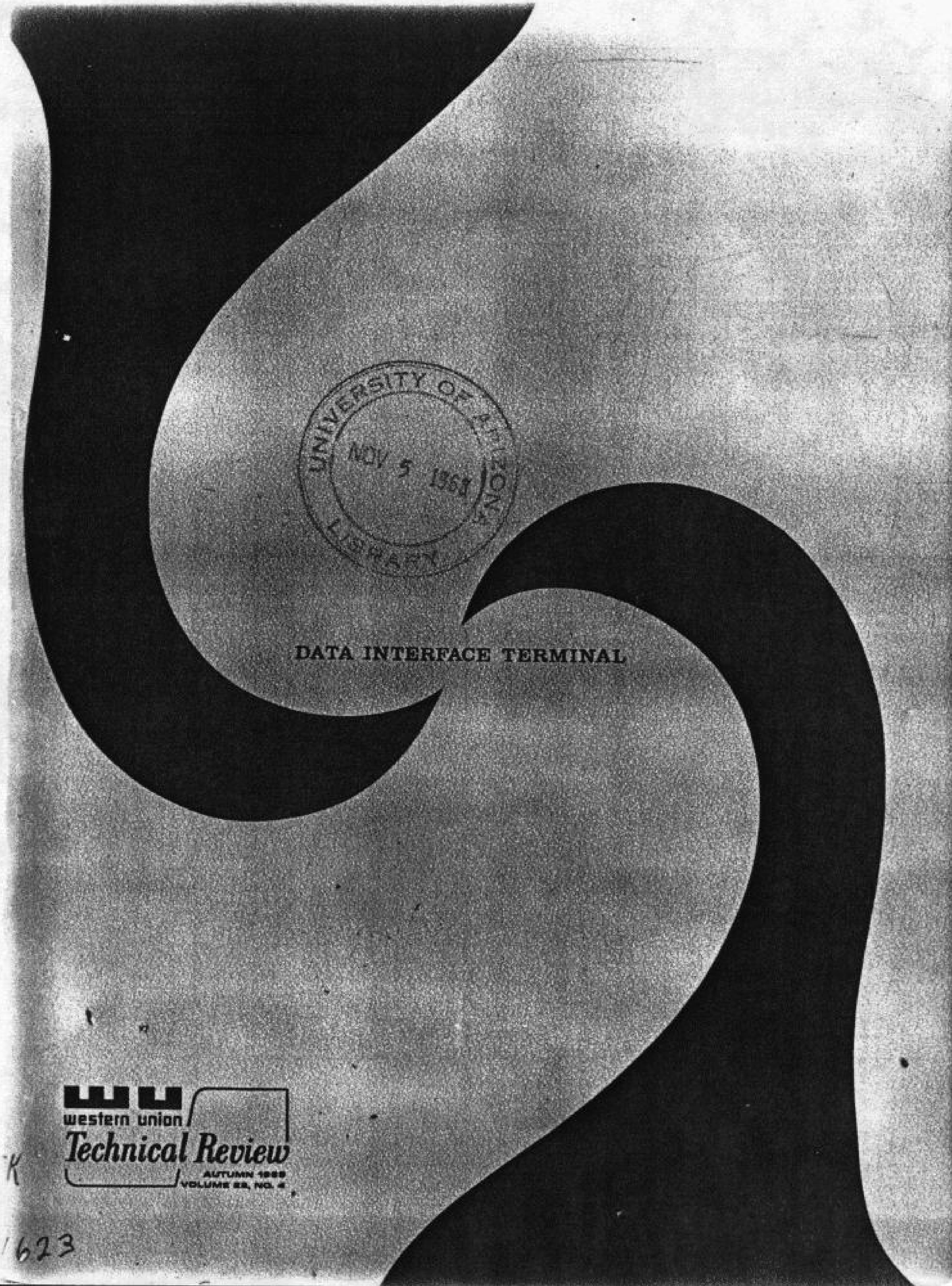

DATA INTERFACE TERMINAL

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COVER–Abstract Design showing the interface of data flow with the Data Interface Terminal, DIT

DIT (Data Interface Terminal) Provides Automatic Access to Computerized Data Terminals

John D. Kennedy and J. A. Pocchia

Introduction

Western Union placed in service early in 1966 an Advanced Record System (ARS) designed to provide the General Services Administration of the United States Government with a combined circuit switching and computerized message switching system capable of handling the teleprinter interchange load of the various government agencies. At present the system uses the USASCII code primarily, operating on a half-duplex basis at 100 wpm, with Baudot code a secondary capability. It has grown in size so that presently 1800 customer lines are served, with major expansion planned. The system provides an inherent advantage over the majority of existing systems due to the "Answerback" generation and comparison system designed into the ARS network. Other systems verify that a subscriber is connected, while the ARS automatically verifies that a particular called subscriber is connected by electronically comparing the transmitted subscriber's address digit code with the automatically generated subscriber's answerback, before completing the connection.

During the growth period of this system the need to interface agency computerized and other types of data processing systems or equipment with the ARS became evident. An analysis of overall requirements revealed that several interface arrangements would be required. To limit the number of arrangements and to permit one family of interface units to meet all requirements, regardless of the data equipment manufacturer, the use of Electronic Industries Association Standards RS 232-B and SP890 was specified for the interfaces between the data terminal and the communications system.

A Data Interface Terminal 12822-A was accordingly designed to meet these requirements. It provides automatic access between an ARS station and a computerized Data Terminal for calls in which queries and answers are handled during the same call, also for calls where that data terminal defers the reply, automatically calling back the ARS station when the reply is ready. The DIT was designed primarily for use with computerized Data Terminals; however, it may be used with other types of Data Terminals such as a Card Transceiver. The DIT design, with minor modifications, may be extended to other common switching networks or store-and-forward systems, either narrowband or wideband.

Data Interface Terminal

The Data Interface Terminal, DIT, shown in Figure 1, is a self-contained unit using Western Union's standard line of discrete transistor logic cards. It will operate satisfactorily over a temperature range of +40 to +120 degrees F. and a relative humidity range of 20 to 95 percent. It is powered from a local 117 volt, 60 cycle ac source. Power consumption is approximately 400 watts.

The DIT consists of the following:

a) Electronic card chassis 11704-C, equipped with a Sending Distributor Modification Kit.

b) Selecter Control Unit (SCU)—12844-A.

c) Maintenance Test Panel 12846-A (this includes a 120 volt power supply).

d) Power Supply 11706-B (±12V).

e) Operator Control Panel 12847-A.

f) Automatic Calling Unit (ACU)—12843-A.

g) Equipment Panel 11950-C.

Space is provided in the base of the DIT cabinet to mount a data set.

This set may be either of two types: a Data Loop Transceiver, if the DIT is located within 15 miles of the nearest ARS District Office; or a Carrier Type Data Set, if the DIT is beyond 15 miles. For multiple installations, the Data Sets may be rack mounted.

All units are interconnected by removable cables and equipment racks are hinged, where necessary, to permit easy access for maintenance.

Modular design of all units permits various rack or cabinet mounting when multiple installations are required. It is planned to concentrate as many as three DITs in one standard cabinet.

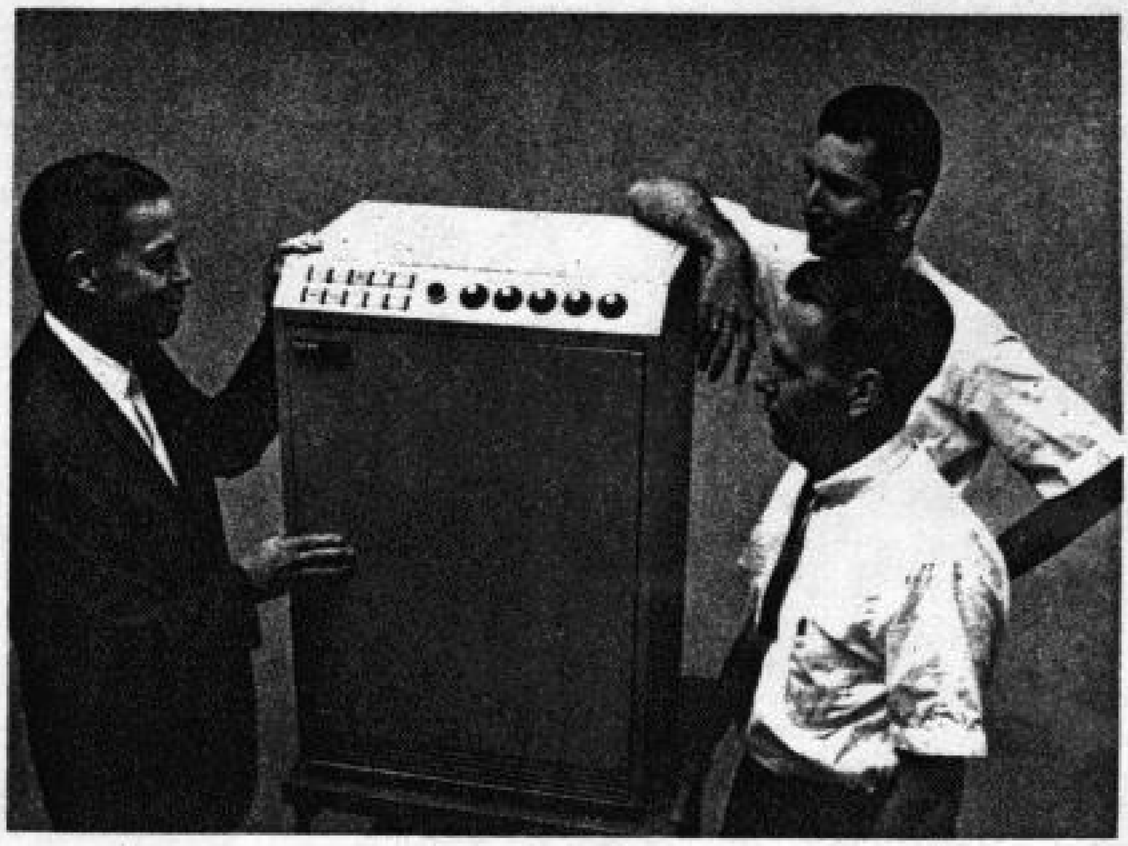


Figure 1—DIT is shown to John K. Nelson (left) Manager of ARS Terminal Equipment Engineering by the designers of this unit John D. Kennedy (right front) and Joseph A. Pocchia (right rear).

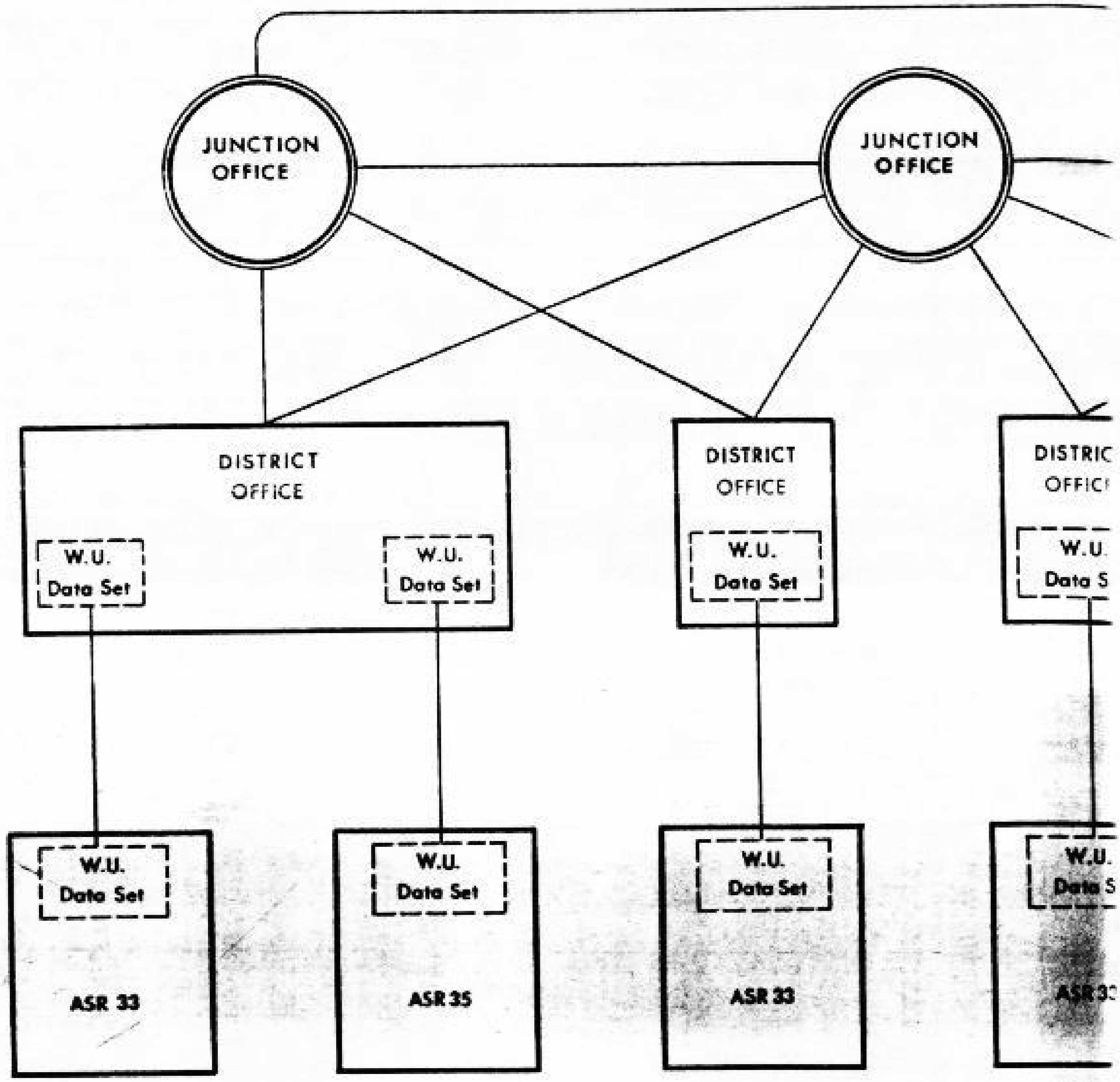
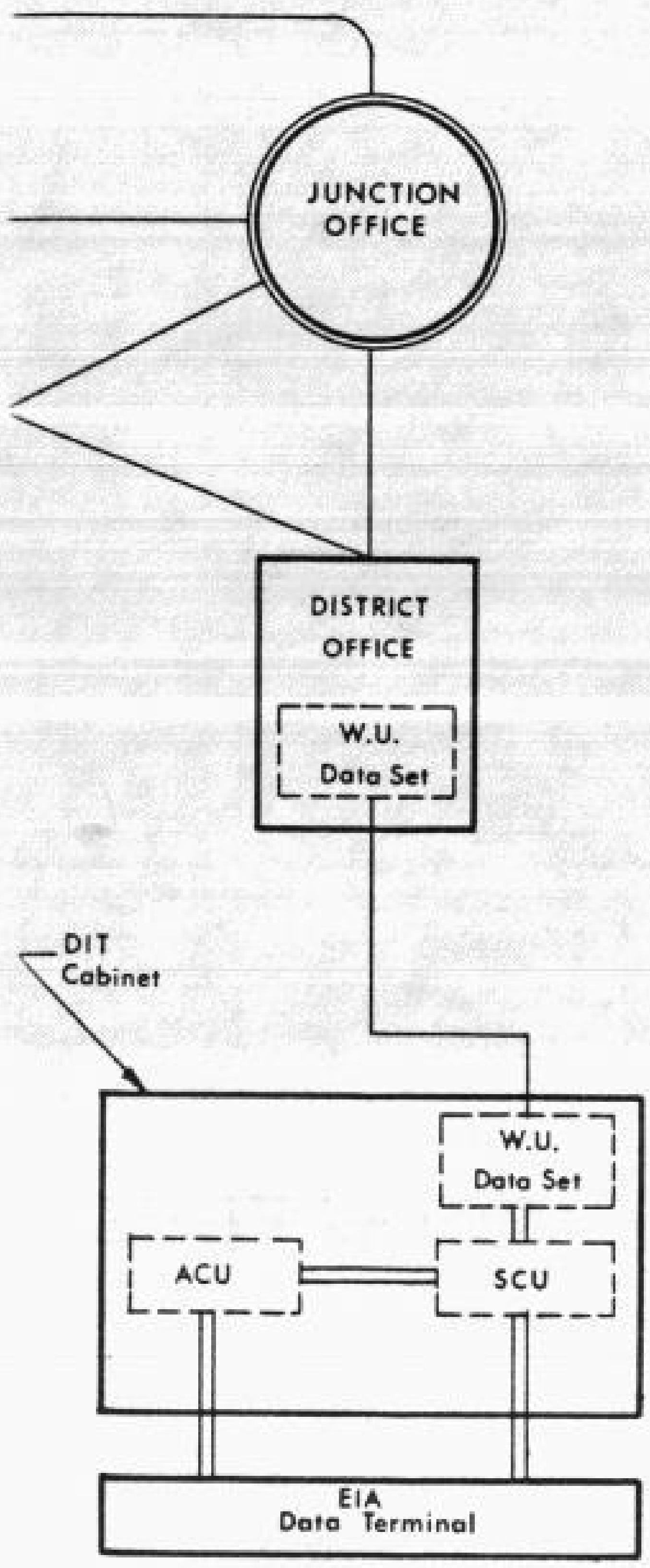


Figure 2—Interconnections of a DIT with an EIA DATA TERMINAL and

Interface with Switching System

Figure 2 illustrates the interconnection of a DIT with an EIA Data Terminal and the ARS Circuit Switching Network, CSN. The DIT performs all the required "hand-shaking" or signalling procedures with the CSN, including generation of an automatic answerback. The Data Set is the "signal interface" between the CSN and the DIT.

In the idle state, the facilities between the CSN and the DIT Data Set are held in the positive or spacing condition. All EIA control leads shown in Figure 3 between the Data Terminal and the DIT, except the CD lead (Data Terminal Ready) are "off." Electronic Industries Association Standards RS232B states that the control leads shall be considered "off," when the voltage on them is more negative than −3 volts with respect to circuit AB (signal ground); and these leads shall be considered "on," when the voltage on them is more positive than +3 volts with respect to circuit



ng Network.

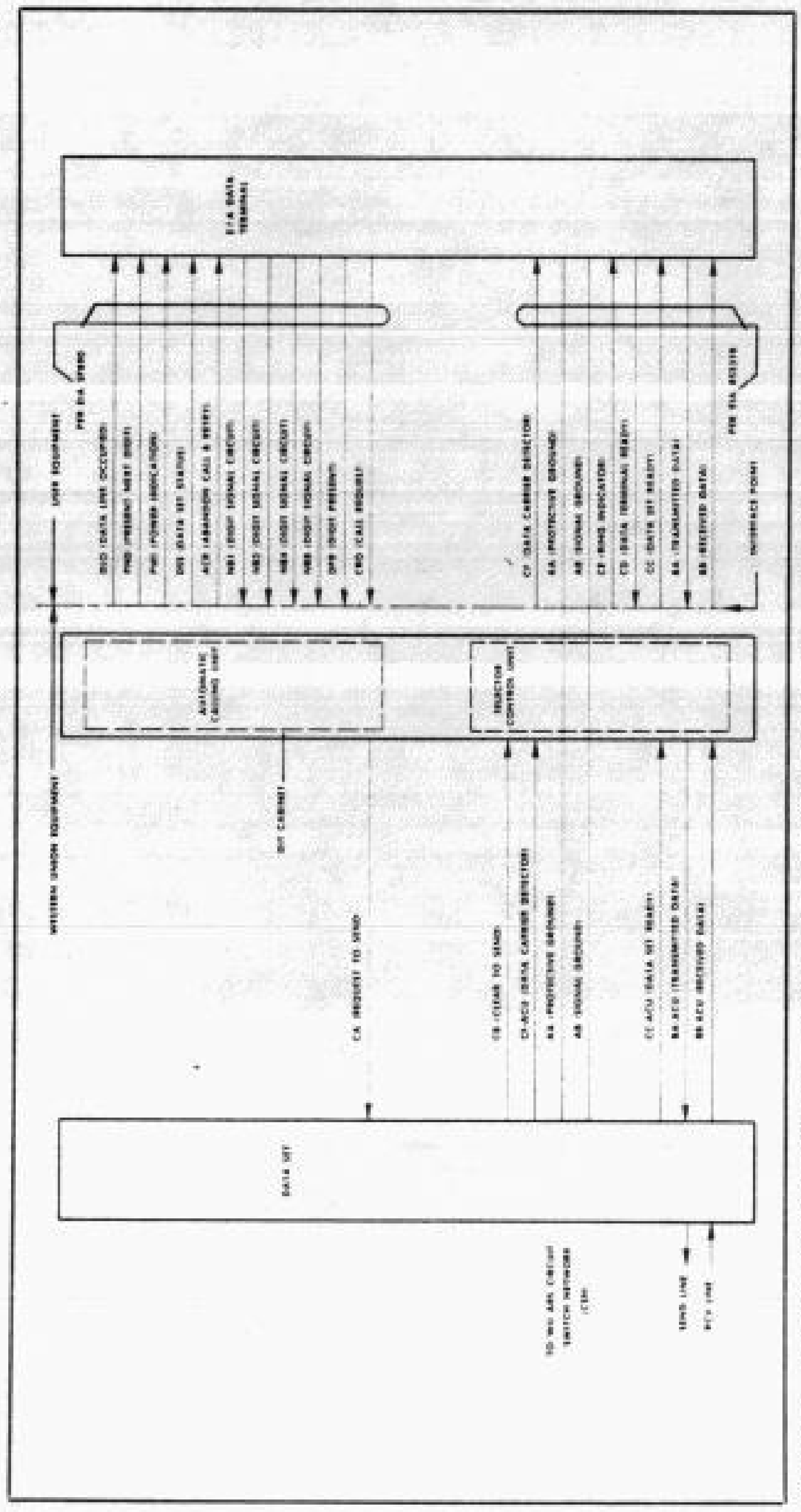


Figure 3—Interconnection Diagram showing EIA Control Leads between the DIT and the EIA Data Terminal

AB. The CD lead may be held either "on" or "off" depending upon whether the Data Terminal will accept calls automatically or accept them subject to the control of the Data Terminal. When the ACU is used, all EIA control leads between the ACU portion of the DIT and the Data Terminal will be held "off," except for the PWI (Power Indicator) lead. The PWI lead will be held "on," indicating to the Data Terminal that the DIT is powered. A request to send by the Data Terminal can only be initiated when the DIT is in the above state.

Modes of Operation

A DIT equipped Data Terminal can operate in four basic modes, two automatic and one manual sending modes, also a receiving mode. These four are:

1. *Calls* **"Automatically"** *initiated and received with data transmission at any code and speed up to 180 baud*

   To initiate a call **automatically** the DIT is equipped with the Automatic Calling Unit Model #12843-A. The Data Terminal initiates a request to the CSN by turning on the CRQ (Call Request) lead to the DIT as shown in Figure 4. CRQ remains on either until the message or the circuit connection has been completed, depending upon individual Data Terminal requirements. Turning CRQ on advises the CSN that the DIT desires a connection to a station.

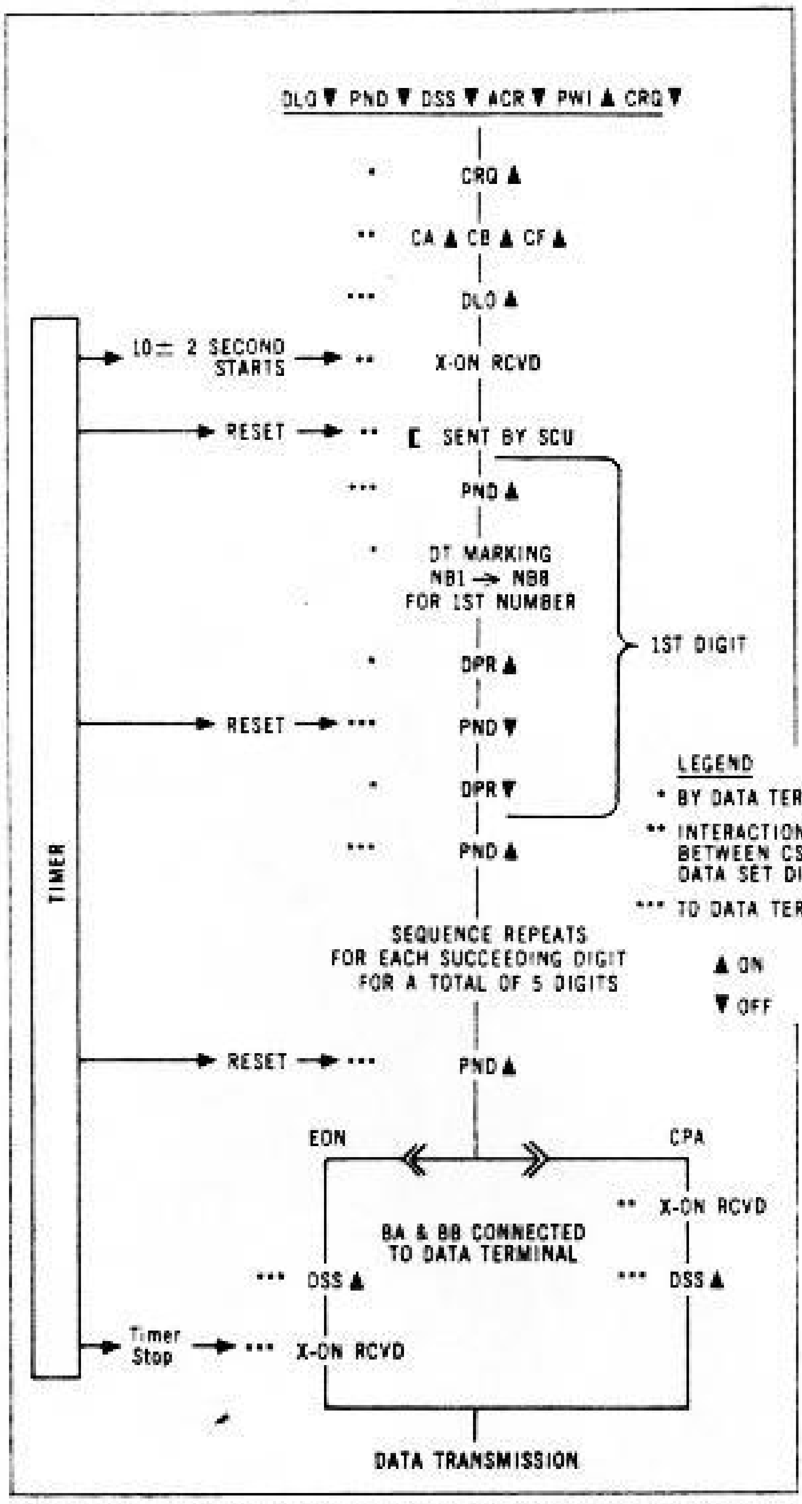


Figure 4—Sequencing Diagram for Calls Automatically Initiated with Data Transmission at any code and speed up to 180 Baud

The CSN establishes the connection between the DIT and the CSN and sends the "Proceed-to-Dial" signal (X-ON) to the DIT. The DIT then transmits the bracket character [stored within it and turns on the following leads to the Data Terminal: CF (Data Carrier Detector), DLO (Data Line Occupied), PND (Present Next Digit). The PND lead notifies the computer to place the first station address digit in binary form on the four NB leads (Digit Signal Circuits) to the DIT. The DIT converts the binary number provided by the computer to the required USASCII representation. After placing the binary coded representation of the first dial digit on the NB leads, the computer will turn on the DPR (Digit Present) lead to the DIT. The DIT will then transmit the first digit at 110 baud to the CSN and turn off the PND lead to the Data Terminal. The Data Terminal responds by turning off the DPR lead to the DIT. The DIT again turns on the PND lead to the Data Terminal and the sequence is repeated, until the complete address digit code has been transmitted.

At this point, the DIT has two operating options available, the End of Number (EON) and Calling Party Answer (CPA). With the EON option, the DIT will complete the connection between the Data Terminal and the CSN as soon as it sends the address digit code. With the CPA option, the DIT will not complete the connection until the "Called Party" has been connected to the CSN. In either case, upon reception of the complete address digit code by the CSN, it will attempt to establish a circuit connection to the called party.

At this point, a connection may be established to the called party or the call may be abandoned for one of the following reasons:

a) Called station busy.

b) Trunk busy.

c) Faulted or deranged condition.

d) Invalid address.

If the CSN determines that a busy condition exists, it will send a busy signal to the DIT, which may be either an OCC for a busy station or OCL for busy trunks, followed by a disconnect. The DIT, upon receipt of either busy signal, followed by the disconnect, will start the Busy Timer sequence, hold DLO "on," and turn ACR (Abandon Call and Retry) "on." The Busy Timer will prevent the Data Terminal from initiating another call, holding DLO and ACR on until the timer "times out." The Busy Timer is variable from a few seconds to a maximum of 90 seconds. This feature was incorporated to compensate for various traffic conditions and prevent a Data Terminal from engaging common exchange equipment unnecessarily.

When the CSN determines that a Deranged (DER) condition exists or that an invalid address has been received, it will send a DER signal to the DIT, followed by a disconnect. The DIT starts the Deranged Timer, holds DLO "on" and turns ACR on. The Deranged Timer has the same variable range as the Busy Timer and was incorporated for the same reason.

When a circuit connection is completed to the called station, the CSN requests a station identification code from the called station by transmitting a "Who Are You" (WRU) signal to that station. The response is received by the CSN and also by the DIT. When the EON option is used, the Data Terminal will also receive the station identification code. The CSN makes a comparison of the transmitted address digit code with the received station identification code and if a comparison does not exist, it will disconnect the two terminals. If a comparison exists, the CSN sends a Proceed to Transmit (X-ON) to the DIT and the Data Terminal. The Data Terminal may now transmit information to the called station. With the CPA option the station identification response will not be received by the Data Terminal since the connection between the Data Terminal and the CSN has not been completed. The CSN will make the comparison and proceed as above. The reception of the Proceed to Transmit signal by the DIT turns DSS (Data Set Status) on, notifying the Data Terminal that it may now transmit information to the called station.

After a connection has been established, data may be exchanged through the CSN at any code or speed up to 180 baud. Upon completion of transmission, either called or calling parties may initiate a disconnection. The Data Terminal initiates a disconnection by turning CRQ off. If the Data Terminal is programmed to hold CD on during transmission CRQ may be turned "off" as soon as connection is made to the CSN. In this case, the Data Terminal may initiate a disconnection by turning off CD.

The Data Terminal is prevented from initiating another call after disconnection for a pre-set, but variable, amount of time by the Data Line Occupied Timer. During this timing interval, the DLO lead to the Data Terminal will be held on. The Data Line Occupied Timer has the same range as the Busy and Deranged Timers. This feature was incorporated to prevent a Data Terminal, such as a computer, from monopolizing the common exchange equipment.

2. *Calls* **"Automatically"** *initiated and received with data transmission at 110 baud USASCII*

The DIT may be used in conjunction with a Data Terminal to initiate calls **automatically** without the use of the Automatic Calling Unit. Figure 5 is a sequence diagram for initiating a call automatically.

The Data Terminal initiates a request to the CSN by turning on the CA (Request to Send) lead to the DIT. A circuit connection is then established between the DIT and the CSN and the Proceed to Dial signal is sent to the DIT. At this point the DIT may be programmed to turn on any or all the following leads: CF (Data Carrier Detector), CB (Clear to Send), CC (Data Set Ready). The Data Terminal then transmits "[" followed by the 5 address digits in USASCII code at 110 baud. The DIT may also be programmed to transmit the "[" instead of the Data Terminal and then turn on the above leads. The DIT passes the address digits to the CSN, then monitors the leg from the CSN to detect a connection completed, a busy, or a deranged signal.

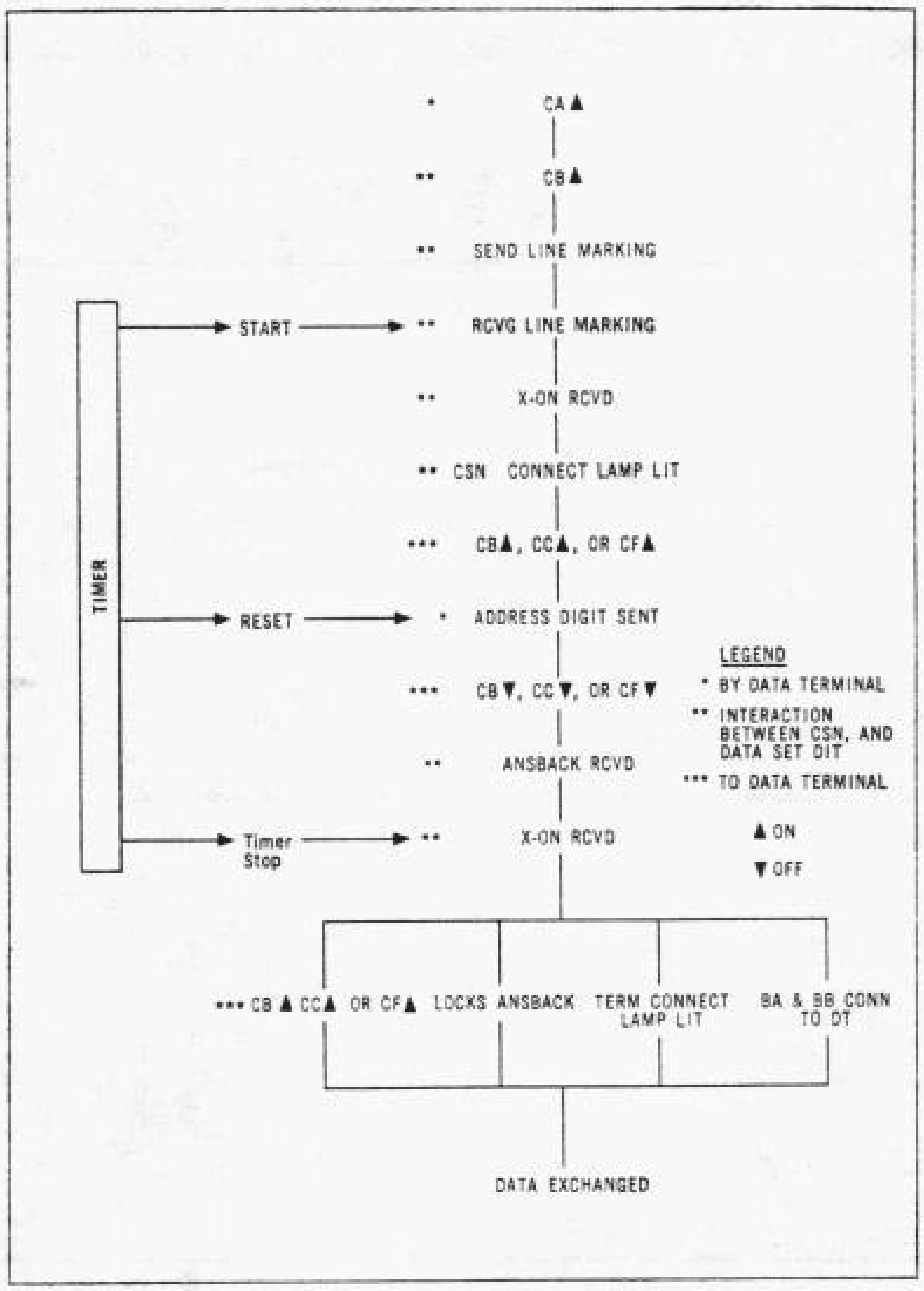


Figure 5—Sequence Diagram for Calls Automatically Initiated with Data Transmission at 110 Baud USASCII

The CPA and EON options are available at this point. With the CPA option, the DIT will count the address digits and may be programmed to turn off any or all of the above leads upon counting the fifth address digit. The DIT will then complete the connection between the Data Terminal and the CSN and may be programmed to turn on any or all of the above leads when it detects a Proceed to Transmit signal.

With the EON option, the DIT will complete the connection between the Data Terminal and the CSN when it counts the 5th address digit, holding the above leads on. With this option, the Data Terminal will receive the automatic answerback of the called party followed by the Proceed to Transmit signal. If the DIT detects a busy or deranged signal, it will drop the connection, thus preventing another call from being initiated for a predetermined time. After a connection has been established, data may be exchanged through the CSN.

Upon completion of data transmission, either the called or calling party may initiate a disconnection. The Data Terminal initiates a disconnect by turning CA "off". If the Data Terminal is programmed to hold CD "on" during transmission, CA is turned "off" as soon as the address digits have been sent to the CSN. In this case, the Data Terminal initiates a disconnect by turning off CD.

3. *Calls* **"Manually"** *initiated and automatically received with data transmission at any code and speed up to 180 Baud*

The Data Terminal operator can originate a call manually, independent of the Data Terminal, by pre-setting the five address rotary switches on the Operator Control Panel, shown in Figure 6, to the address digit code of the station to be called. The operator then depresses the Request pushbutton located on that panel, which turns off the idle lamp, and notifies the CSN that the DIT desires a connection to another terminal. When the CSN is ready to receive the address digit code it will send a Proceed to Dial signal to the DIT. The DIT lights the CSN connect lamp on the operator control panel and automatically sends the character "[" followed by the five digits pre-selected in the address switches.

The DIT has available two operating options, the End of Number (EON) and Calling Party Address (CPA), as previously defined. With the EON option, the DIT will light the terminal connect lamp on the operator control panel and complete the connection between the Data Terminal and the CSN as soon as it transmits the address digit code. Upon reception of the address digit code from the DIT, the CSN attempts to establish a connection to the called party. With the CPA option, the connection will not be completed and the terminal connect lamp will remain off until the Proceed to Transmit signal is received.

From this point, the circuit connection phases of the DIT operation are as previously described for automatic operation. Failure to establish a connection to the called party will be indicated by the appropriate lamp (Busy or Deranged) on the operator control panel. Either party can disconnect at the completion of transmission. The Data Terminal operator can initiate a disconnect by depressing the Disconnect pushbutton. At any time, independent of the normal operating mode, the DIT can be used to initiate a call manually.

4. *Calls* **"Automatically"** *Received with Data Reception at any Code and speed up to 180 Baud*

Figure 7 is a sequence diagram covering reception of a call. In the idle condition, the receiving legs between the DIT and CSN are spacing. All control leads except CD, between the DIT and Data Terminal are "off". CD may be held "on" or "off" depending upon the option selected by the Data Terminal. The CSN notifies the DIT that a subscriber has requested a connection to the DIT equipped Data Terminal by turning the DIT receive leg to Marking. The CSN establishes a connection between the DIT and the CSN and sends the characters "WRU WRU" to the DIT which turns on the CE (RING INDICATOR) lead to the Data Terminal. The Data Terminal then turns on CD if it is not already on. CD "on" is an indication to the DIT that the Data Terminal is conditioned to receive data. In response to CD "on" and the reception of WRU, the DIT sends its nine character automatic answerback, CR CR LF [XXXXX to the CSN. After sending the answerback, the DIT turns DSS "on" and connects the Data Terminal to the CSN, which notifies the remote calling station to transmit if the answerback compares with the address digit code. Data may now be exchanged between terminals and either terminal may originate a disconnect cycle. The DIT equipped Data Terminal initiates a disconnection by turning CD "off."

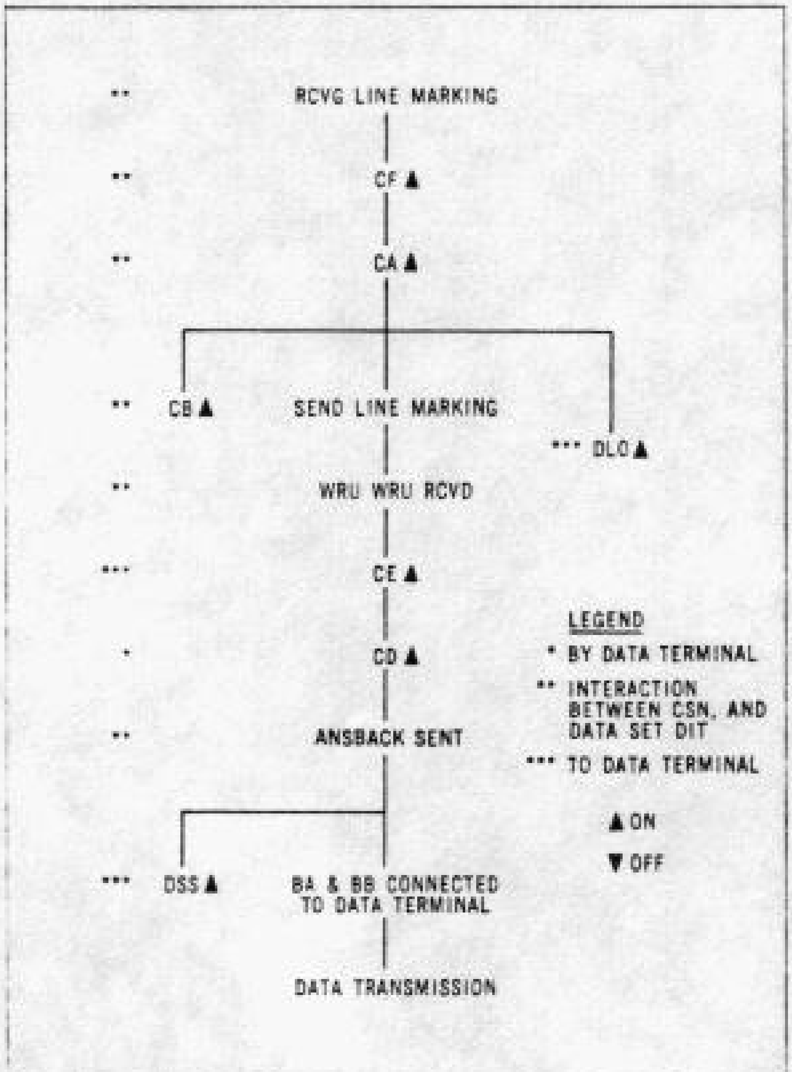


Figure 7—Sequencing Diagram for Calls Received with Data Reception at Any Code and Speed, up to 180 Baud

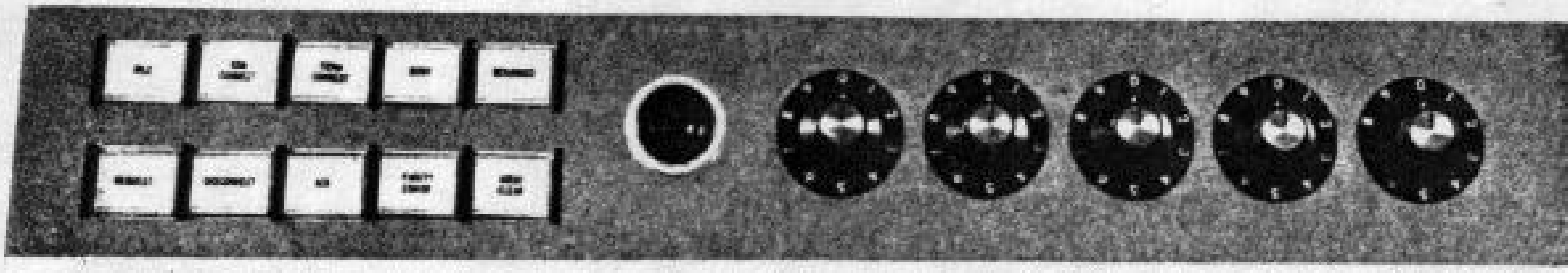
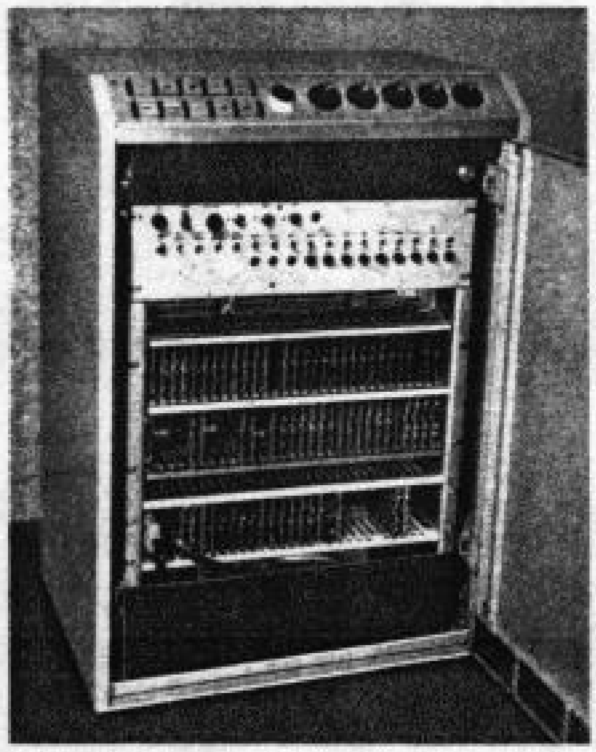


Figure 6—Control Panel for Manual Operation

Unique Testing and Maintenance

- *Data Terminal Operator Tests*

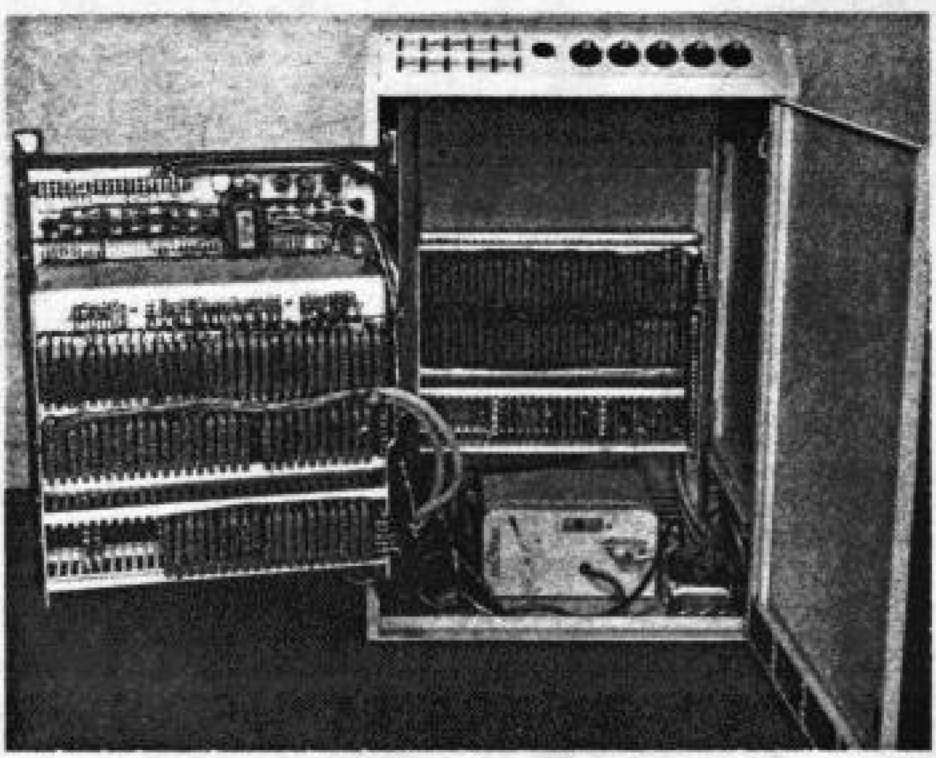
  When a DIT equipped terminal is programmed for automatic operation, the DIT Operator Control Panel is not normally used. If trouble is suspected, either with the Data Terminal, DIT, or CSN, an operator may call any subscriber, including the WU district office test printer, by positioning the address rotary switches to the desired address digits and depressing the Request pushbutton. If the CSN connect and terminal connect lamps light, it can be assumed that the DIT and CSN are working properly.



DIT cabinet opened for automatic operation

- *Western Union Maintainer Tests*

  A common application of the DIT will be in conjunction with a customer furnished computer data terminal. In such an installation, test equipment such as an ASR Set normally used for local maintenance testing is not available. The DIT therefore incorporates a simplified maintenance test panel consisting of lights and switches. A mantainer may substitute the maintenance panel for the Data Terminal by moving two connectors. The Maintainer Test Panel is equipped with 8 switches which allows any character configuration in USASCII to be set up. In conjunction with the sending distributor of Electronic Card Chassis 11704-C, the test panel is able to generate the control characters normally sent by the CSN, allowing the test panel to simulate the CSN. The test panel can also be used to simulate the Data Terminal, switches being provided to simulate the control signals normally originated by it, with lights provided to indicate the status of the control leads between the Data Terminal and the DIT. A bust back switch located on the maintenance panel, allows the maintainer to bust-back the DIT signals, allowing the DIT to be tested independently of the CSN, facilities and Data Terminal.



Simplified Maintenance possible with DIT

Optional Features

The DIT has three optional programming features and an optional panel:

- *Even Parity Detection*

  The DIT may be programmed to detect parity errors on incoming calls for USASCII 110 baud transmission. When a parity error is detected the DIT initiates a disconnection, sends a programable character to the Data Terminal and lights a parity error lamp on the Operator Control Panel. This lamp remains lit until the Parity Error Reset pushbutton on the Operator Control Panel is depressed. Failure to depress the Reset pushbutton will not interfere with the reception or the initiation of another call.

- *Audio Alarm*

  The DIT may be programmed to sound the alarm on the Operator Control Panel upon receipt of an incoming message or upon detection of a parity error. The alarm activated by reception of an incoming message is silenced by depressing the Audio Clear pushbutton on the Operator Control Panel or is automatically deactivated at the time of disconnection. The Parity Error Audio Alarm is reset by depressing the Parity Error Reset pushbutton.

- *Connection Verification*

  The DIT may be programmed to send its answer-back upon reception of a "WRU" at any time during or at the end of data transmission, in order to verify circuit connection.

- *Equipment Panel*

  With this optional panel 11950-C, the DIT can provide the following extra features:

  - Motor Control
  - Transmitter Control
  - High Voltage (± 120) signalling between the DIT and the Data Terminal.

J. D. Kennedy, Supervisor, Terminal Equipment Engineering, in Private Systems Projects, Planning and Engineering Operation, is responsible for the system engineering of terminal equipment for the Western Union GSA/ARS system. He assisted in the design of several reperforator systems and was Assistant Project Manager for the Emergency Automatic Transmission Systems provided for the Joint Chiefs of Staff and Air Force.

Mr. Kennedy joined Western Union in 1954. He received his B.S. degree in Electrical Engineering from Louisiana State University in 1951 and holds a Professional Engineer's license.

J. A. Pocchia, designer of the Data Interface Terminal has left Western Union to take a position with one of our customers. His photo is on page 123.

SAS
A Management Tool To Evaluate the Dynamics of Change

This article describes in general terms the application of simulation to operational management. Many problems related to operational management can be solved by analytical techniques rather than simulation techniques. No attempt has been made in this article, to define parameters that justify utilization of simulation instead of analytical processes. However, our experience has indicated that in an increasingly complex communications environment, simulation can provide effective data for system control and management.

by E. S. Elsam and J. J. Riggs

Western Union, under contract to the United States Army Strategic Communications Command (USASTRATCOM), has developed a software program to be used for evaluation of Overseas AUTODIN. This program, called Systems Analysis Simulator (SAS), was conceived primarily as a manager's tool to evaluate the effects of change on a vast communications network, such as Overseas AUTODIN and to predict with reasonable accuracy, the effects which such change may impose. These changes may be increased traffic volume, more stringent requirements for speed of service, increased high precedence traffic or new and faster peripheral devices.

Overseas AUTODIN

The characteristics and functions peculiar to the Overseas AUTODIN switching centers were analyzed resulting in a dynamic model called SAS. Within certain planned constraints, a dynamic model permits the analyst freedom to experiment with operational conditions without affecting the operational system. The software program developed for SAS has been designed modularly, so that any of the Overseas AUTODIN switches could be simulated by simply changing the parameters of channel configuration. The model is designated to permit the user to pre-set real world parameters such as range of terminal speed, volume of traffic, etc., and then vary these parameters to examine both the internal and external effects which these variations cause upon the switching center. While simulation has been utilized as a design tool, this article describes the application of simulation to operational evaluation.[1]

The ideal method for evaluating the performance of any physical object is to test it under realistic conditions. Very often, systems that are expensive or complex are almost impossible to evaluate under conditions of heaviest load.

The underlying purpose in the development of SAS was to evaluate the Overseas AUTODIN Automatic Switching Center (ASC) without devoting large amounts of manpower and equipment to that sole end. Out of this basic idea came the requirements of building a model, a simulation, of the ASC which would enable evaluations of performance to be accomplished independent of the physical switching center. The basic requirements for constructing SAS were:

(1) That it be a flexible analysis tool.

(2) That it be usable by non-programmers.

(3) That it enhance the ability of system managers to analyze a switching center under dynamic conditions.

Performance Factors

In the case of Overseas AUTODIN some of the operating criteria are based upon "throughput," and "message delay." These are called performance factors as opposed to such criteria as accuracy, reliability, security, or cost. These two basic factors determine the performance. A definition of throughput and message delay, and how they can vary in the communications system will emphasize the major role these factors play in the SAS.

(1) Throughput.

Throughput, in a communications system, is defined as the total amount of traffic passed successfully through a switch, in a period of time. The generally accepted units for measuring throughput are lineblocks per second. The throughput equation is:

$$\psi = \frac{L_i + L_o}{T}$$

where

ψ — Throughput
L_i — Lineblocks successfully transferred into system
L_o — Lineblocks successfully transferred out of system
T — Average cycle time of Message Processor Program

It is apparent from this equation, that as we vary the load (lineblocks) of the system, the throughput (ψ) will vary directly. However the term "T" is not only a function of system load, but other system parameters which cause the throughput curves to be not linear. A family of throughput curves for an ASC is shown in Figure 1.

Each of the dotted curves shows a variation of throughput with a variation of processor cycle time under constant load, X_1, X_2, X_3, and X_n. When an extra overhead uses up processing time, causing cycle time to increase from T_o to T_1, we experience a decrease in throughput of ψ_o to ψ_1.

If we increase the load on the system from X_1 to X_2, keeping the overhead constant, the throughput increases from ψ_o to ψ_2, with a concurrent increase in cycle time, T_o to T_2.

Each dotted curve represents the variation in throughput for a particular percentage of the maximum data capacity of the processor software package, and X_n represents the maximum processing capacity. Therefore, the maximum throughput values would be in the range defined by the curve X_n. Since the objective of the communications analyst is to keep system performance at a peak, he is usually trying to keep the system operating at peak throughput by minimizing processor overhead at each discrete load level.

Throughput is a general performance indicator and has little meaning unless it is paired with some value of switch-imposed message delays. That is, we could be experiencing a high throughput, but in truth the system might be so backlogged as to seriously hamper the entire switching network.

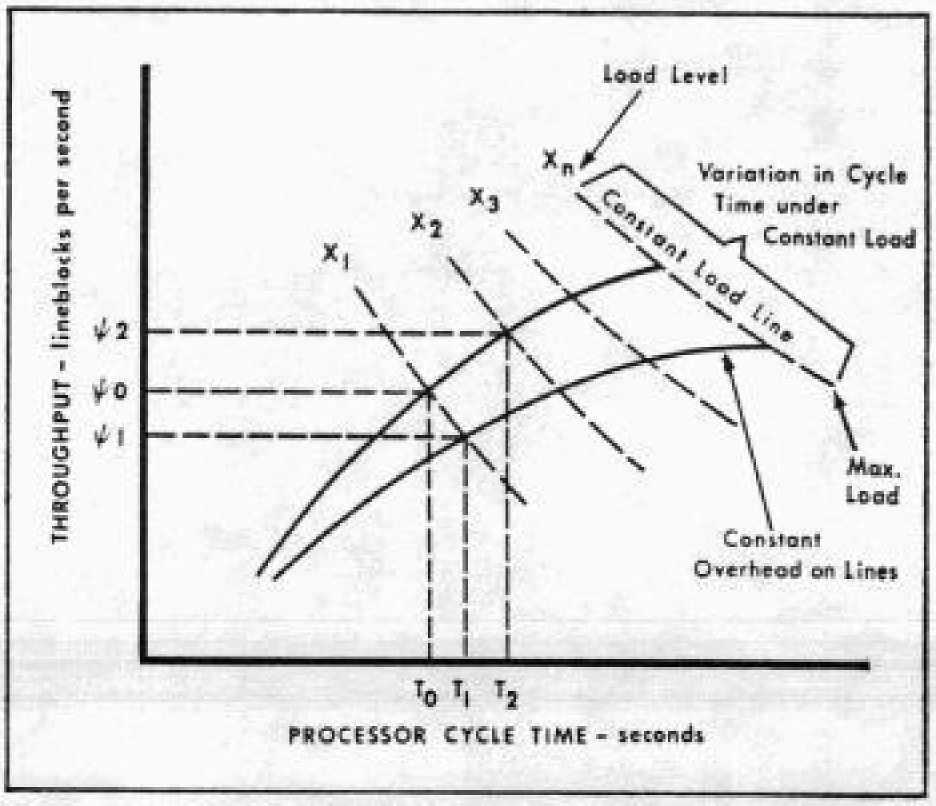


Figure 1—Throughput Curve for an ASC

(2) Message Delay.

There are two factors involved in message delays. There is a certain amount of time which will be required to transmit or receive a message from a tributary. This time is primarily dependent upon the message length and line speed. Also, there is a nonproductive time which a message must experience; the switch-imposed delay.

We can see this from the typical system represented in Figure 2.

The total time required by this system to deliver a message over the path ABCD is $\triangle T_1 + \triangle T_2 + \triangle T_3 + \triangle T_4 + \triangle T_5$. The times at switch nodes B and C are delays imposed by processing overhead and by waiting lines, or queues. It is obvious that the communications planner can influence $\triangle T_1$, $\triangle T_3$, and $\triangle T_5$ by changing the speed of the lines

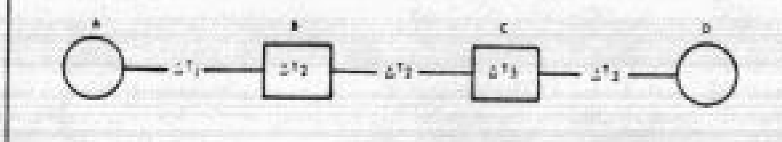


Figure 2—A Typical System

or by changing message length. However, what can he do to influence the $\triangle T_2$ and $\triangle T_4$ times? What can he do to avoid the waiting lines which are the major contributing factors to switch-imposed delay? The reasons for queue buildups are intuitively very clear: a building queue occurs when messages arrive at a channel more rapidly than they can be processed. In other words, there is an imbalance of traffic volume and channel capacity; the planner must anticipate reducing the first or increasing the latter before queuing problems are solved.

SAS is designed to assist the analyst in identifying message delay problems before they can become serious in the real system. Specifically, SAS measures End of Text (ETX)-in to ETX-out ($\triangle T_2 + \triangle T_3$) and ETX-in to Start of Header (SOH)-out ($\triangle T_2$). These are called Speed of Service (SOS) and processing delay, respectively. By varying message length, precedence, volume, and line parameters properly, the analyst can keep processing delay and SOS to the very minimum. The objective to be pursued would be to achieve minimum delay for the entire range of throughput values which the switching center might experience.

Simulator Design

The primary purpose of SAS was not to assist in designing a new system which was still on paper. Several ASCs were in place and had been tested before SAS was completed. Therefore, the basic logical functions of SAS were well defined and had to be reflected in the coding of the simulation program. The general approach used in the design of the SAS logic was as follows:

(1) Select those functions which were vital for analysis of a switching center.

(2) Examine how the ASC performed in each functional area under changing conditions.

(3) Decide how much fidelity the model was to have in each functional area.

(4) Devise a feasible method for causing each modeled function to react to changes realistically.

(5) Express the final logic design in simulation language.

(6) Validate SAS results.

The design of any store-and-forward system dictates that a minimum of basic functions must be modeled for effective simulation. These functions are:

(1) A traffic source

(2) A traffic sink

(3) A line buffering device (Optional)

(4) Line and traffic data variations

(5) Queuing and scheduling operations

(6) Storage operations

(7) Peripheral device operations

Traffic Source

The model of the traffic source or the data input for the ASC, as shown in Figure 3, is based on the capability of the simulation language (GPSS III) to generate units of traffic at either a fixed or variable rate. The traffic generating function in the SAS is a single source which creates "messages" at specified intervals, called the interarrival time (IAT). Thus, by changing the IAT value specified, the SAS user can vary the traffic load entering the system.

From the point source of traffic, messages are routed to input line models, based upon the expected percentage of the total traffic for the individual lines. For example, Input line #1 may receive a specified 4 percent of the traffic generated. The line models pass the traffic into the simulated Line Traffic Coordinator (LTC) at a rate specified by the user. This rate will be inversely proportional to the Effective Transfer Time (ETT) of the real line in seconds per line-block. As the "messages" pass through the input line model, they are split into segments, according to their length, and are placed temporarily in the simulated LTC storage. Various devices, not shown here, are used to limit the input traffic if the LTC storage becomes overloaded.

Line and Traffic Data Variations

Besides length, the messages are assigned number of routing indicators, levels of priority, and other identifying information. The assignment of parameters is done by the model in accordance with distributions specified by the user. These distributions are represented in Figure 3. All of these functions are performed independently of other portions of the simulator program.

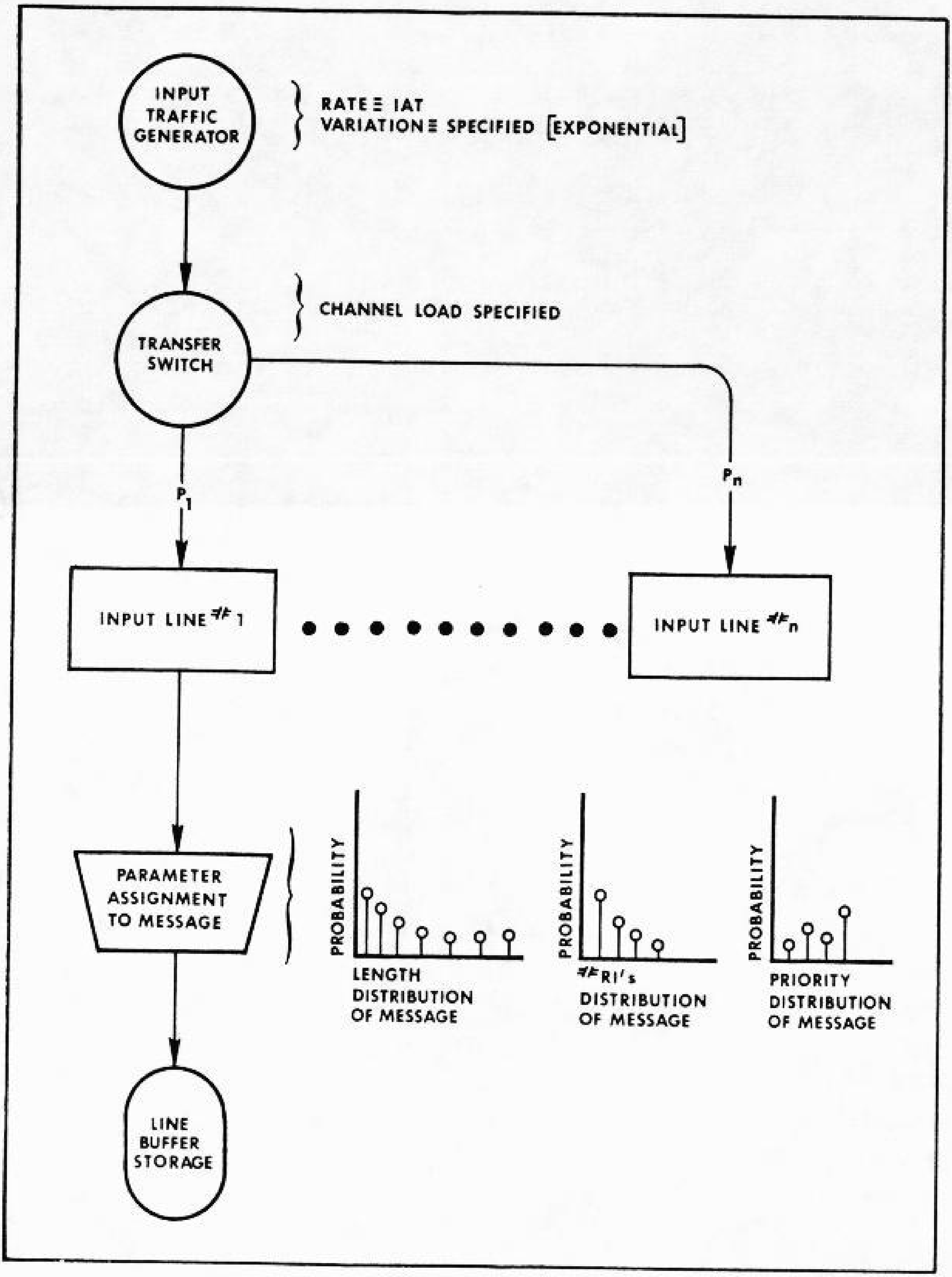


Figure 3—Data Input Model for the ASC

Traffic Sink

The Data Output model shown in Figure 4 describes the function of sending stored traffic from the switch and is again based upon the simulation language's capability to generate traffic units (messages). However, in this case, the "messages" are generated only when two criteria are met: (1) A "line" is available for traffic; (2) traffic is queued for the line. When this occurs, simulated message data is taken from a point source and sent to the appropriate line. Thence, it is buffered temporarily and "transmitted" out of the LTC at the specified ETT for that line. The simulation language provides a sink for the message data, which ceases to exist once it has been successfully "transmitted."

Models

The models of traffic input, output, and line buffering which have been described briefly, interact with a more complex set of models that perform the functions of the Message Processor (MP). These are:

1) Scheduling—The line buffer (LTC) model accumulates message segments and is scanned periodically by the scheduling model to ascertain which data must be brought in or sent out.

2) Routing—Input "messages" are routed, based on a specified distribution, to the appropriate output queue. The distribution for routing is the percentage of the total ASC output traffic which is expected to be handled by each output "line."

3) Queuing—In the model of MP functions, a matrix of counters is maintained, by precedence, for each output "line." Each "message" entering the simulator is added to one or more counters (queues), depending upon the number of RIs assigned to it. At the same time, as "messages" are being sent out of the simulated ASC, these queues are decremented. This process allows an observer to ascertain how many "messages" are waiting for transmission for a particular line.

4) Storage—The model of the storage unit (drum) is composed of a counter and a matrix. These control system overflow conditions, and make certain that an accurate balance of "messages" on queue and on drum is possible. When a "message" segment is brought into the simulator, an equivalent amount of "drum storage" is used up. When the proper number of deliveries of the "message" has been accomplished, the "drum" space is released.

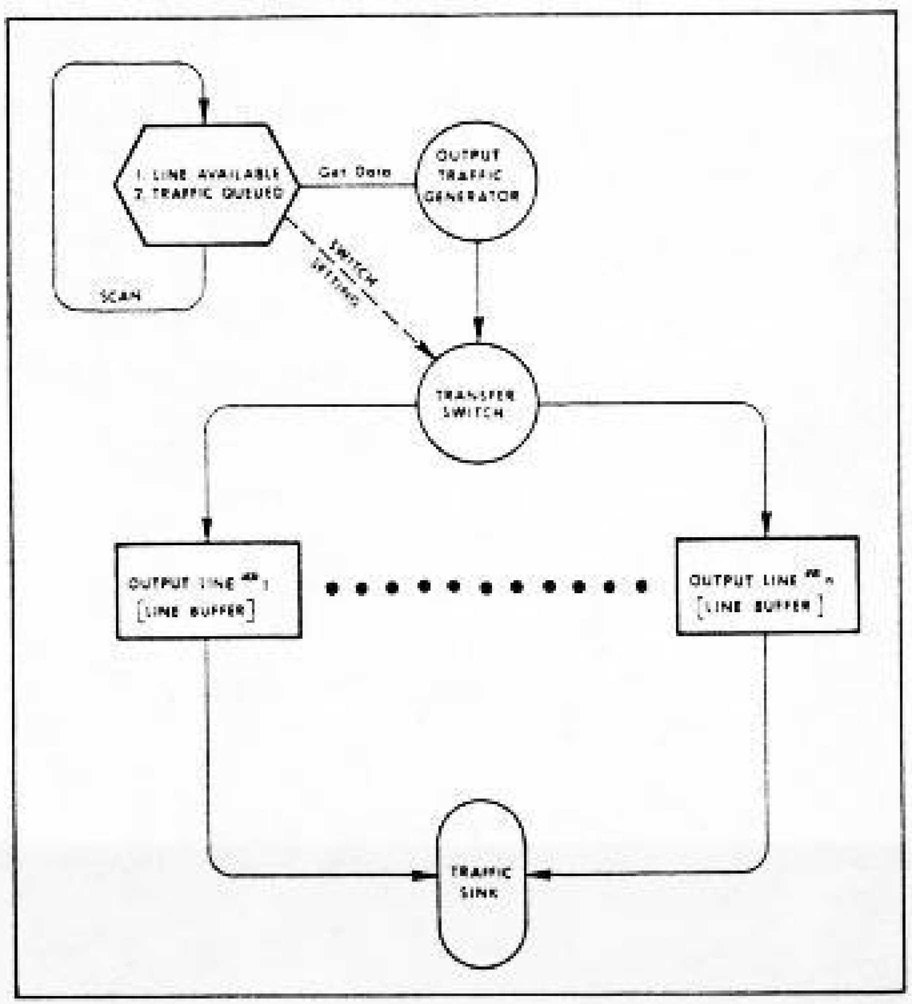


Figure 4—Data Output Model

Message Processing

The entire simulator path of a message is shown in Figure 5. After generation, temporary buffering, assignment of message length and other attributes, each input "message" is recorded fully in the drum and queue matrices and is then terminated. This approach was followed to save computer memory space. On output, the messages are reconstructed from the data held by the matrices, and are sent out. An algorithm was worked out which solved the problem of properly removing message data from the drum when no "messages" (except Flash) were retained from input to output. As a result, when a "message" is completely transmitted, a calculation is made to determine if the "drum" should be decremented. This method successfully allows the simulated ASC Drum to "dry up," if necessary.

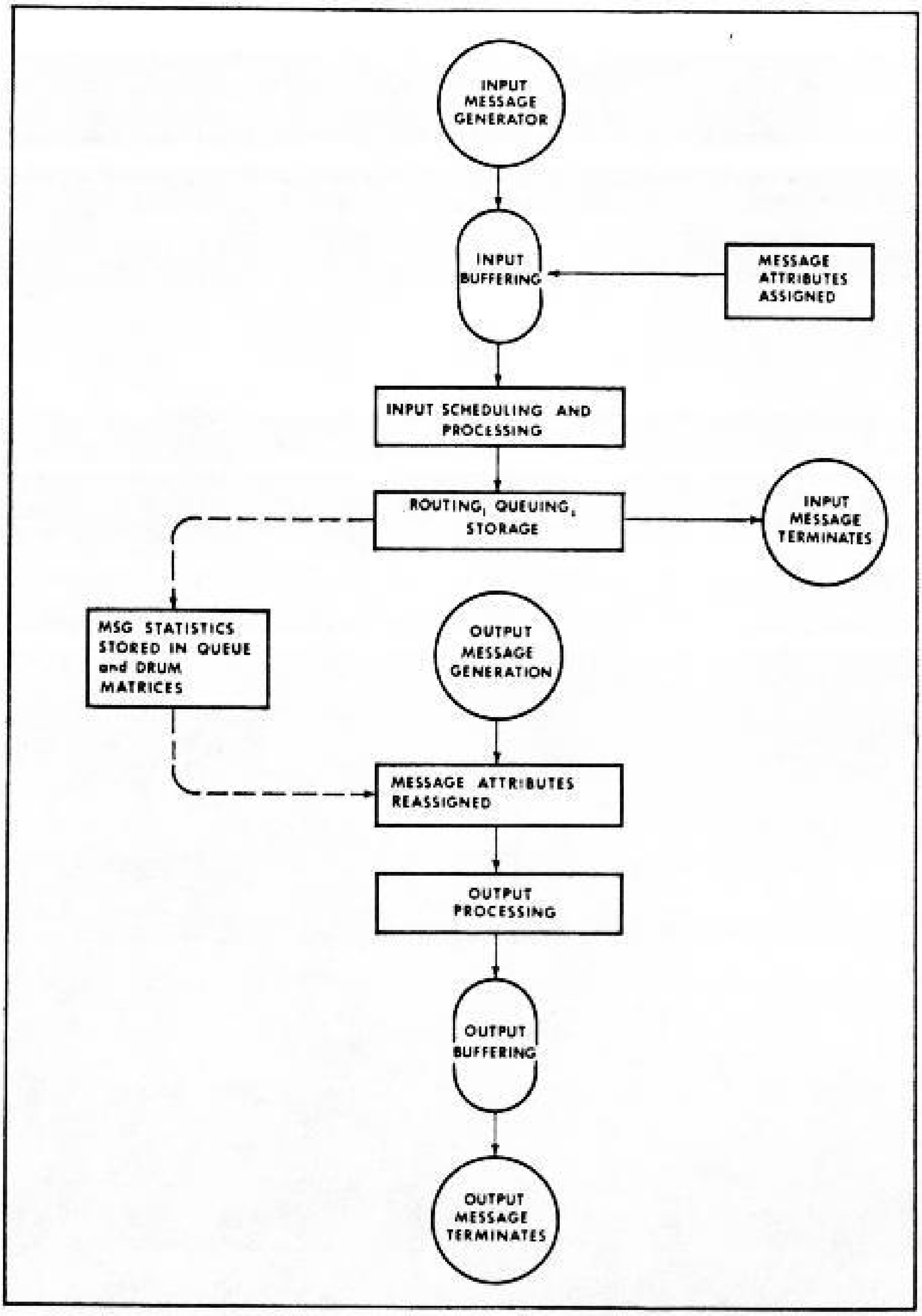


Figure 5—Message Path

SAS Structure

An overview of the simulation design for SAS is shown in Figure 6. This Flow Chart shows five paths:

(1) Input "message" path.

(2) Information interchange path among segments.

(3) Major control path.

(4) Minor control path.

(5) Output "message" path.

It should be noted that the LTC models on the left of the figure, the MP program cycle model (center), and the peripheral device models are independent. The SAS operates quite like the MP since it is cyclic in nature and is controlled by a model of the MP "Base Sequence" program shown as the Major Control path. The various independent sequences of model operations are initiated and controlled by the control path.

By comparing Figures 6 and 7, marked similarities are observed between the SAS simulation design of an ASC and the real ASC functional structure. The simulation is as detailed a copy of the real ASC functions, as constraints permit.

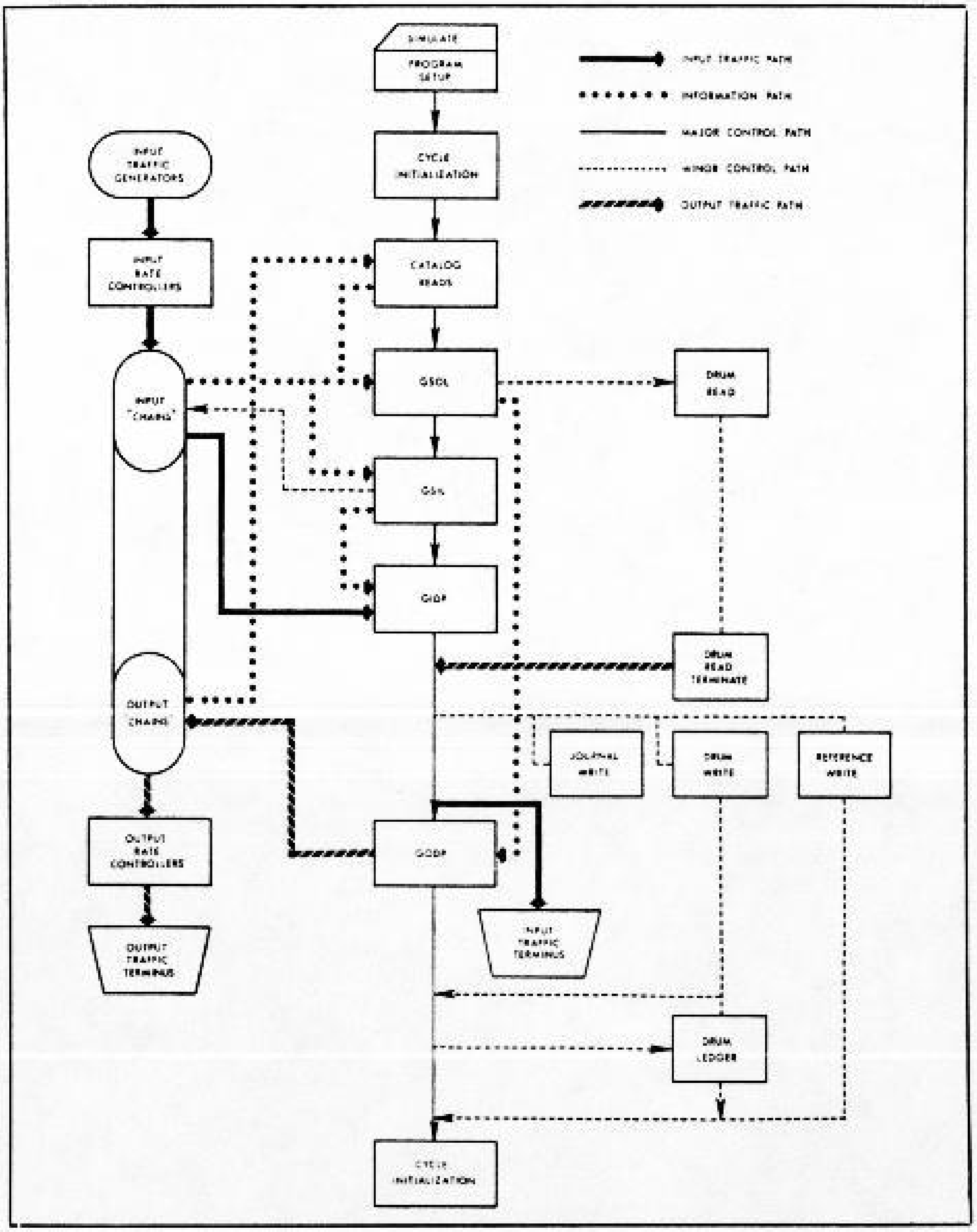


Figure 6—SAS Simulation Design of an ASC

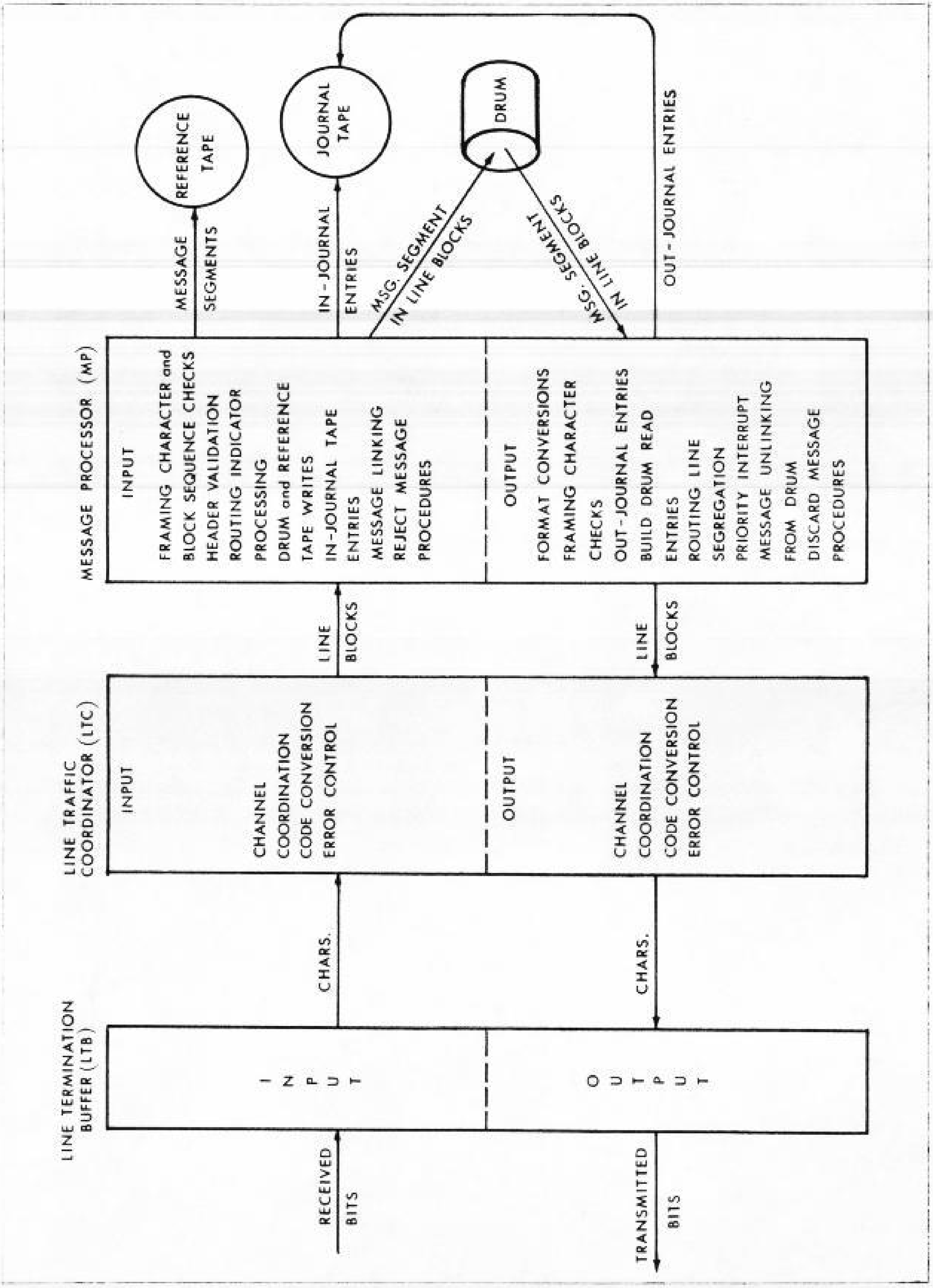


Figure 7—Path of a Message through the ASC

SAS Input

A partial listing of the system parameters which are to be specified by the SAS user when initiating a run includes the following:

- Line No.
- ETT Forline
- Traffic Distribution In
- Traffic Distribution Out
- Message Length Distribution
- Routing Indicator Distribution
- Message Exchange Information
- Precedence Distribution

Although this information is derived manually, it may also be an automated input.

SAS Output

Figures 8 (a), (b), (c), and (d) are typical print-outs of the information the SAS user receives at the completion of a run.

Figure 8 (a) shows summarized ASC data obtained from SAS. These data printouts are analogous to the "system status" printouts of the actual system. However, channel queues are not shown.

Figures 8 (b), 8 (c), and 8 (d) show the detailed output of SAS. Figure 8 (b) shows, for a particular SAS cycle number, the cumulative average cycle time and throughput values and details of drum and queue occupancy. Figure 8 (c) continues the demonstration of detailed results by showing queue lengths for each line on an individual precedence basis. Total queue for each line is also shown. Figure 8 (d) demonstrates, for a given point in the SAS run, the cumulative average SOS and processing delay results, for each precedence.

Applications

Generally, the size and complexity of an ASC precludes a one-channel-at-a-time approach to solve ASC traffic problems. The interdependence of all ASC hardware and software components demands a total system approach to these problems. Simulation is a useful tool for a total system approach to problem analysis, enabling the Manager to segment the effect on the entire system by changing a minimum of the traffic parameters. In evaluating store-and-forward systems, the two most significant problems are: (a) node congestion, and (b) node performance.

(a) *Node Congestion*

This phenomenon occurs when one or more nodes in the network becomes saturated to the level where propagation of the congestion to other points occurs in the network. Most of the planner's efforts are concerned with avoiding this condition. Many of the factors involved require long-range planning because, once established, they are difficult to change quickly when a problem occurs. Some factors contributing to congestion are:

(1) Insufficient channel capacity on certain paths.

(2) Imbalance of traffic routing—certain nodes have arbitrarily heavier loading than others.

(3) Insufficient transient storage.

(4) Internal processing deficiencies, such as severe throttling of output.

(5) Abnormal traffic conditions, i.e., large influx of very long messages.

(6) Rapid increase of the input rate of traffic.

Some of the variables which can be changed in studying node congestion are described below. Five of these are represented by models in the SAS program, such as:

(1) *Traffic Volume.* As more terminals become actively connected to an ASC, the Communications Manager must determine the effects of increased traffic upon ASC performance. Normally, a Communications Manager is not concerned with traffic volume until the ASC approaches its maximum number of connected terminals; e.g., when the 150th terminal is connected to a 200-line ASC, traffic problems will be more severe than when

Fig. 8(a)

Fig. 8(b)

Fig. 8(c)

Fig. 8(d)

Figure 8—Four Typical Printouts of SAS Reports

the 75th terminal is activated. However, there may be critical, short-term periods of heavy traffic volume for a 75-line ASC. In these cases, the Manager must ascertain the rate of traffic increase, the rate of queue build-up, the activation of Overflow Tapes, and the efficiency of the ASC software. By holding the other external factors of the ASC constant (such as message length distribution), the Manager can observe the effects of varying traffic influxes on Throughput and Message Delay. The SAS is designed to assist the Manager in obtaining those statistics necessary to relate the effects of increased traffic volume to the expected performance of the ASC.

(2) *Channel Configuration.* This term is defined as the number and types of channels which are connected to an ASC at any single point in time. Channel configurations have a very significant effect on traffic volume. Consequently, the Manager must study the effects of adding or deleting particular channels at an ASC. However, the problems which most often occur in this area involve the economics of channel management in the ASC itself. For example, when the problem of deciding whether to replace several low-speed linked channels with a single line of higher speed arises, the Manager is concerned not only with the ASC Throughput, but must also determine if the new channel increases message delays for that particular traffic path. Also, he determines the cost of the new channel and its tributary equipment to evaluate it in terms of improved speed of service and improved traffic handling performance. Conversely, the economic effects of retaining large numbers of slow channels might be considered. Accordingly, the Communications Manager must ask himself, "Can we afford not to change our line configuration?"

(3) *Precedence Consideration.* While the percentages of precedence levels will fluctuate slightly over a long period of time, contingency situations do arise when one level of precedence assumes far more than its normal share of the load. This has critical effects upon the other traffic in transit through the ASC.

This condition occurs if a system user decides to raise all of its critical supply reports to higher precedence. The SAS is a management tool which can be used by the Manager to recommend contingency traffic handling procedures at the ASC. Given sufficient information, he could predict, for a customer, how much message delay might be expected for the upgraded traffic. The routing of messages, variations in traffic volume, and variations in length of messages are included in the analysis.

(4) *Message Length.* Messages may vary from 1 to 500 lineblocks. The traffic through an ASC may periodically indicate peculiar trends in message length, although it normally remains fairly consistent. The message length distribution at an ASC may change permanently due to the character of the traffic introduced from new tributaries, or due to the decision of a customer to batch its traffic in larger or smaller quantities. Either of these situations, although different, tend to change the message length distribution for an ASC. Using the SAS, the Manager can observe the effects of longer or shorter messages by changing the message length distribution on a punched card. Effects of Throughput and Message Delays are observable, and trends for a series of length distributions may be plotted to serve as general guidelines for system management. Hypothetically, it is possible to obtain the "optimum" message length for each large volume customer at an ASC, and to advise him what his batched message length should be.

(5) *System Efficiency.* The Manager may have problems in improving software/hardware efficiency, or in the capacity/speed of peripheral devices. In the solution of these problems, he must consider the effects on the total ASC environment. By using SAS, these effects can be gauged.

For example, if it were proposed to improve the effectiveness of the ASC by speeding up the average instruction time of the processing devices, SAS enables the Manager to directly verify the predicted increases in throughput and decreased message delay times. In fact, the Manager might desire to use SAS for experimenting with the system to determine possible areas of improvement, and thereby initiate action to obtain costs for specific system modifications, such as increases in input/output buffer storage or drum capacity. The procedures for using SAS are not designed specifically for manipulations of internal ASC functions, based on the finding that the majority of problems would be in the areas of traffic and channel characteristics. However, the AUTODIN Manager can selectively vary the structure of SAS to satisfy a wide variety of problem solutions in this category.

(b) *Node Performance Trends.*

The second significant problem a system manager observes is the performance trends of his switching nodes. Assuming the techniques for observing performance are available, node performance is judged or evaluated according to that of another site. That is, the Manager has no absolute set of performance standards which will allow him to recognize problems for a widely varied set of conditions of lines and traffic. He usually has no means for determining whether a site is operating efficiently or not unless a comparison is made with another, similarly configured node. Only by long experience and careful observation and correlation can performance standards be established. Of course, if the system is modified, the performance standards will have to be reestablished by the same time-consuming means.

Absolute performance standards are possible when a simulation tool, such as SAS, is applied judiciously. This tool can be applied to the analysis of a wide variety of system operating configurations and traffic conditions.

The results of this analysis generates a set performance data which demonstrates the variation of Throughput and Speed of Service for each combination of channel configuration and traffic. Given a sufficient number of performance curves, the Manager can compare present system performance with an absolute performance standard for a set of conditions very close to the actual. Furthermore, when future system configuration and traffic conditions are foreseen, these could be used to determine probable system behavior.

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Voice Communications Network for Echo-Free Conferences

The equipment described in this article has been operating successfully for two years. The author wishes to thank the vendors who helped to get the equipment operational. The Ericsson PAX AKD860 worked faultlessly. Modifications to the PAX by ComTech Corporation produced a four-wire circuit switch and this company designed and manufactured the conference access equipment. The six-way, four-wire conference hubbing units and associated transistorized amplifiers, manufactured by Altec Lansing, provide very satisfactory nationwide conference service.

Ronald S. Dodgson

INTRODUCTION

Western Union operates a voice communications network which interconnects a number of message-switching computer processors in a coast-to-coast network. To speed up the management and programming of this system, a special dial-telephone network has been installed. This voice coordinating network has some rather unusual features which include:

a. Special switching equipment which is not overloaded with traffic from other switching systems,
b. "Four-wire" switching between users,
c. Priority override, and
d. A capability for automatically setting up voice conferences among three groups of conferees.

Two of these features are described in more detail as follows:

a) ISOLATED NETWORK

When one realizes that this coordination network is for management and control of a major communications system, one quickly recognizes the need for a circuit switch which is completely isolated from all other switching equipment. Such a network is most urgently needed because other systems are operating at peak loads. For this reason all available switching equipment such as Broadband, could not be used and it was necessary for Western Union to construct a new switching network.

b) FOUR-WIRE SWITCHING

The need for four-wire switching between users is best explained by describing the transmission problem for nationwide conferences. When a subscriber is connected to the public telephone network, electrical signals go in both directions, to and from the subscriber, over the two wires which connect the telephone to the telephone exchange. Inside the subscriber's subset, a network of electronic components steers the signals from the handset microphone down the line toward the distant subscriber; also, the signals coming from the other end are directed to his receiver. This network is a compromise designed for the "average" line. As such, it is imperfect, and causes some of the incoming signal to be reflected back toward the distant subscriber who will, if the distance is sufficient, hear the reflected signal as an echo of his voice.

Similarly, when the signals on a two-wire pair are connected to a carrier or radio (microwave) facility, they have to be separated into two electrical paths or pairs of wires, one pair in each direction. When this occurs, it then becomes a four-wire circuit. Generally, four physical wires are not in the facility, instead only the equivalent electrical circuit exists. Each time a conversion is made from two to four wires, or vice-versa, a network of components in a "hybrid" circuit sorts out the direction of the signals.

It is extremely difficult to match the electrical characteristics so that the hybrid circuit will work perfectly. Imperfections in the hybrid circuits cause echoes to be returned, from a distant end, back toward an originating subscriber so that he hears an echo of his voice some time after he has spoken. On transcontinental circuits where thousands of miles are involved, these echoes can become very annoying to the person who is speaking.

Normally, echo suppressors are provided to reduce the transmission in the return direction, when one party is speaking. While this effectively reduces echoes and multiple echoes, it also dumbs the distant subscriber, until a time lag of the echo suppressor has elapsed. When intercontinental conference networks are designed, it is necessary to prevent echoes returning from conferees' circuits, because the echoes reverberate around the conference and produce chaotic results.

Western Union recognized that the ideal design of a conference network is one which provides four wires to each subscriber's subset. Four-wire, long-distance switched systems provide excellent talking characteristics with a very high degree of intelligibility. One example of such a system is the present Western Union Broadband Exchange. The four-wire switched conference network described in this article is a second example.

Circuit Switch Hardware

Expandability, and a requirement for crossbar equipment were limits imposed by the customer. A crossbar is an electromechanical device having sets of conductors running both horizontally and vertically. On command, these conductors make electrical interconnections where they cross. In this application, the arrangement of the crossbar matrices can be compared to a rotary switch having 3 conductors and 50 outlets. This convention is used in Figures 1, 2, and 3.

Equipment availability, its capability of being modified for four-wire usage, and its reliability were discussed with many vendors. The private automatic exchange Type AKD860, manufactured by L. M. Ericsson in Sweden, was chosen. This equipment was immediately available in a warehouse in New York; and, with some special rewiring it could be modified for four-wire service. These switchboards also had other required facilities, such as priority override for selected extensions and tie-line circuits which were used as access circuits for the conferencing equipment.

Fifty subscriber lines are mounted in a cabinet and up to five cabinets, a total of 250 lines, may be connected together. Each 50-line cabinet is 4'10" high, 3'4" wide, and 10" deep. The cabinets are built for mounting against the wall. They may be swung out by means of an ingenious trolley wheel and hinge, if it should be necessary to have access to the back-plane wiring. All modules containing relays and other equipment are plugged in and removable from the front; thus, access to the rear of the cabinets will seldom be required.

The switching device in the AKD860 is a "code switch" which is a modern and compact form of crossbar switch. It provides for twin contacts, and no holding current is required to maintain connections once they have been made. All interconnections between cabinets are arranged on plug-in, prewired cables.

Figure 1 is a single line diagram of the talking paths and their interconnection between units 1 and 2 before modification. Subscriber lines have two-code bar appearances; one is on the line finders* and one is on the connectors.** For

*Line finder action is similar to an operator answering a call. It searches for a calling line and connects it to a link circuit, the equivalent of an operator's cord circuit.
**A connector makes the connection between a link circuit and a called line.

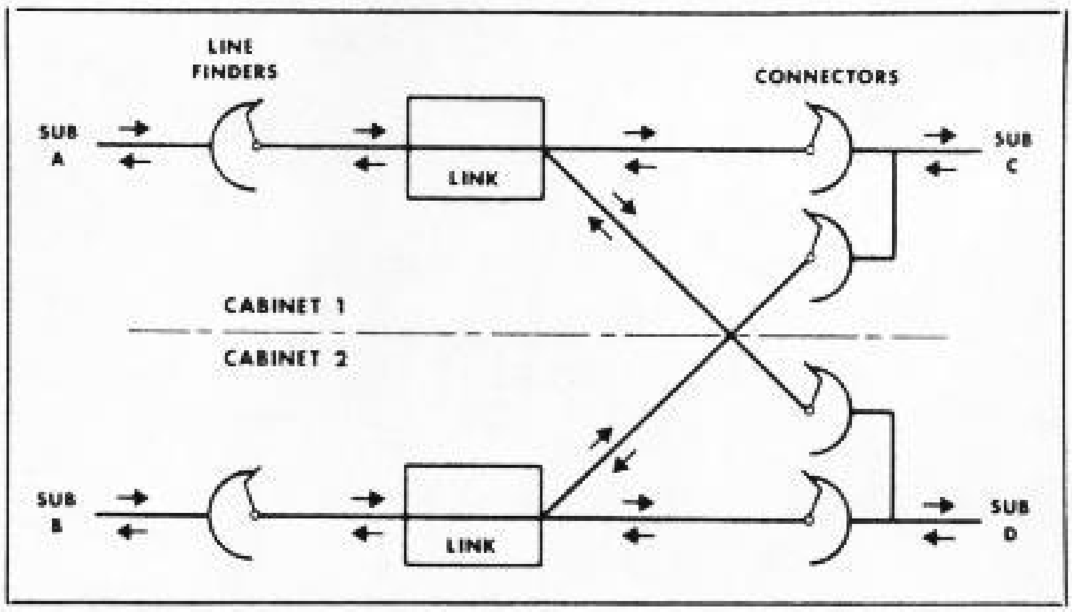
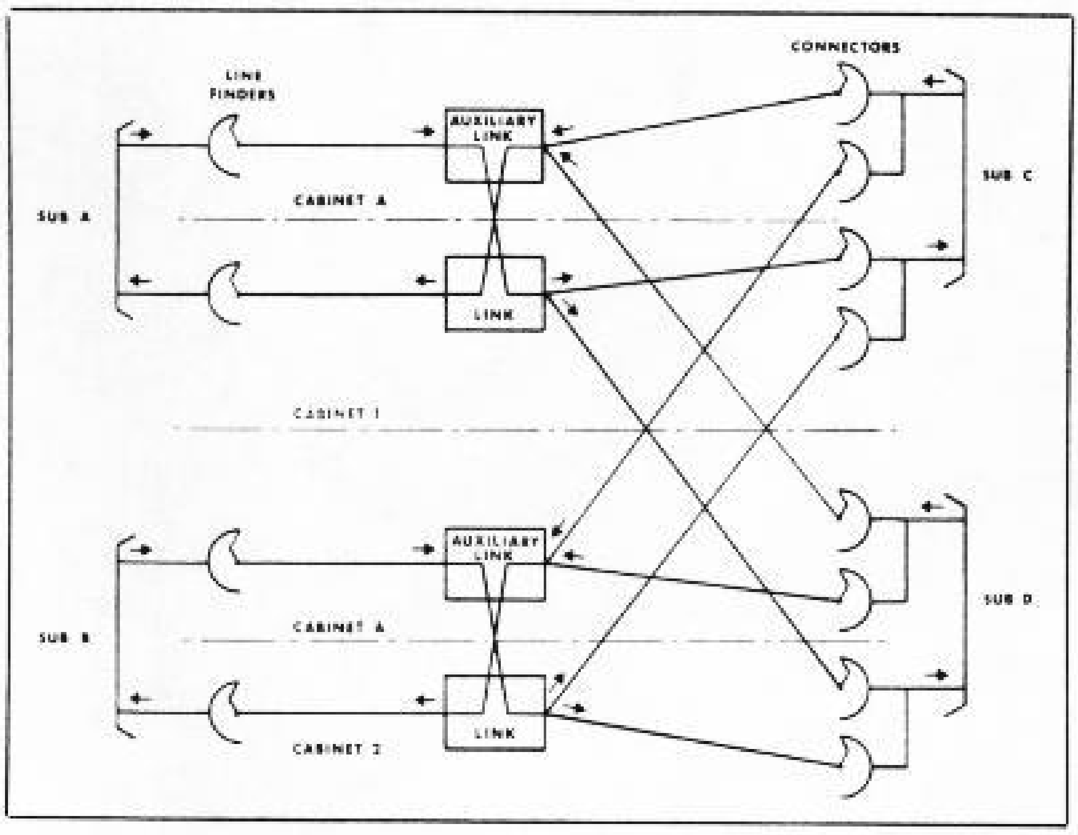


Figure 1—Single Line Talking Path between Two Units.

simplification, single appearances are shown; A and B, as originating subscribers are connected to line finders; C and D are called subscribers wired to the connectors. The line finders and connectors are multiplied together. Each of 5 links in a unit has a line finder serving 50 subscribers and is cabled to a connector in every unit. All talking paths in this figure are two-way, two-wire circuits. Modification into four-wire circuits requires one pair of wires for the subscribers' transmitter and another pair for the receiver.

Due to mechanical constraints, a duplicate set of line finders and connectors, with an auxiliary circuit for each link, was provided in a third cabinet. This is shown in Figure 2. Since the original link provided the dial, ringing, and busy tones, the calling subscriber's receiver was wired, via the line finder, to the link. His transmitter was wired to the auxiliary link via the duplicate line finder. As explained above, the line finders and connectors are physically multipled together. Therefore, the connectors in the original units are also wired to the subscribers' receivers.

To connect the transmitter of the calling subscriber, wired to the auxiliary line finders, to the receiver of the called subscriber, wired to the original connectors, required a modification within the circuit switch. The modification consisted of isolating the line finder and connector sides in the original link, and then reconnecting them to the auxiliary link as shown in Figure 2. In this way, a four-wire circuit switch was produced with



Each line represents a pair of transmission wires.
Cabinet A with Auxiliary Line Finders, Links and Connectors has transformed the original equipment in cabinets 1 and 2 into a 4-wire switch

Figure 2—A Four-Wire Circuit Switch.

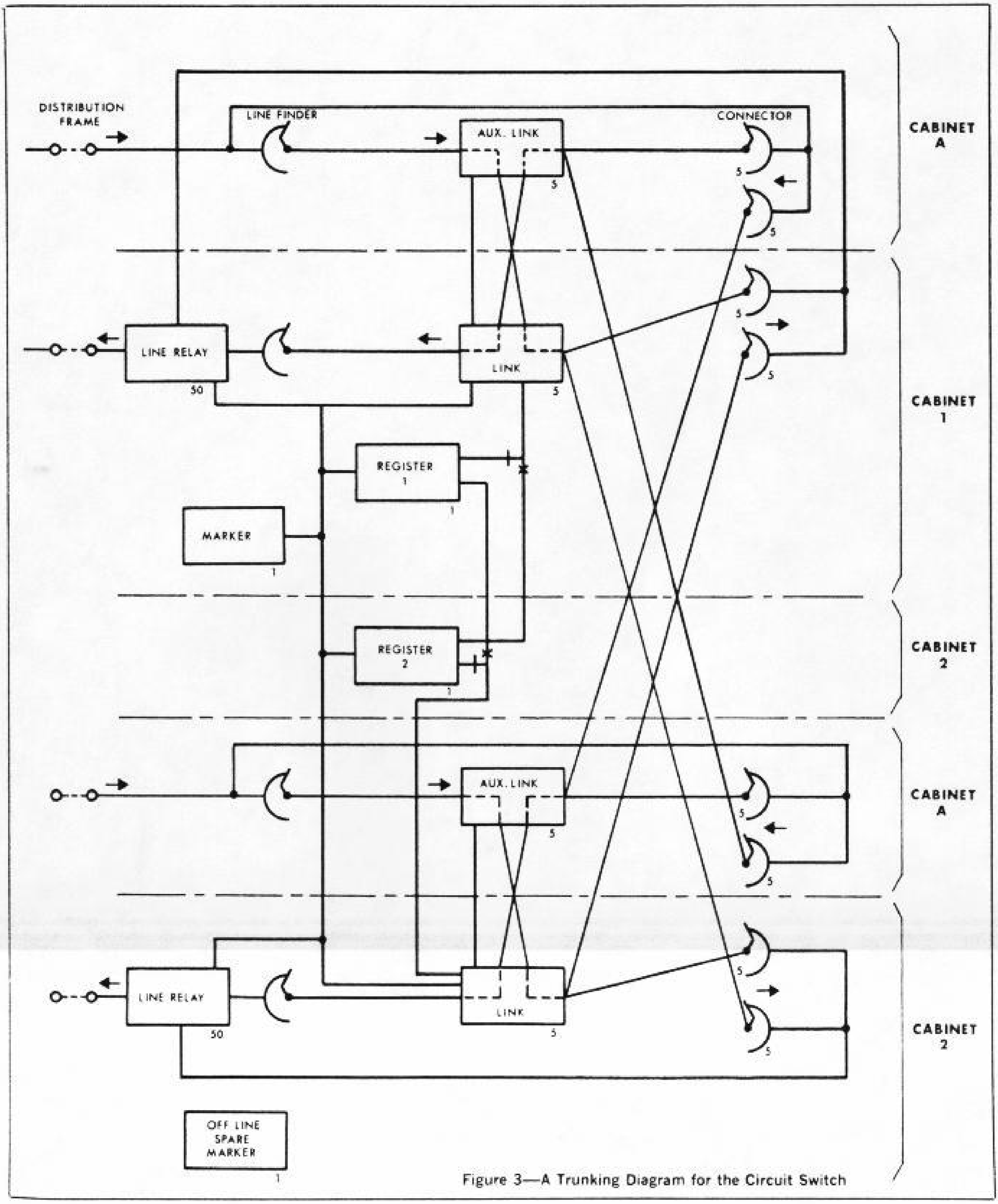


Figure 3—A Trunking Diagram for the Circuit Switch

electrical isolation for each direction of transmission. This allowed the manufacturers' standard equipment and interunit cables to be retained.

Auxiliary link circuits with relays for duplicating the switching connections of the original links were added for the auxiliary line finders and connectors. Figure 3 is a trunking diagram for the circuit switch, including the common control registers and markers that operate in a standard manner. Auxiliary line relays are not required for the auxiliary line finders and connectors because they have isolating contacts. Precautions were taken in the redesign to follow the manufacturer's practices to ensure that the code bar contacts are never opened or closed while current is flowing, and that the operation of the code bar magnets is correct.

A dilemma over the signaling between the subscriber and the circuit switch occurred. Because signaling must extend over the long-distance microwave circuits, the subscriber and the circuit switch are not connected by physical wires. On the microwave, the dial pulses must travel on the circuit from the subscriber, because they must be ac signals passing along the transmission path; that is, the circuit connected to the subscriber's transmitter and the auxiliary link. On the circuit switch, the dial pulses must be on the circuit connected to the original link, which is connected to the transmission path going in the opposite direction (toward the subscriber's receiver).

The dilemma was resolved by the connections on the microwave signaling units. A very large number of standard 2600 Hz single-frequency signaling sets are used for non-physical circuits throughout the telephone industry. They are operated by a technique generally known as "E and M" after the designations of the signaling wires. (Originally E was probably derived from the European name for ground (earth) and M was the alphabetic initial for mark.)

The inputs and outputs of E and M signaling systems are uniform and, for the four hook switch positions of the two ends, are as follows:

Signal West to East	Condition at West		Signal East to West	Condition at East	
	M Lead	E Lead		M Lead	E Lead
On hook	Ground	Open	On hook	Ground	Open
Off hook	Battery	Open	On hook	Ground	Ground
On hook	Ground	Ground	Off hook	Battery	Open
Off hook	Battery	Ground	Off hook	Battery	Ground

The system enables simultaneous signals to be sent in both directions without interference.

The four-wire subset is connected to a "loop to E and M" converter at the subscriber's location. The hook switch conditions, dial pulses and local ringing signals are translated to E and M signals of a 2600 Hz single frequency signaling set.

At the circuit switch end, the E and M signals are connected to another "E and M to loop" converter. The derived loop/disconnect dialing signals on the loop side of the converter are then taken to the circuit switch original link, while the transmission circuit is taken to the auxiliary link.

The ringing signal for called subscribers is handled in a similar way. It leaves the switch, from the original link, via the connector to the "E and M to loop" converter and then to a signaling circuit which generates a 2600 Hz signal. When this signal is received at the called subscriber's terminal, the converter translates the signal into a local 20 Hz ringing pulse. The answering off-hook condition is returned to the circuit switch, via the E and M signals, and reconverted to a loop signal to trip the ringing.

How To Set Up A Conference Call

The conferencing unit was designed as applique equipment to the circuit switch and a similar unit can be used with any circuit switch. When any subscriber sets up a conference call he dials the conference number, which connects him, via a tie-line circuit, to one of two access circuits, Figure 4. The tie-line circuit access is used because in the circuit switch, a metallic path is provided from the subscriber's line to the access circuit, thereby removing all components which might tend to attenuate the voice and also to provide a dialing circuit. The two access circuits permit two conferences to be set up simultaneously. When the subscriber reaches the conference access circuit, he receives a distinctive tone to inform him to dial a digit to choose a preset group of conferees. In the application described three repertoires of conferees are available, and digit one is not used as a selecting digit because it would conflict with an abandoned call. When the repertoire digit has been received, ringing tone is returned to the originator and a warning tone is transmitted to both parties of all calls which any of the conferees happen to be making. This warning tone alerts

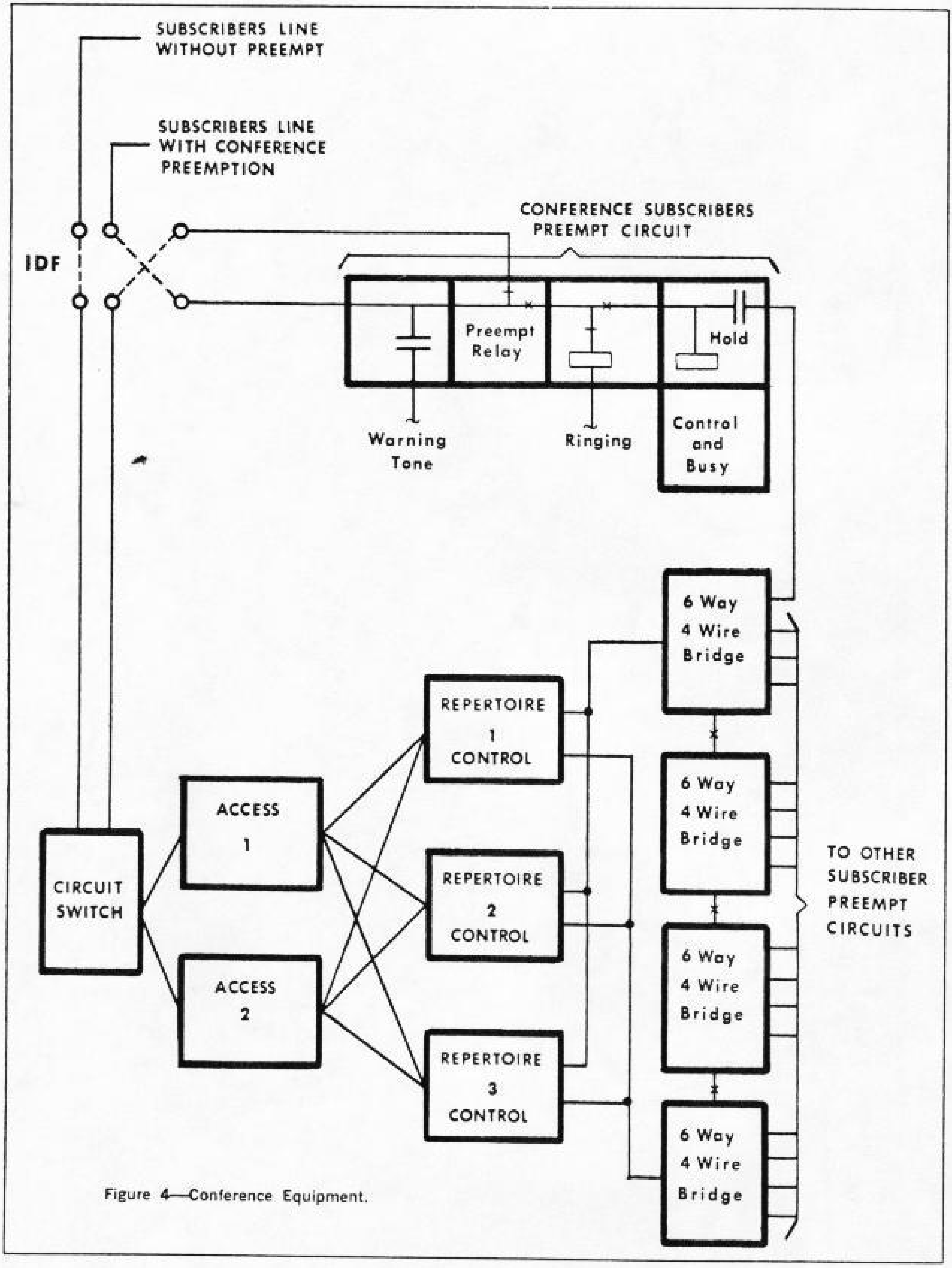


Figure 4—Conference Equipment.

the subscribers to the fact that the call will be interrupted for a conference. This tone gives sufficient time for a few sentences to be exchanged before the subscribers are preempted from the circuit switch and connected to the conference.

If a conferee should attempt to initiate a call during the warning tone period, he also would hear the tone and not dial his call. At the end of the warning tone period the lines of all subscribers who are conferees in the specific repertoire are disconnected from the circuit switch by transfer contacts of a relay and connected to the conference unit. A ringing tone is sent to the originator, which upon stopping, advises him to begin polling the conferees.

The equipment sends a continuous ringing signal (as a distinctive calling alert) to all conferees' lines. Subscribers who are off hook, because of preemption from a normal call, immediately trip the ringing; others trip the ringing when they answer. When the ringing on a line is tripped, the subscriber is connected to the conference hubbing or bridge equipment described below. If a subscriber does not answer the ringing signal before it stops, he cannot enter the conference. Otherwise, a subscriber returning to his phone after it had been ringing for a conference and originating a call would be connected to a conference in progress with possibly confusing results. The length of the conference ringing signal is adjustable. An interesting feature is that if the subscriber who originated the conference, via the tie-line and the access circuit, is one of the predetermined conferees, his call is transferred from the access circuit to his normal appearance on the hubbing equipment when his preempt relay operates. This frees the access circuit. On the other hand, if the originator was not one of the predetermined conferees he will remain connected to the conference via the access circuit after the preempt relays have connected the other subscribers. This arrangement enables any subscriber or a conferee who is away from his normal phone, to attend a conference by being the originator. When a subscriber is no longer required in a conference, he can leave by hanging up his phone; the last subscriber to go on hook restores the conference equipment to normal. In the normal condition the access circuit is not used; a conferee can leave the conference by going on hook, call any other subscriber on the network for information, and then reenter the conference via the access circuit.

To provide the transmission interconnection between a number of telephones for conferencing, a hubbing unit or conference bridge is used. Figure 5 is a cubic representation of a four-subscriber, 4-wire conference bridge. Figure 6 is the schematic diagram of the wiring of this bridge. In the single line diagram of Figure 5, each corner is a connection to a subscriber's line, either in-

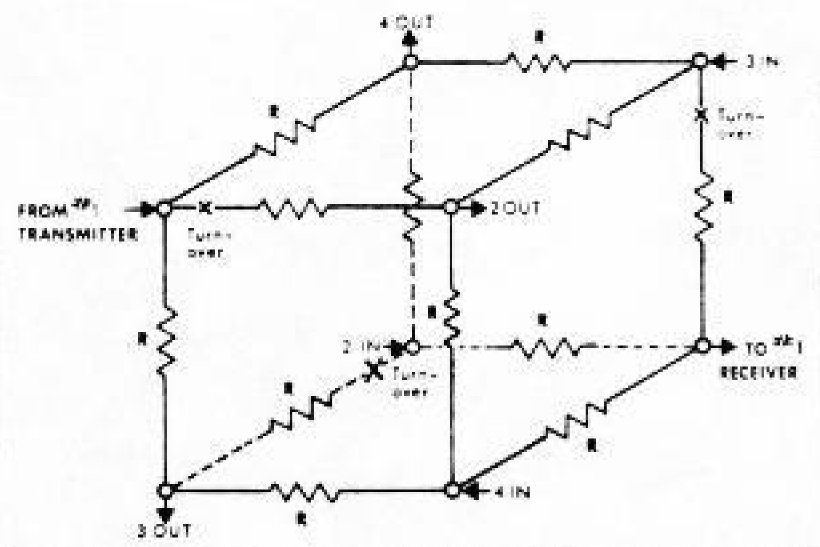


Figure 5—Cubic illustration of 4-Way, 4-Wire Conference Bridge.

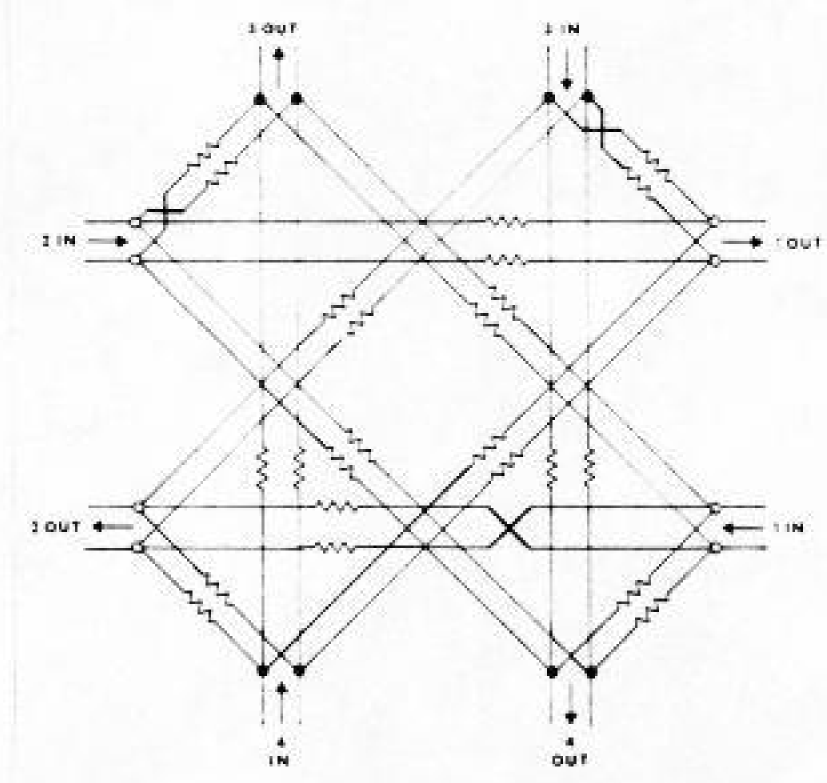


Figure 6—Schematic Diagram of 4-Way, 4-Wire Conference Bridge.

ward (from his transmitter) or outward (to his receiver). Each edge of the cube represents a pair of wires, each having an identical series resistance, R. Transpositions or turnovers are provided at the points marked "X" (refer to Figure 6 for details). External to the bridge, every input and output is terminated in an identical electrical load in the form of a transistorized buffer amplifier output or input.

Consider each fact of the cube separately, say the face with corners 1 IN, 2 OUT, 4 IN, and 3 OUT. It will be seen that a current entering at 1 IN will divide and travel to the corners 2 OUT and 3 OUT but because of the turnover in the path to corner 2 OUT, the voltages at these corners will be opposite in polarity. If we consider that these two currents will arrive at corner 4 IN, it will be seen that they cancel each other because of their opposing voltage.

The current which enters at 1 IN will divide 3-ways and travel over direct paths of equal resistance (attenuation) to leave the bridge at 4 OUT, 2 OUT, and 3 OUT. There are obviously many indirect paths between 1 IN and each of these three outputs. For example, there are two parallel paths around a cube face to each output, but such currents will have passed through three resistors and will therefore have three times the attenuation of the direct path and because of the reversals will have a voltage reversal (180° out of phase) with the current through a direct path. However, the sum of all the indirect paths does not make much difference to the direct circuit between an IN and OUT corner. But for the two directions of transmission of a particular subscriber, e.g., 1 IN and 1 OUT, the various paths can be traced out and it will be seen that such corners are connected by six parallel paths, each of which has three times the attenuation of a direct path between an input and an unrelated output of the bridge. The currents through three of the parallel paths are 180° out of phase with the other three and will therefore cancel each other. Actually, ideal conditions are not achieved in practice due to minor variations in the resistances of the bridge and the external loads. The loss between any input and the corresponding output is about 70db, the loss between an input and the other outputs is approximately 17db which is made up by the amplifiers connected to each output. The input amplifiers provide correct terminations for the bridge but are set for zero gain.

While this description of "How to Set Up a Conference Call" applies to a conference bridge serving only four subscribers, it is apparent that when more than four subscribers are to be in conference, a number of bridges must be connected together and that the bridge-to-bridge interconnection will reduce the available subscriber connections. Therefore, six-way bridges were used in this application. The operation of a four-way bridge is easier to explain than the operation of a six-way bridge. The six-way bridge uses essentially the same method of phase cancellation and attenuation between the IN and OUT pairs of each subscriber while providing a satisfactory transmission path from any IN pair to all other OUT pairs (about 19db attenuation).

RONALD S. DODGSON, Director of Circuit Switching, is a consultant to Marketing in the Government Communications Systems Department for various systems such as ARS, NASA 600, AUTODIN, etc.

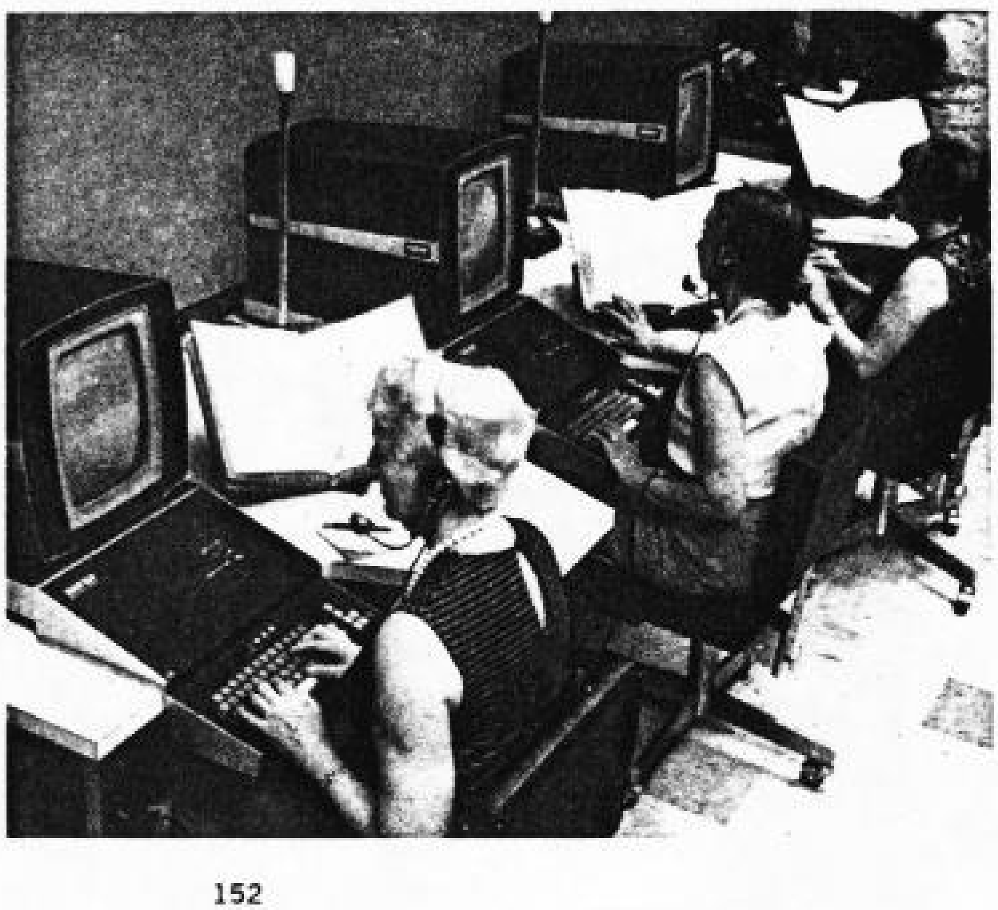
Mr. Dodgson joined Western Union in 1965. He had previously analyzed problems of direct distance dialing for the Puerto Rico Telephone Company where he was Manager of Engineering and Chief Engineer for a manufacturing facility for International Telephone and Telegraph Co. In his association with General Telephone Laboratories, he designed circuits for interconnecting switching systems and for the direct distance dialing of the Independent Telephone Industry.

Improved Service Time with New CRT-TELMAP Equipment

R. P. Murphy

A significant improvement in service time has been noted when telephoned telegrams from customers have been accepted using the new CRT—TELMAP equipment. Actually, telephone recorded messages represent about thirty percent of the total traffic. This equipment was placed in service during May 1968 in the New York Telephone Room on the thirteenth floor at 60 Hudson Street Headquarters, on a field trial, and has been operating successfully ever since.

Figure 1—New Field Trial Installation of CRT Position Equipment



New Equipment

Western Union specified the type of CRT position equipment that was most suitable for this on-line field trial in late 1966. In addition, Western Union designed a TELMAP unit to accept messages from the CRT equipment via the Central Display Control and to automatically transmit them to the Public Message Service network. The TELMAP, TELephone Message Automatic Processor is responsible for large savings in message handling time.

Figure 1 is a photograph of the three positions installed in the New York Phone Room. Almost a hundred additional typewriter positions, not completely manned, are now used to receive a large number of telephone messages and requests for special services from customers sending telegrams.

How a Call is Accepted

a) *Recording*

Telephone recording operators, at the present positions, accept incoming calls from telephone call distribution equipment. They record telegrams on a typewriter, as they are received over the telephone. The telegrams are typed in double space and may be verified with the customer before he hangs up. Operators correct or edit the telegrams by "X-ing out" characters or incorrect words and retyping the corrections in the space above the lines. The operator then makes a "word count" and inserts this number, plus other billing and control information, into the message format.

b) Routing

Messages are then placed in a mechanical belt, which transports them to a routing operator. At this point, routing symbols are inserted, in pencil, in the header of the message.

c) Sorting

Upon completion of these tasks, the routing operator places the message in another mechanical belt for transport to a Sorting Station. Here, clerks sort messages for priority and pass them to the sending operators for transmission over the proper outgoing trunks. For example, full rate messages have priority over Day or Night Letters and are handled first.

At present, the routing and sorting personnel also receive facsimile and teleprinter telegrams, as well as those from local counter service and messenger pick-up.

d) Sending

The sending, or Main-Line operators, then punch messages on paper tapes; these are then fed into line transmitters.

Advantages of CRT Telephone Recording

1) The new CRT telephone recording equipment allows the recording operator to perform some additional tasks such as routing and sending at that same position; thus eliminating the transportation of messages around the local office and eliminating the retyping of each message at the Sending Position. An important feature of this system is—that while an operator can continuously make the necessary corrections, she maintains the message on a viewscreen similar to a television screen and can observe the actual message to be sent in "clean copy" before it is transmitted.

2) All the steps, subsequent to recording in the transmission of the message must be completed in less than fourteen minutes. According to a sampling of messages taken in the present field trial, telephone messages are being recorded, automatically handled and sent in approximately seven minutes. Message recording time is that time spent in contact with a customer. However, it is now possible to eliminate much of the time previously consumed in manually handling messages by use of this new equipment.

The three CRT—Keyboard units and a Central Display Control constitute the equipment required to record a message and maintain its display during composition.

A telephone recording position table, shown in Figure 2, was designed and built by Western Union incorporating appropriate human factors engineering. Books for rating and routing shown to the right in Figure 2, are supplied to each operator position. A supervisory light is mounted to the left of the CRT screen. Telephone control keys, associated with the operator's headset, are mounted just beyond the keyboard. The telephone recording position table is designed to provide the operator with convenient access to the equipment. The CRT screen is actually recessed behind the keyboard in order to force the proper distance between the operator's eyes and the display.

Figure 2—Telephone Recording Position Table Designed and built by Western Union

The keyboard is a typical typewriter keyboard, with additional message control keys grouped to the right. There are two such message control keys: the SEND PAGE and CLEAR. However, an extra control key must be depressed with either of these two keys to cause a command to be initiated, so that the message is not erased and sent prematurely.

Figure 3 is a block diagram of the three CRT—Keyboard positions, the Central Display Control and the TELMAP unit used in the automatic message handling and sending.

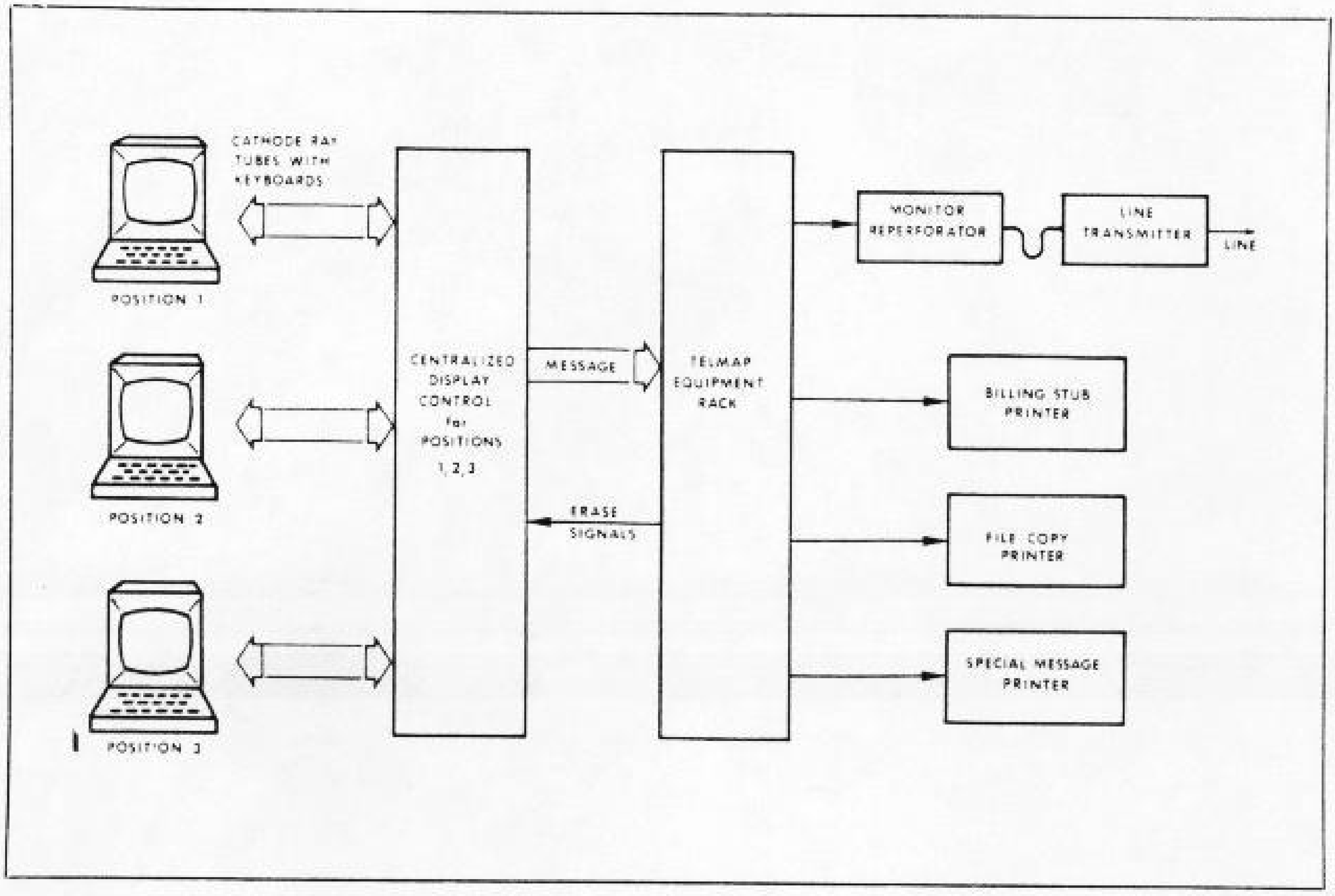


Figure 3—Message Flow From Recording Position Through TELMAP Unit

TELMAP

The TELMAP equipment was designed and built by Western Union to accept messages from the CRT—Keyboard position equipment via the Central Display Control. In addition to transmitting the message to the line, it automatically provides other outputs such as local file copies of a messages and billing stubs.

As shown in Figure 3, the TELMAP unit also "outputs" to a special Message Printer. This allows messages to be printed out at the option of an operator. This printer is used for (1) very long messages, (2) international messages, (3) bust messages, where customers call back later to provide lacking information.

The TELMAP unit is designed to perform, automatically, the following functions:

1) Provide positive message capture.
2) Prevent loss of message.
3) Accept message data at high speed from the CRT equipment and convert the sending or transmission rate to 75 wpm.
4) Extract "billing information" and print out a billing stub for each message.
5) Convert the format accepted to that required by the network.
6) Automatically insert message sequence number.
7) Translate the code from ASCII to Baudot, before sending messages.
8) Print out a copy of each message for local filing.
9) Allow the operator the option to print out any selected message on a special printer.

A block diagram of the message flow through the TELMAP unit, is shown in Figure 3. Its logic control circuits recognize and act upon special symbols inserted into the format, by the operator, at the time of recording. The special symbols are read as instructions and billing data is extracted.

"The system is great" said Miss Rebecca Kall, CRT Supervisor in the Telephone Room, shown in Figure 4. "I like the system because billing copies are clean, legible and accurate for the customer."

Operation of Telmap

TELMAP accepts message data from the display equipment and stores it on paper tape using a high speed DRPE punch. Each character has the "parity" of its code checked as it is punched in the tape. This insures that a "bit" was neither lost nor added in the code representing a character as it was transferred. When all characters in the message have been punched and no parity errors are detected, a signal is sent to the display equipment which causes the CRT screen to be erased, thus indicating to the operator that her recording task is completed.

At this point, the paper tape is automatically fed into a Western Union designed tape reader. The tape, as it is fed into the Message Processor, will control the automatic handling and sending of a message and the operation of the printers. The output sent to the line is paced by means of the code translator at 75 wpm.

The hard copy output fulfills the requirements for maintaining file copies of all messages, and for the generation of billing stubs. The "special printer" fulfills the requirement for printing out of those messages which require special handling. To do this, the operator merely inserts an XX symbol in the header of the message where the routing symbols normally are inserted. The TELMAP then activates this "special printer" to record the message and does not send the message over the line.

Figure 4—CRT Supervisor, Rebecca Kall, shows the legible, accurate billing information possible with the TELMAP unit.

Advantages of Telmap

1) Rapid Handling of Messages
   The most significant advantage of Telmap is the rapidity with which a message can be automatically handled. Once the operator has depressed the "SEND PAGE" key, further operation is entirely automatic. Only two factors may limit the speed of message handling: these are: the transfer to the DRPE punch and the transmission speed of the network. Message data is transferred from the CRT units to the DRPE at a rate of 180 characters per second. This requires about two seconds to transfer a message of 400 characters. Transmission speed of messages to the Reperforator Center is at 56.7 baud or 75 wpm. The code translator, at the output of the Telmap, paces the message processor output tape reader at 75 wpm. A 400 character message can be transmitted over the line in about 53 seconds. Two storage bins hold the slack paper tape, produced at a high rate by the DRPE Punches, until the message processor can accept it at a rate determined by the code translator. Approximately 60 seconds, 1 minute, is required to get a message on-the-line after the "SEND PAGE" key has been depressed. Additional delays may appear infrequently because of retransmissions from the CRT equipment caused by detection of parity error(s) if the equipment is in fallback mode.

2) Accumulated Messages Handled Promptly
   More than one message can accumulate in a storage bin while waiting to be read out. It should be pointed out that two DRPE punches are incorporated into the design for greater overall reliability of the TELMAP unit.

3) Reliability
   In the event that two retransmission attempts do not result in a successful capture of a message from the CRT on DRPE punch tape, the other DRPE punch is automatically "switched in." If three retransmission attempts do not result in a capture of the message, the supervisor can copy the message from the CRT screen and send it by another means, thus avoiding loss of message.

Field Trial Installation

Figure 5 shows the TELMAP unit, with front cover removed.

A panel, containing all the controls and indicators, appears at the top of the unit. The operating mode of the TELMAP can be determined from this panel.

The upper part of the uncovered section, shows the two DRPE punches. The lower section contains the Message Processor and the Code Translator.

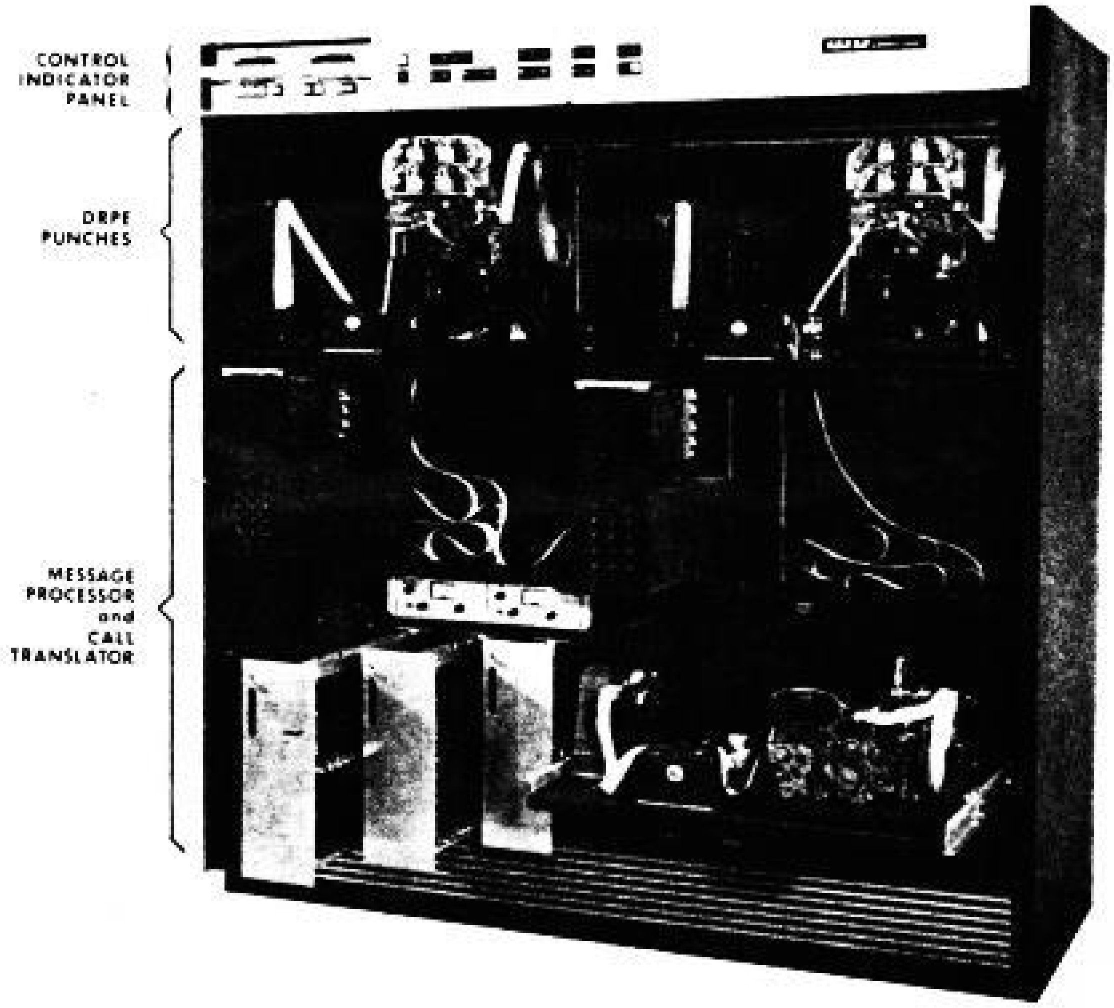


Figure 5—TELMAP unit (cover removed) installed in Phone Room

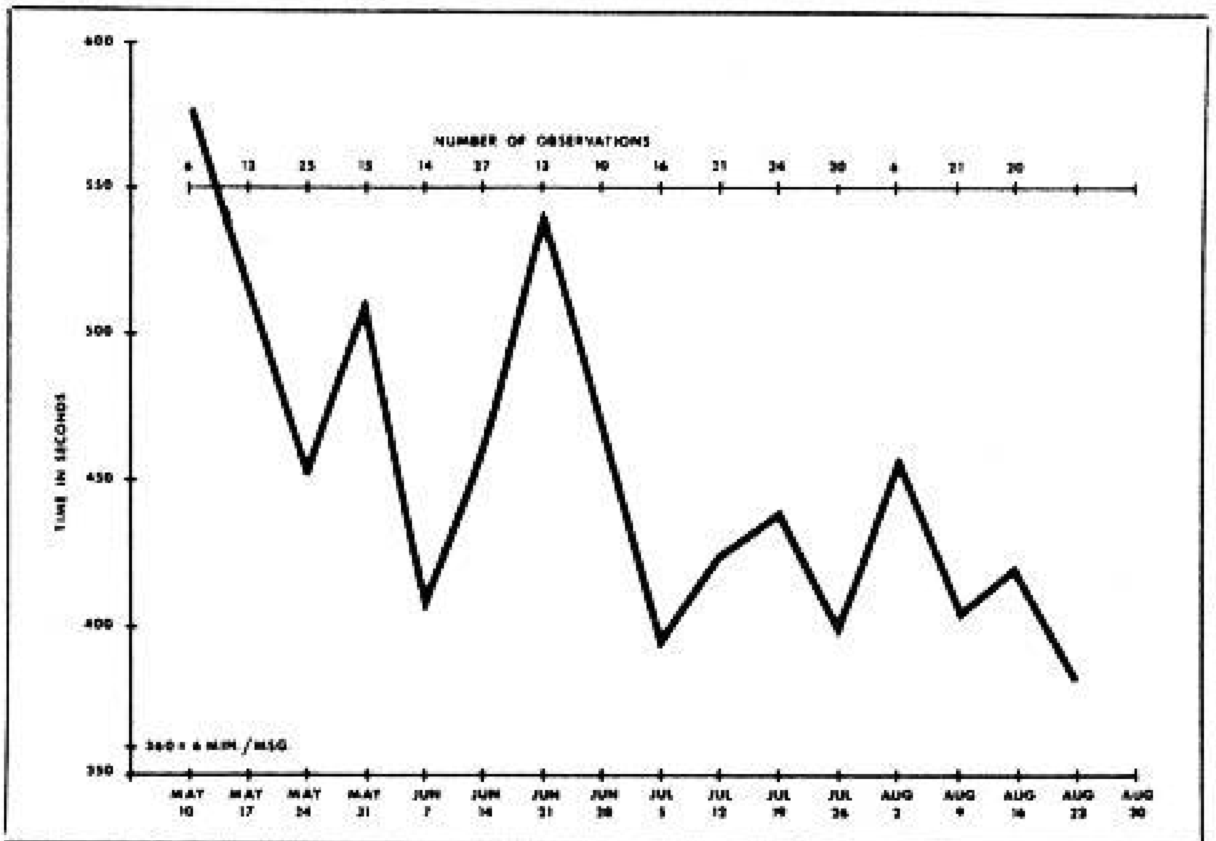


Figure 6—Plot of Data Showing Reduced Service Time Over a Period of Four Months in Field Trial

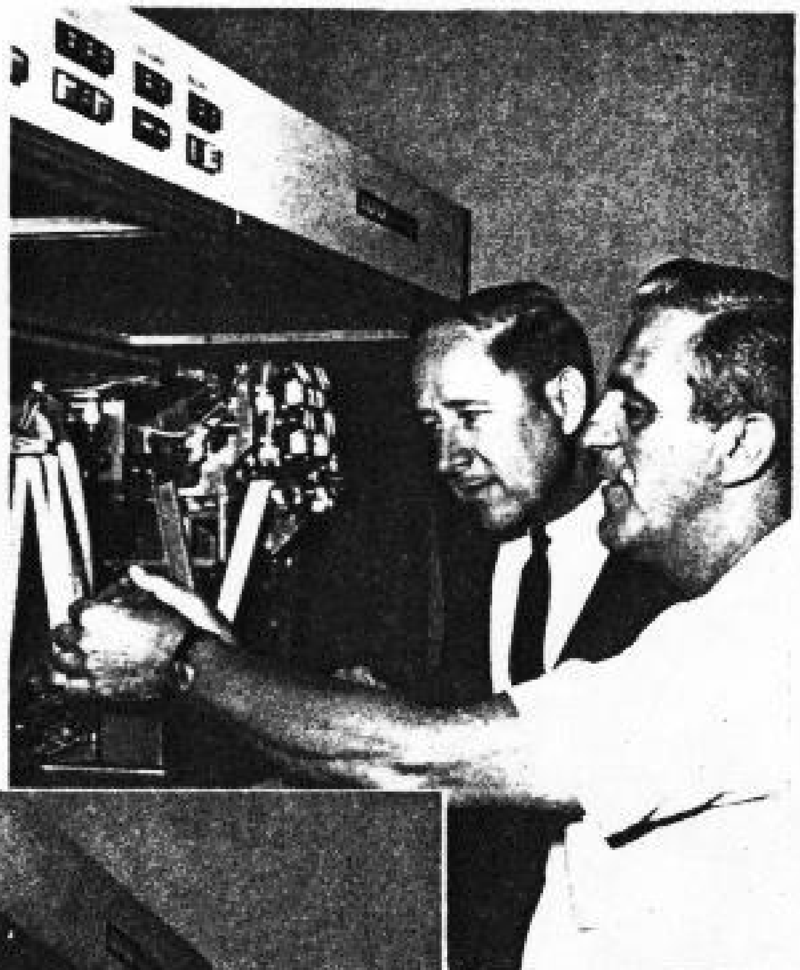
Field Trial Results

The equipment installed in the New York Phone Room, has functioned well during the initial period of training operators and debugging equipment. Figure 6 is a plot of reduced service time, over a period of 4 months, as the operators became more familiar with the equipment.

In order to illustrate the advantage of automatic handling equipment, let us compare it with the previous method of acceptance of telephone messages into the system. It is required that a full-rate message be delivered in an hour. Western Union's criterion for clearing messages from the local office is less than 14 minutes.

The new CRT—TELMAP equipment takes about five minutes "to record" the average message—this is largely customer contact time, however, the big advantage is that TELMAP requires one minute for the message to enter the system. This is considerably less than the 14 minutes allowed.

As a continuation of this project, the economic feasibility of different equipment configurations is being investigated for accomplishing the automatic handling of messages, in connection with telephone recording in large city offices. It is anticipated that a configuration which includes a computer to perform the automatic message handling may further reduce handling time.



Mr. Murphy, author of this article discusses with Joseph Polito, T&R representative in the Technical Facilities Department the results of tests.

Richard P. Murphy, Manager of the Terminal Equipment Systems Engineering in the Planning and Engineering Operation, is responsible for establishing requirements for terminal equipment for the Modernization Program.

Prior to joining Western Union in 1966, he has many years of experience in Systems Engineering in Communications and Aerospace computer-based systems with Bell Telephone Laboratories and General Precision Laboratory.

Mr. Murphy received his B.E.E. in Electrical Engineering from Clarkson College of Technology, and later attended graduate courses at M.I.T., Brooklyn Polytechnic Institute and Bell Telephone Laboratories. He is a senior member of the Institute of Electrical and Electronics Engineers and a member of Tau Beta Pi. He has two issued patents and one submission under consideration by the Western Union Patent Department.

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Interface
Automatic Access
Data Terminals
Test and Maintenance

Kennedy, John D. and Pocchia, J.: DIT (Data Interface Terminal) provides Automatic Access to Computerized Data Terminals

Western Union TECHNICAL REVIEW, Vol. 22, No. 4 (Autumn 1968) pp. 122 to 131

The Data Interface Terminal, DIT, was designed by Western Union for the Advanced Record System placed in service for the General Service Administration in early 1966. It provides automatic access between any ARS station and a computerized data terminal for calls where the queries and answers are transmitted during the same call.

While the DIT was designed primarily for use with computerized data terminals, it may also be used with other types of data terminals such as a Card Transceiver. The design of DIT may be extended to other common switching networks or store-and-forward systems, either narrowband or wideband.

The unique Testing and Maintenance features of this unit are described.

Simulation
Management Tool
Overseas AUTODIN

Elsam, E. S. and Riggs, J. J.: SAS—A Management Tool to Evaluate the Dynamics of Change

Western Union TECHNICAL REVIEW, Vol. 22, No. 4 (Autumn 1968) pp. 132 to 143

The characteristics and functions peculiar to the Overseas AUTODIN switching centers were analyzed by Western Union for the United States Army Strategic Communications Command. A dynamic model, called SAS meaning Systems Analysis Simulator, was developed as a result of this analysis.

This article verifies that in an increasingly complex communications environment, simulation can provide effective data for system control and management.

Voice Communications
Conference Calls
Message Switching Processors

Dodgson, R. S.: Voice Communication Network for Echo-Free Conference

Western Union TECHNICAL REVIEW, Vol. 22, No. 4 (Autumn 1968) pp. 144 to 151

Western Union operates a voice communications network to interconnect a number of its message-switching computer processors in a coast-to-coast network.

This article describes a four-wire switched conference network which provides excellent talking characteristics with a very high degree of intelligibility. Included in this article is a description of "How to Set Up a Conference Call."

Customer Service
Modernization
New Equipment

Murphy, R. P.: Improved Service Time with New CRT-TELMAP Equipment

Western Union TECHNICAL REVIEW, Vol. 22, No. 4 (Autumn 1968) pp. 152 to 157

A significant improvement in service time has been the result of using the new cathode ray tube display unit combined with a telephone message automatic processor—for accepting telegrams by telephone.

This article describes the operator position equipment described by Western Union and the automatic handling of the message through the TELMAP unit, also designed by Western Union.

The operation of the equipment is reviewed and the advantages of the equipment to our customers is pointed up.

Patents and Trademarks Recently Issued to Western Union

Patent No.	Title of Patent	Inventor
3,400,329	"Method and means for correcting amplitude and delay distortion in a transmission path"	William D. Cannon
3,400,801	"Reusable inking cartridge"	Oscar W. Swenson
3,404,338	"Method and means for measuring and correcting delay and attenuation in a transmission channel"	William D. Cannon

Trademark Registration No.	Title of Mark
823,827	"Broadband Exchange"
825,483	"Dollygram and Design"
830,008	"Select-A-Band"
831,615	"Dolly-Gram" (word)
835,666	"WU" (word)
835,667	"WU" WESTERN UNION (design)
837,295	"Melody-Gram"
841,033	"Recruit-A-Gram"
841,368	"Melody-Gram" (design)
846,463	"Dalcode"
851,643	"Info-Com"

Our Editor Says:

Looking Ahead to 1969

The TECHNICAL REVIEW *has documented significant milestones in our engineering progress in the four 1968 issues of our technical publication.*

As I look ahead to 1969 and plan future issues, the editorial schedule for 1969 promises even more significant documentation of our progress. Just to give our readers a preview—the January 1969 issue will be devoted to QUALITY ASSURANCE. Some of the articles planned for that issue are:

- *Western Union's Quality Assurance Program*
- *Performance Control*
- *Reliability Projection and Analysis*
- *Test and Evaluation Engineering*
- *Failure Analysis*

Quality assurance has always been of paramount importance to Western Union. However, techniques and standards change over the years. The January 1969 issue will describe some of the new standards, new techniques being explored by Western Union engineers to improve service and enhance our modernization program.

Mary C. Killilea, Editor