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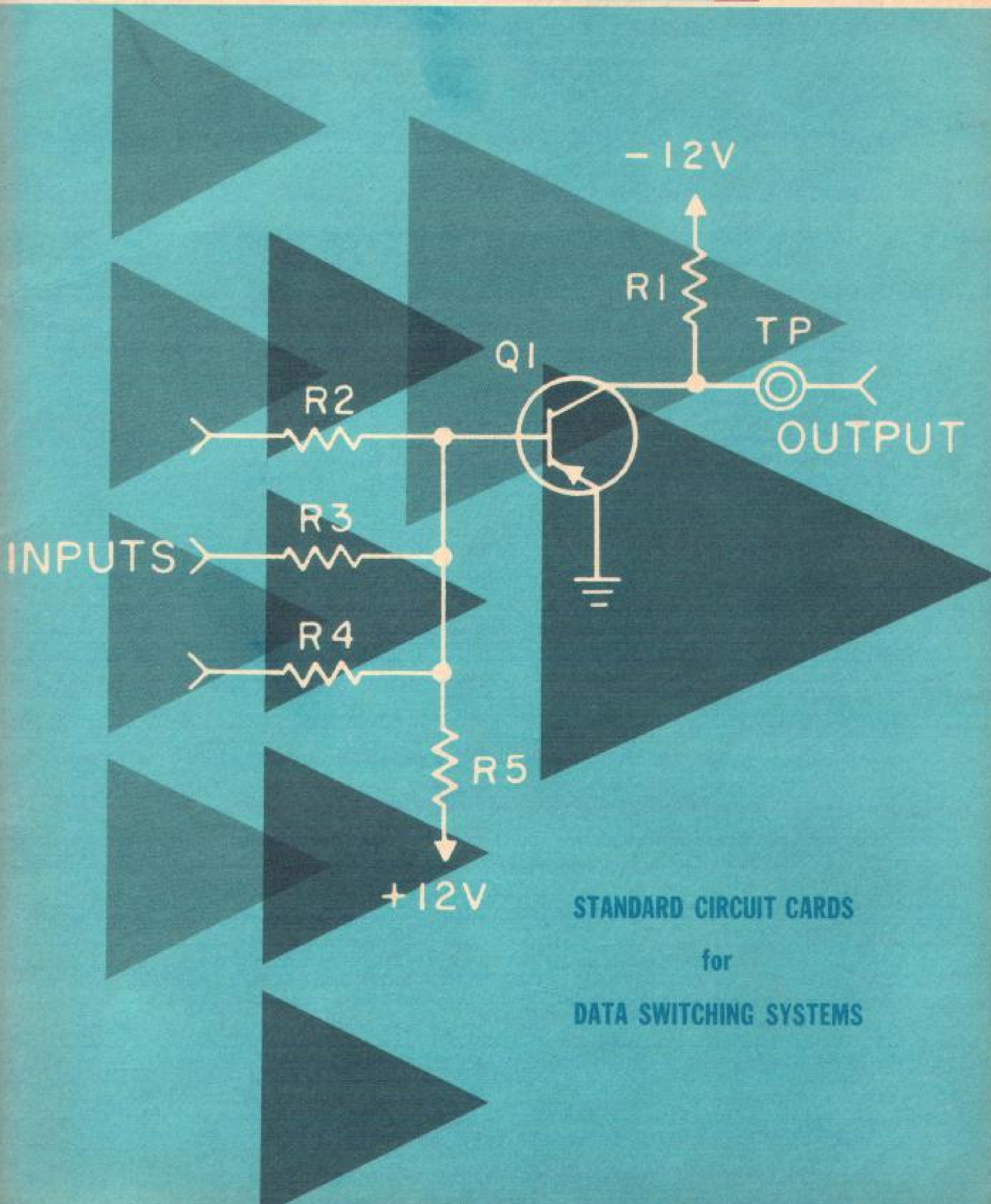

STANDARD CIRCUIT CARDS for DATA SWITCHING SYSTEMS

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Volume 17

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Standard Circuit Cards For Data Switching Circuits

The high cost of maintaining data transmission systems presents a challenging problem to the communications industry. To meet this problem, Western Union has standardized a family of digital switching cards to minimize maintenance costs and reduce obsolescence.

A review of the printed circuit cards designed by Western Union for use in their data switching systems indicated that some duplication might be eliminated. Many of these circuit cards were originally designed on a system basis and although their functions were similar they could not be interchanged between systems. In addition, separate test equipment had to be designed to locate marginal and defective cards in each system. As a result of this review, a family of six solid state printed circuit cards were developed and standardized by the company for use in relatively low speed digital switching systems. These six cards were designed to meet most of the anticipated future needs of the company in low speed circuitry. Other printed circuit cards used only in special purpose applications have also been standardized. However, they will not be discussed in this article.

The printed circuit cards used in earlier systems were not standardized because their design was not based on the use of transistor-resistor logic (TRL) circuits. Transistor-resistor logic offers advantages over the printed circuit cards previously used. (A logic circuit is a type of circuit which can be used by itself or in conjunction with other logic circuits to implement various functions such as frequency division, counting, registration, computation and format conversion.)

Standard Circuit Cards

The six solid state printed circuit cards now standardized are:

1. Transistor-Resistor NOR Gate
2. Flip-Flop
3. Mono/Astable Multivibrator
4. Emitter Follower and Automatic Reset
5. Adjustable Frequency LC Controlled Oscillator
6. Power Amplifier

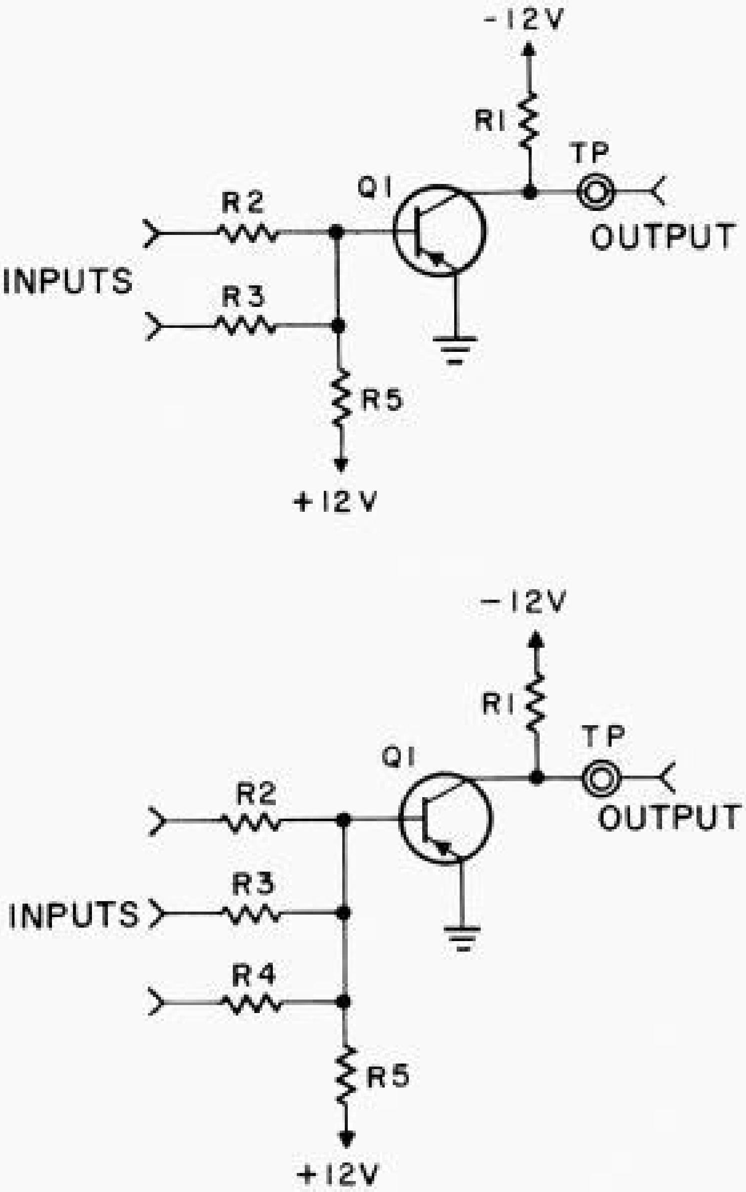

Figure 1. Transistor-Resistor NOR Gate

(a) The Transistor-Resistor NOR Gate Circuit, referred to as the NOR Gate, has two or three inputs as shown in Figure 1. The NOR circuit can

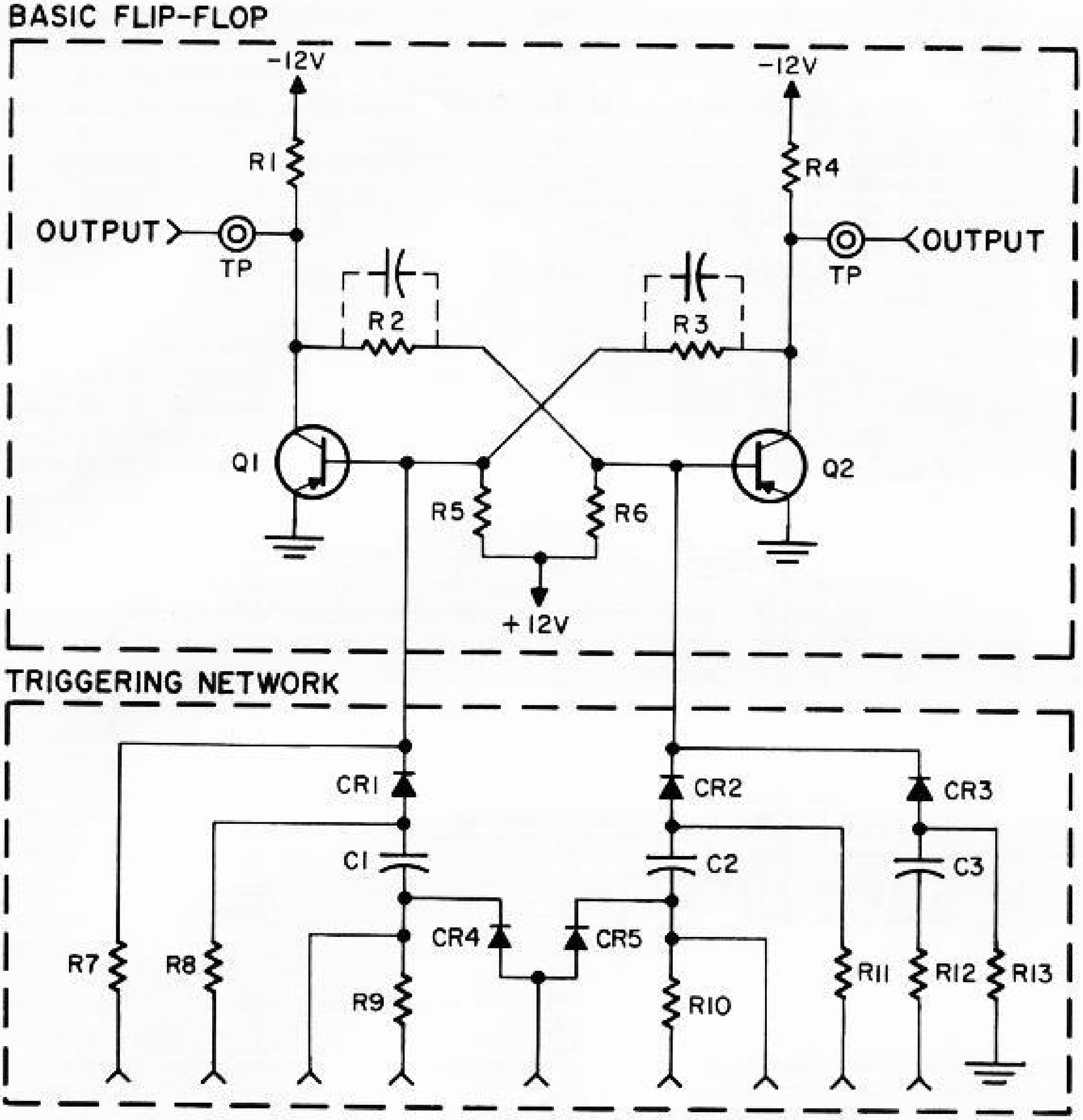

Figure 2. Flip-Flop

perform most common logic functions. If any input is sufficiently negative, the output will be very close to ground. If all inputs are ground or open, the output will be negative. Therefore, in many applications, the NOR Gate performs OR circuit logic for negative inputs and AND circuit logic for ground inputs. In many cases the NOR Gate is used to invert and/or amplify the input signal. In addition, two NOR Gates may be connected to form a dc flip-flop.

(b) The Flip-Flop circuit, shown in Figure 2, is commonly used in binary counters and shift registers, or as a storage element. The circuit comprises the basic flip-flop and its associated triggering network. It can remain in either of its two stable states, "set" or "reset," indefinitely. The "reset" state is defined as the condition in which transistor Q1 is fully "ON" (its collector is very near ground potential), and Q2 fully "OFF" (its collector is at a negative potential). In

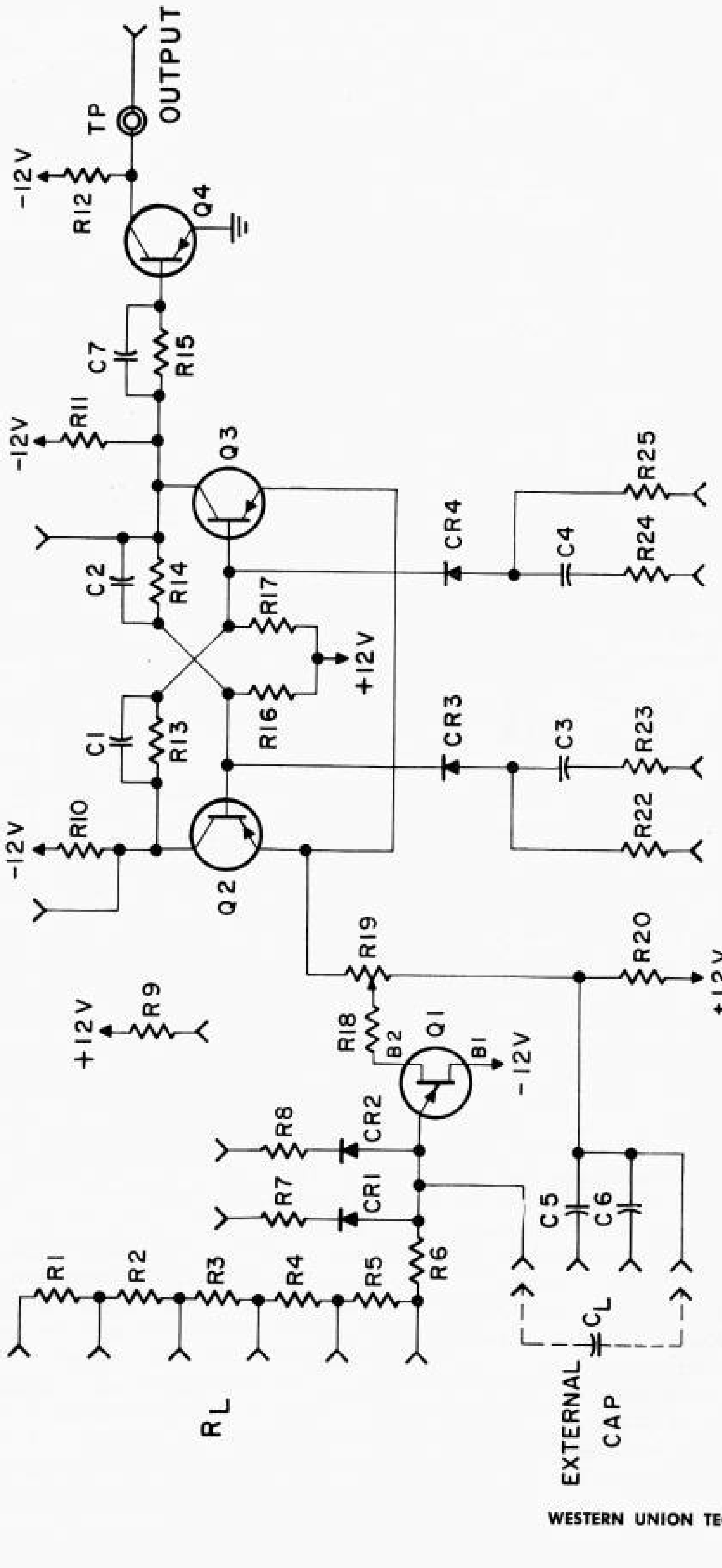

Figure 3. Mono/Astable Multivibrator

the "set" state the opposite is true; i.e., Q2 is fully "ON" and Q1 is fully "OFF."

The flip-flop can make an abrupt transition from one state to the other, when an appropriate input signal is applied to its triggering network. Included in the trigger circuit design are ac and dc reset terminals, low speed trigger inputs, high speed trigger inputs and pedestal inputs.

(c) The Mono/Astable Multivibrator is a dual purpose circuit, shown in Figure 3. As a Monostable Multivibrator, commonly referred to as a "ONE SHOT," it can provide an output signal with a variable time delay or variable pulse width. As an Astable Multivibrator, the circuit can provide clock pulses of varying frequencies. However, in the Astable mode of operation, its output frequency is not as accurate as that of the oscillator circuit described below. The various output frequencies, time delays, pulse widths and modes of operation are obtained by external strapping on the card's connector.

(d) The Emitter Follower and Automatic Reset, shown in Figure 4, are separate circuits on the same printed circuit card.

Because of its current-amplifying capabilities, the Emitter Follower is often used as a driving stage between the output of a NOR gate or flip-flop and its load.

The function of the Automatic Reset circuit is to insure that all flip-flop circuits connected to it are initially in the reset state when system power is first turned on or, if any interruption of power occurs. An Emitter Follower is usually used in conjunction with the Automatic Reset in order to increase the number of flip-flops which it can reset.

(e) The Adjustable Frequency LC Controlled Oscillator, shown in Figure 5, is composed of two basic circuits: a push-pull LC oscillator circuit and a squaring circuit. The oscillator is used as a square wave generator. It provides an accurate time base reference for counters and shift registers. The frequency of the output pulse train obtained depends on the external strapping on the card's connector of the 8-tap inductor in the circuit. Seven discrete frequencies are available.

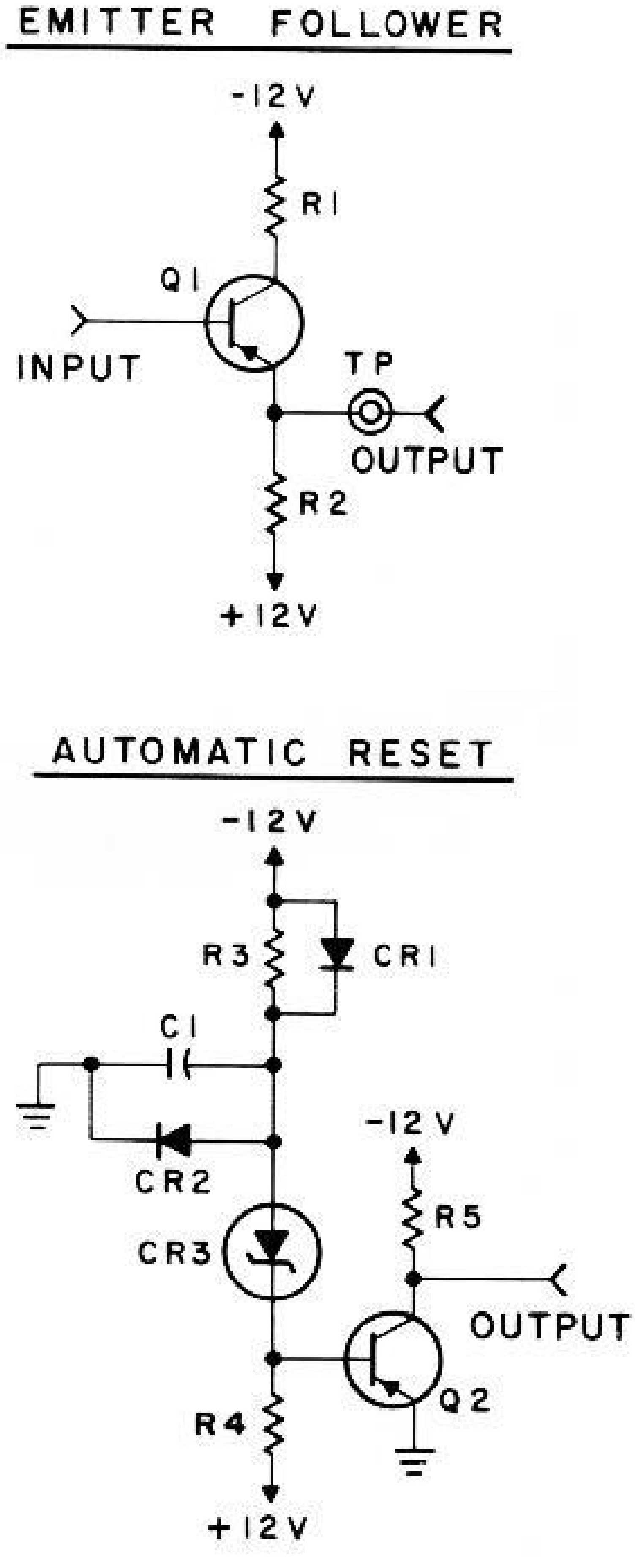

Figure 4. Emitter Follower and Automatic Reset

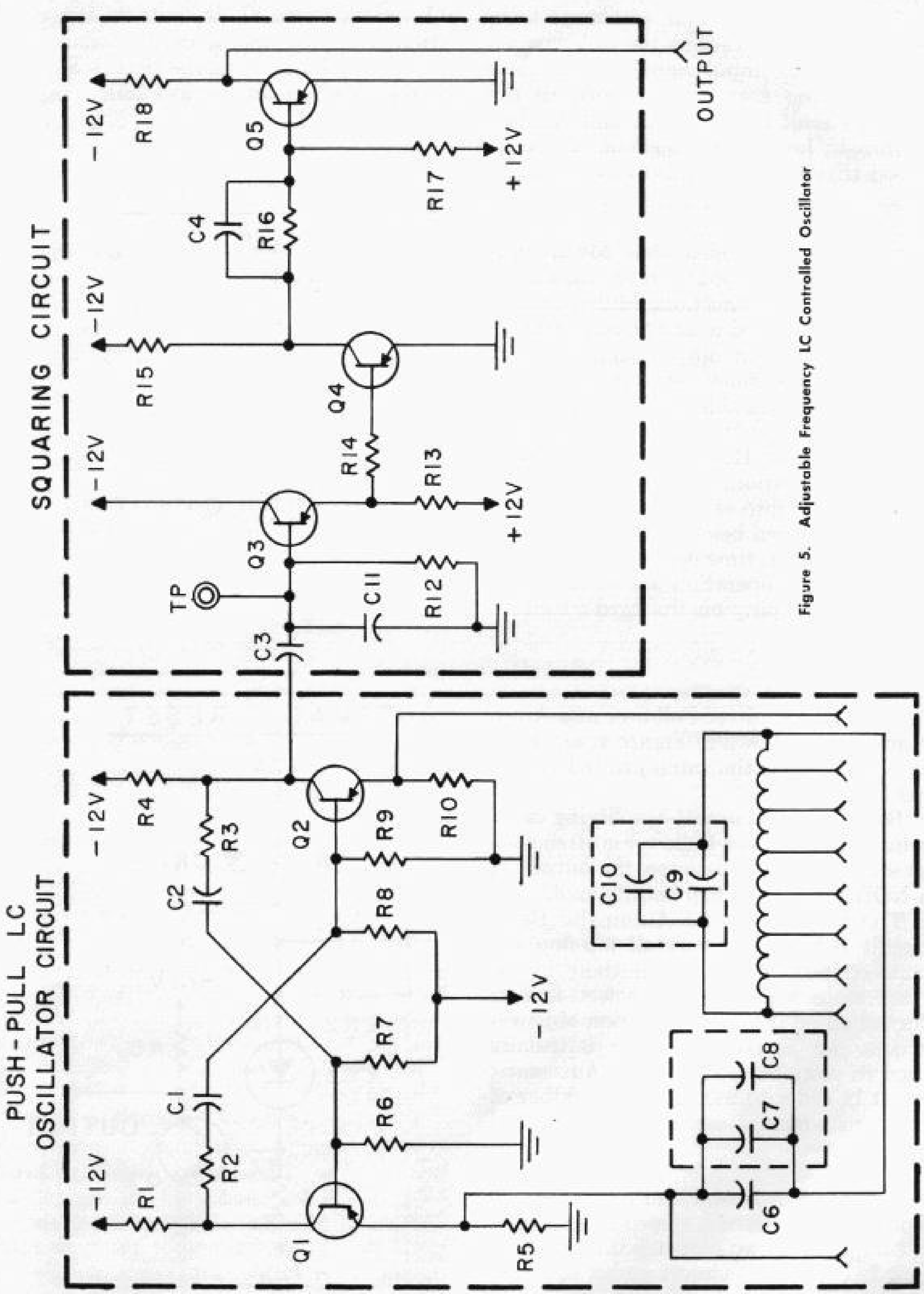

Figure 5. Adjustable Frequency LC Controlled Oscillator

(f) The basic Power Amplifier circuit is shown in Figure 6. This circuit was designed to drive loads that require up to 3 amperes and voltages up to 120 volts. The loads may include selector magnets, lamps, relays, etc. To obtain the various output drive currents and voltages, four different Power Amplifier printed circuit cards, similar to Figure 6, are available. The basic Power Amplifier circuit is on each card, however, resistor values and the Q_2 power transistor for each amplifier card are different. A total of seven different output currents and three different output voltages can be obtained from the four cards by external strapping on the card's connector.

- *Versatility*—Strapping of the connectors enable the printed circuit cards to perform various operations thus increasing their flexibility.

- *Compatibility*—Power requirements and power terminals on each card are the same. Resistor tolerances and transistor types are identical on all cards.

- *Ease of Maintenance*—Test points, corresponding to the critical voltage levels in each circuit, are accessible for trouble-shooting. Each card can be removed easily from its connector for maintenance.

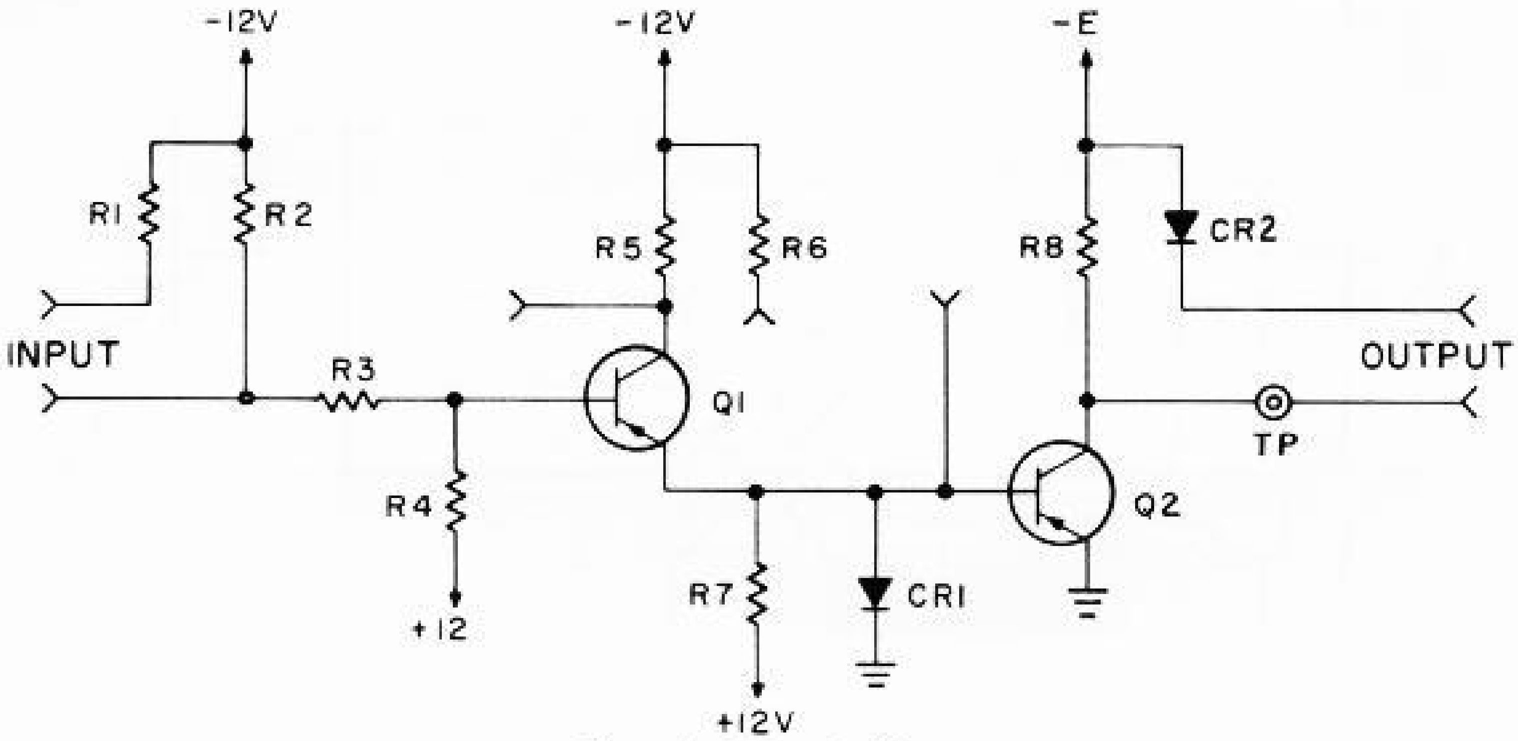

Figure 6. Power Amplifier

Features

The principal features of the standard circuit cards are:

- *Reliability*—The six standard printed circuit cards were designed to achieve high reliability. The philosophy of design used is the "worst-case" technique. This technique permits satisfactory operation of each circuit should all component values and supply potentials change simultaneously in an unfavorable direction. In addition, since any combination of the six cards were designed to operate together, "worst case" loading conditions and drawing capabilities were carefully considered.

Applications

The standard circuit cards have already been used at Western Union in the design of basic system components. Some of these components are:

- DC Flip-Flop
- Code Converter
- Counter
- Series-to-Parallel Shift Register
- Register

DC FLIP-FLOP: The interconnection of two NOR gates, as illustrated in Figure 7, forms a dc Flip-Flop. The output of each NOR gate is tied to one of the base resistors of the other NOR gate. Application of the power supply potentials to the circuit will saturate one of the transistors and thus drive the other transistor off. The parameters, that determine which one of the transistors saturates when power is applied, are: the current gain (H_{FE}) of the transistors, the cutoff frequency of the transistors and the amount of deviation from the rated resistance value of the transistors' base resistor. In general, the transistor with the smallest base resistor, the largest current gain, and the highest cutoff frequency or any combination thereof will be the one to saturate. Applying sufficient negative dc potential to the input base resistor of the off transistor will cause it to saturate and thereby force the other transistor to be cut off.

output signal will appear. As an example, the character A in Baudot Code is "one" and "two" marking, "three," "four" and "five" spacing. Marking is defined as ground potential and spacing as negative potential. Figure 8 shows the character A, as it has just passed under the mechanical tape transmitter pins. Pins one and two are closed, pins three, four, and five are open. As stated previously, the output of a NOR gate will be negative only when all its inputs are at ground potential or open. The small triangles in the middle of Figure 8 are symbols for single input Transistor-Resistor NOR Gates. Triangles "A" and "B" represent a 5-input

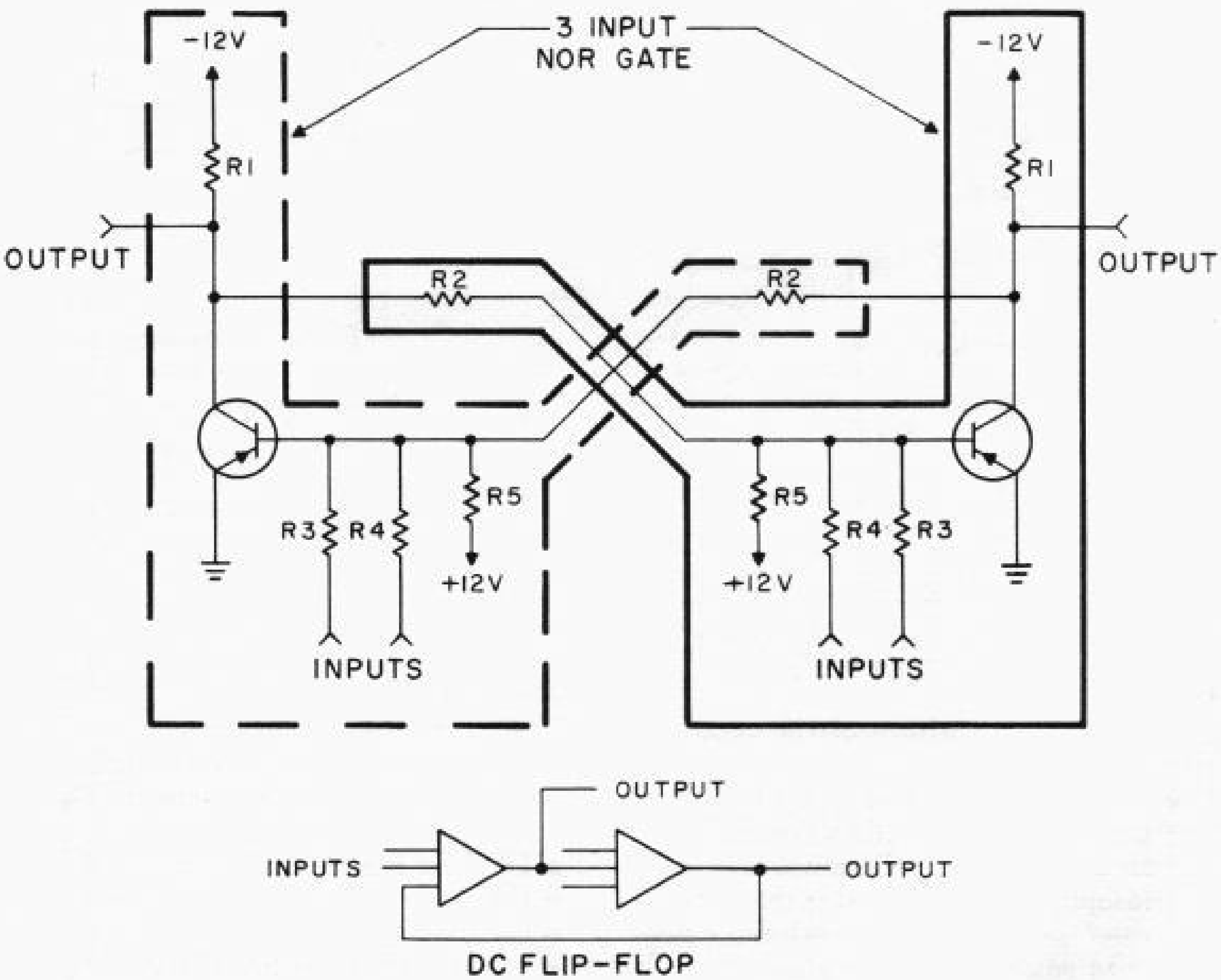

Figure 7. D.C. Flip-Flop

CODE CONVERTER: A Code Converter can be formed by logically interconnecting NOR gates. When the particular character appears under the mechanical tape transmitter pins or is the output of an electronic distributor, a predetermined

Transistor-Resistor NOR Gate. A 5-input NOR gate can be formed by properly connecting two standard NOR gates. The NOR circuitry has been arranged so that all inputs to NOR gate "A" will be at ground potential, only when the character A appears under the transmitter pins. (Note that NOR gate "A" is functioning as an AND gate.) The output of NOR gate "B" will be negative only when the character B appears under the transmitter pins. Character B is "one," "four" and "five" marking, "two" and "three" spacing.

COUNTER: A Counter can be formed by interconnecting flip-flops such that their binary states, "set" or "reset" occur in a predetermined sequence when trigger pulses are applied to its input, as shown in Figure 9. On each of the flip-flops shown, terminal R is tied to X and terminal S is tied to Y. These connections provide necessary reference voltage levels in the triggering circuit which insure proper triggering of the flip-flop. Counters may be designed to have sequences which repeat or recycle on any number of input pulses up to 2^n, where n is the number of flip-flops in the Counter. As an example, consider the case where a single output pulse is desired for every 16 input pulses. To design a Counter of 16 requires 4 flip-flops. To insure that all flip-flops in the Counter are initially in the same state before counting begins, an automatic reset circuit can be used to reset all the flip-flops. The automatic reset circuit will reset all flip-flops connected to it as soon as the power to the system is turned on. In cases where one automatic reset circuit must reset more than four flip-flops, an emitter follower circuit may be used in order to present a high input impedance to the automatic reset circuit and thus enable it to reset a larger number of flip-flops.

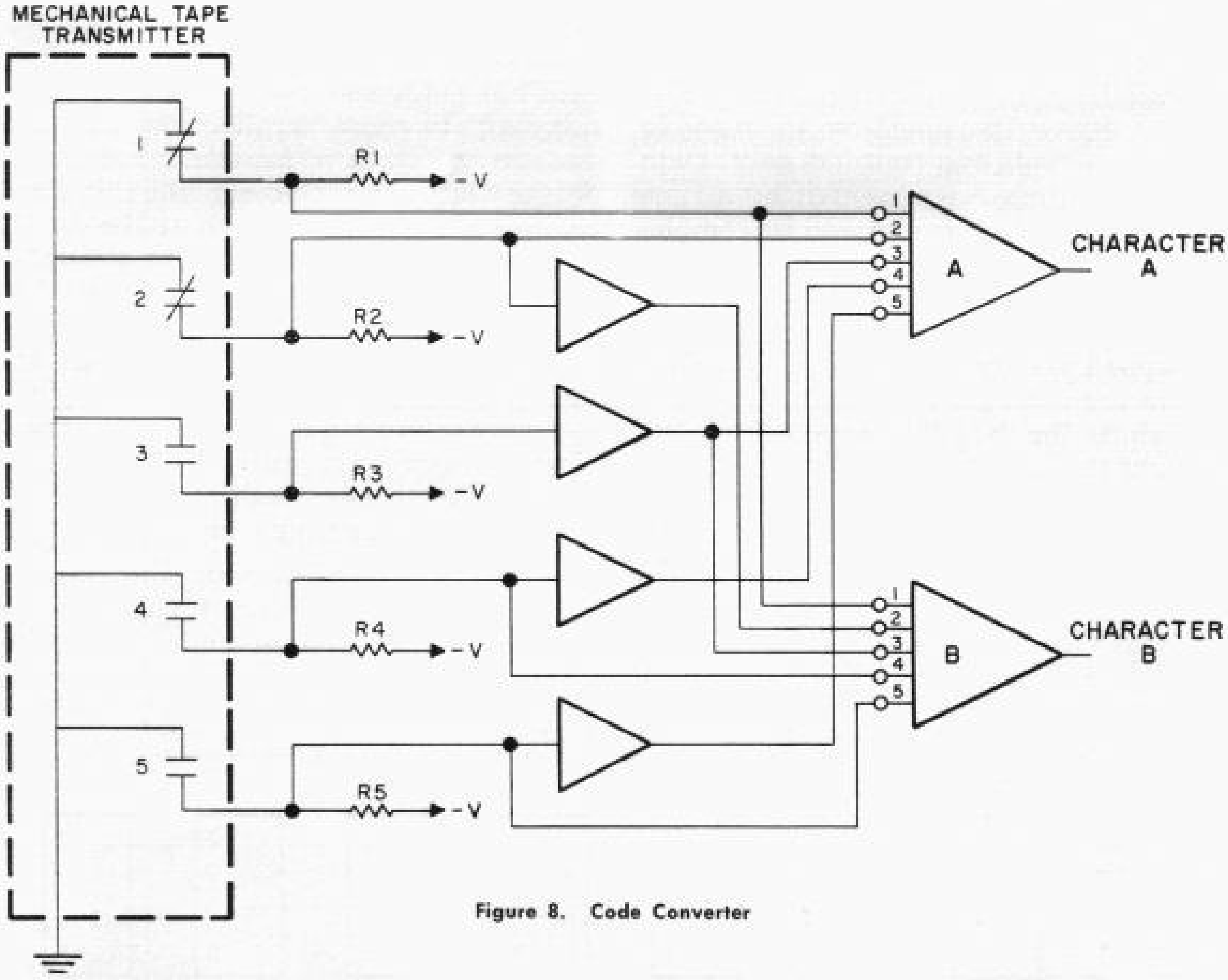

Figure 8. Code Converter

SERIES-TO-PARALLEL SHIFT REGISTER: A shift register is a chain of interconnected flip-flops, arranged to accept or store a group of related bits. One flip-flop is required in the register for each character bit. Thus a character consisting of 7 bits, comprising a start pulse, rest pulse and five information pulses requires a shift

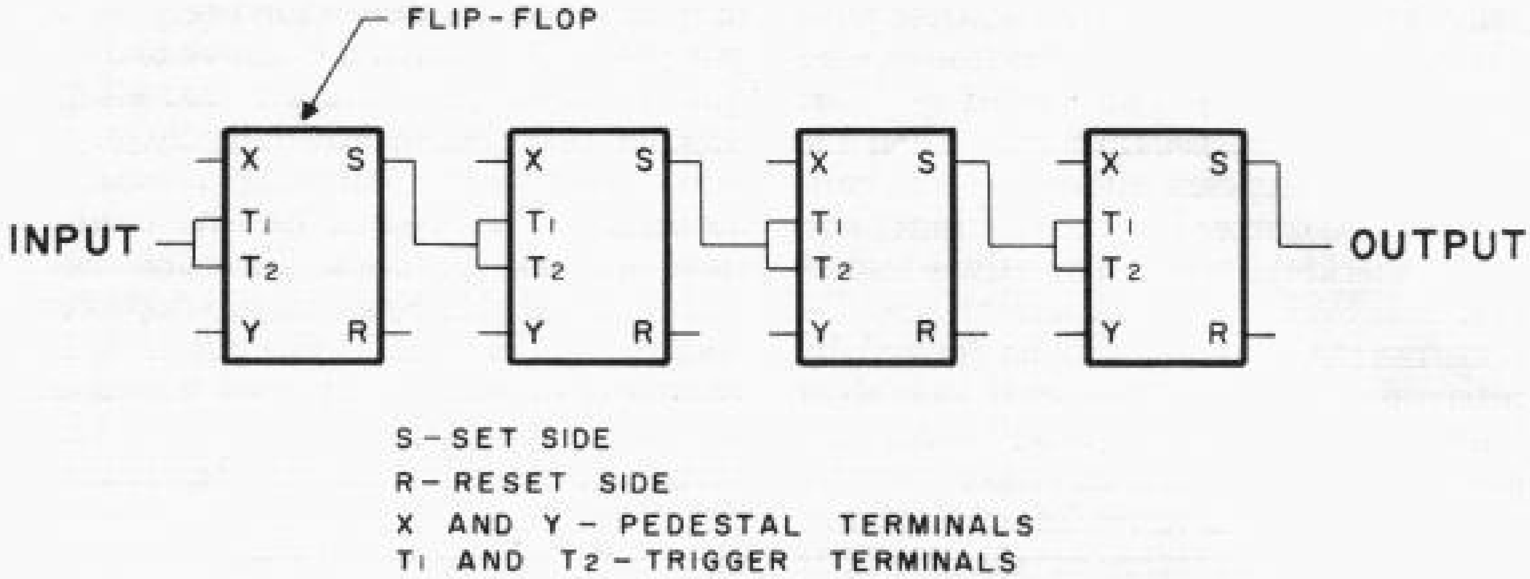

Figure 9. Counter

register consisting of 7 flip-flops. A Series-to-Parallel Shift Register, shown in Figure 10, derives its name from the mode in which it accepts and transfers data. Data in serial form are represented by a time sequence of bits. Each bit and its complement are applied simultaneously to the Y and X terminals, respectively, on the first flip-flop in the chain. A trigger signal is applied via the trigger line, at appropriate times during each character cycle, and shifts the data bits serially from left to right through the seven flip-flops in the chain. Once a complete character is assembled, it will be read out from the register and all flip-flops in the chain are then reset via the reset line. The associated read out gates and read out control line necessary to effect parallel read out are omitted in Figure 10 for clarity. Shifting of the data bits through the flip-flop chain is accomplished by using the oscillator circuit in conjunction with a counting circuit. The oscillator drives the counter which, in turn, provides trigger pulses to the shift register flip-flops at the exact moment needed to shift the incoming information. The oscillator provides a square wave output at a frequency which is an even multiple of the frequency of the incoming line.

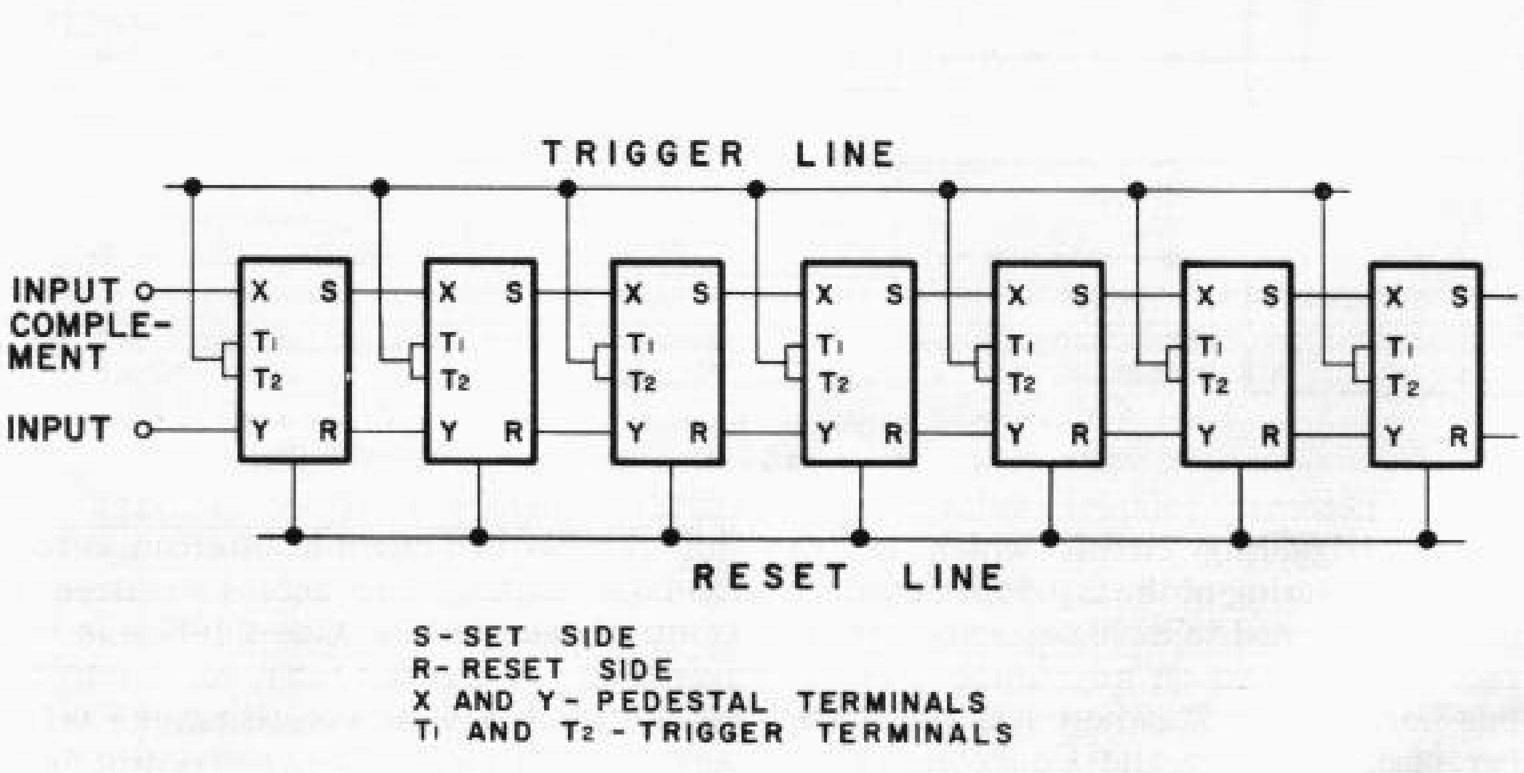

Figure 10. Series-to-Parallel Shift Register

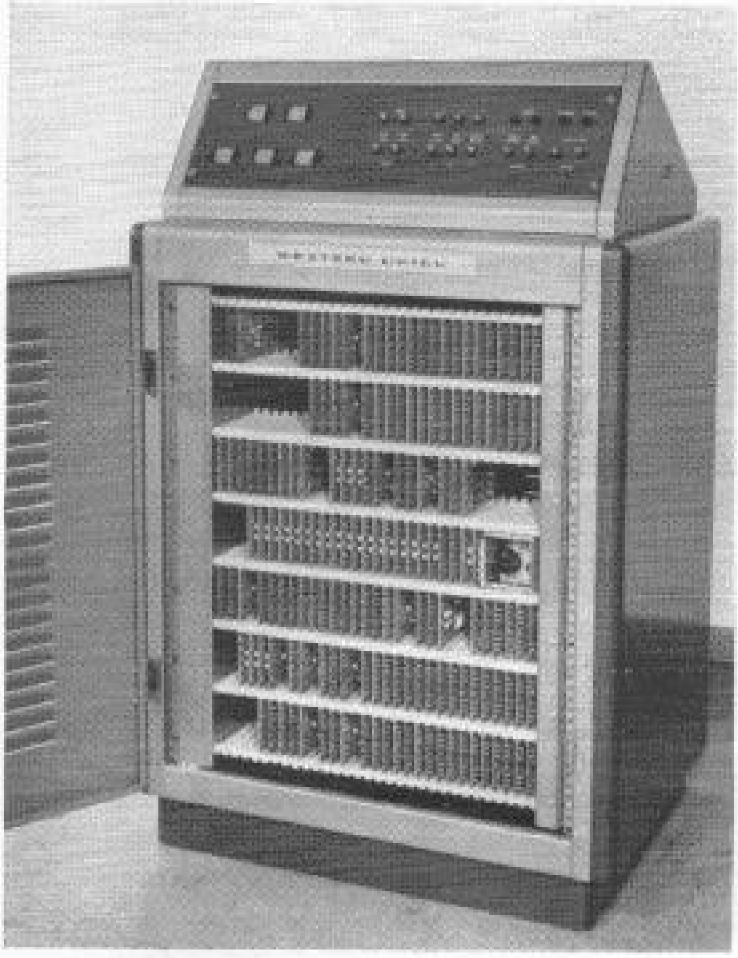

Figure 11. EDAC—Error Detection and Correction System (Front View)

REGISTER This unit stores information in bit form. It will contain a number of flip-flops equal to the number of bits to be stored. The data bits are read into the Register in parallel. If a character read out from the shift register is to be stored in this unit, then seven flip-flops are required. Each flip-flop receives one of the seven bits which make up the character. The Register stores the character until it is reset.

SYSTEMS By combining basic components, entire systems utilizing the standard printed circuit cards are being designed. One example is the EDAC (Error Detection and Correction) system. EDAC is a self checking data handling system used primarily in overseas or other long distance radio circuits where the error rate is high due to fading and interference. This system utilizes approximately 150 standard cards per unit, as shown in Figure 11.

Switching System Plan 301 will use hundreds of the standard cards when put into operation. Designed for computer operation, it will receive information from various outstations, process it, and then store it or route it to its destination.

Future Planning

Systems which previously used vacuum tubes and relays are now being redesigned using the standard printed circuit cards. The rapid acceptance of the six standard printed circuit cards for use in low speed digital circuit design has proven that the move towards standardization was a step well taken. As future needs develop, especially in the field of high-speed digital circuitry, it is felt that the trend there too will be towards standardization of printed circuit cards.

Acknowledgements

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Mr. M. H. Gold is an Engineer, currently assigned to the DATACOM Project Group. Previously, as a member of the Switching Systems Division, Mr. Gold was concerned basically with the design of circuits utilizing Standard Printed Circuit Cards. He was associated with the preliminary development work on the feasibility of magnetic-core shift registers for use in digital switching systems. He designed circuits for Test Set 11324, which tests all printed circuit cards used in Display System 210-A.

Mr. Gold joined Western Union in 1961 after receiving his B.E.E. degree from City College of New York. Presently, he is studying for a M.S.E.E. degree at Polytechnic Institute of Brooklyn. Mr. Gold is a member of the I.E.E.E. and the National Society of Professional Engineers.

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Automatic Switching System-Plan 39

Theory and Design

The dispatchers at Western Union are responsible for the protection and maintenance of Western Union telegraph services. With the rapid growth and expansion of the Company's services the task of the dispatcher is even greater. A new Dispatching Center was established to relieve the additional duties of the dispatcher. This center will speed up the interchange of test and dispatching traffic, thus allowing for the handling of larger volumes of traffic. Automatic Switching System, Plan 39 was designed and installed as the heart of this new Dispatching Center.

System Requirements

Because the main purpose of Switching System 39 is to speed up the interchange of test and dispatching traffic, special consideration was given to the particular characteristics of the circuits and traffic involved. Test and dispatching messages are usually short and abbreviated; they are transmitted via keyboard, and on a single-line basis. Way-station traffic must be transmitted and received on both page and tape printers. Traffic will be between drops or way-stations on both the same line circuit and different line circuits. These characteristics were most important in the final design of Switching System 39.

In addition, the versatility of the automatic system had to be considered. In this system the probability of incorrectly programmed messages, apparatus failures, line circuit failures, etc., could result in partial system tie-ups. Wherever possible, automatic features were incorporated to eliminate these possibilities.

Plan 39 Equipment

Switching System 39 is an automatic, reperforator switching system capable of receiving from and transmitting to thirty different circuits. The equipment of Plan 39 comprises a number of cabinets and tables which can be divided into three distinct groups.

One group, comprising one Sending Equipment Cabinet 10674-A and one 10674.1-A, contains the control and sending equipment for all sending lines. Figure 1 shows sending equipment 10674-A. The thirty sending lines are divided evenly between the two sending equipment cabinets. From these cabinets all transmission from the Dispatching Center can be checked and controlled. Both cabinets have close-out switches and line conditions lamps for all line circuits. The line

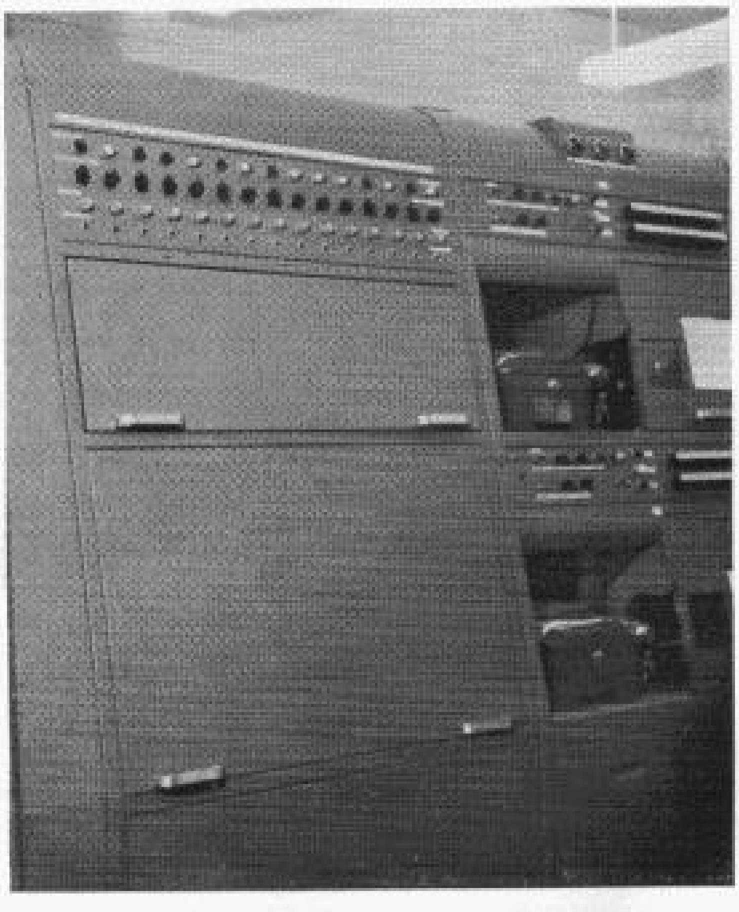


Figure 1. Sending Equipment for Plan 39

condition lamp indicates which lines are open for traffic, which lines are closed to traffic, and where possible line circuit failures have occurred. The close-out switches are utilized to open or close the different line circuits for possible traffic transmission.

The second group, the main portion of the Plan 39 System, consists of 15 units of Switching Cabinet 10672-A. Figure 2 shows the front view of cabinet 10672-A. Each of the 15 cabinets contains two operating positions. An operating position consists of a Printer-Perforator 39-B, a Transmitter Distributor LBXD-2, a rotary switch and associated switching equipment. The printer-perforator is utilized to receive incoming messages in printed-perforator tape form. The LB-XD-2, with its associated equipment and rotary switch, is used to automatically switch and transmit the messages to any one of thirty different circuits. A pushbutton panel is provided, for each operating position, to allow manual pushbutton switching of the messages. Figure 3 shows a row of Receiving and Switching Cabinets 10672-A, at the Dispatching Center.

The third group of equipment is made up of the Monitor Printer Tables 11148-A, shown in Figure 4. These triple-decked tables contain three Type 28 monitor printers. Each printer is used to monitor all the traffic originated by the way-stations on one line. The printers are equipped with stunt boxes and are used to control the flow of traffic into the switching system.

Operation

Messages originated by drops or way stations connected to Switching System 39 consist of two types: (A) messages which pertain only to the drops on the same line or circuit, or (B) messages destined for a drop on another line or circuit. Type "A" messages are of no concern to the center, and are prevented from flowing into the center. Type "B" messages must be switched through the center.

In order to distinguish between the two types of mesages, a message prefix precedes each message. The prefix, "XA Letters Space," is assigned to all Type "A" messages; and the prefix, "XC Letters Space," is assigned to the Type "B" messages. With the message prefix, the monitor printers are able to control the flow of traffic into the system. The stunt box of the monitor printer is arranged to recognize the message prefixes. Once the stunt box has functioned to control the flow of traffic, it will not perform any further function until an "end of message" character combination is received.

Figure 2. Switching Cabinet 10672-A (front view) showing two operating positions

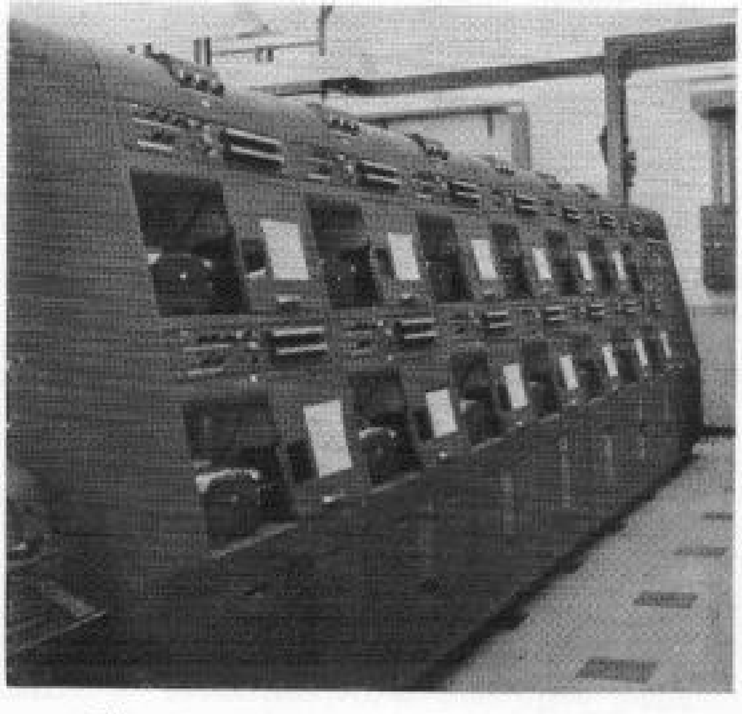


Figure 3. Receiving Equipment for Plan 39

Figure 4. Type 28 Monitor Printers in Printer Tables 11148-A

Figure 5 illustrates the flow of traffic of Switching System 39.

Every message associated with Plan 39 is terminated with two sequential carriage-return characters. The stunt box of the monitor printer recognizes the "end-of-message" sequence and will then be ready to receive another way-station message.

Once a message enters the system it is automatically switched to its proper destination. To distinguish between the thirty circuits, each one is assigned a routing sequence number. To reduce the necessary number of "read" circuits only the digits 0 through 5 are used for these numbers. Immediately after the message prefix, a routing sequence is inserted. The routing sequence is of the form "Figure 01." The first digit in the routing sequence will vary from 0 to 4, and the second digit will vary from 0 to 5. Within these ranges there are thirty possible combinations of two digits, for each of the thirty circuits.

When a message flows into the switching system, it is recorded by means of a printer-perforator at one of the operating positions. The message prefix is utilized to operate the stunt box of the associated monitor printer, and is therefore not recorded by the printer-perforator. Thus, the first characters of the message to be recorded will be the routing sequence. Upon the completion of a message with the "end-of-message" signal, the printer-perforator will automatically tape-feed. The automatic taype feed is necessary to allow the complete message to flow from the printer-perforator to the pins of the associated transmitter-distributor. Should a second message start to be received, the automatic tape-feed will cease.

When the routing sequence of the message reaches the transmitter-distributor, a "message waiting" lamp on the operating position will light. The transmitter-distributor will read the routing sequence and then stop. Associated switching equipment, located in the operating position, will automatically connect the transmitter to the proper line. At this time, the "message waiting" lamp will go out and a "stand-by" lamp will light. If the particular line is not busy, the "stand-by" lamp will go out and an "operate" lamp will light. Transmission from the system will now take place. However, when the particular circuit is busy, the "stand-by" lamp will remain lit and the transmitter will remain stopped, until the circuit becomes idle. Once the transmitter starts to send, it will continue to send until the "end-of-message" signal is encountered. The reading of an "end of message" signal by the transmitter will cause the operating position to disconnect.

Because the test and dispatcher circuits are operated on a single line basis, simultaneous transmission by the system and a way-station on the same line must be prevented. If a way-station is utilizing a particular line and if the switching system receives a message destined for the same line, the operating position in the system will select the line, but it will not send the message. The operate position will hold the message until the way-station ends its message by sending a double carriage return sequence. Once the "end-of-message" signal is detected, the "operate" position will seize the line. To signal the way-stations along the line that a message from the system is about to be transmitted, a string of "T" characters is automatically generated from the Center. After the "T" characters are generated, the system will transmit the message.

Provisions have been made to prevent the seizing of a circuit by an operating position until an entire message has been received. This feature has been incorporated to prevent tying up two line circuits during the transmission of a single message.

With the combination of sending and receiving on both page and tape printers,

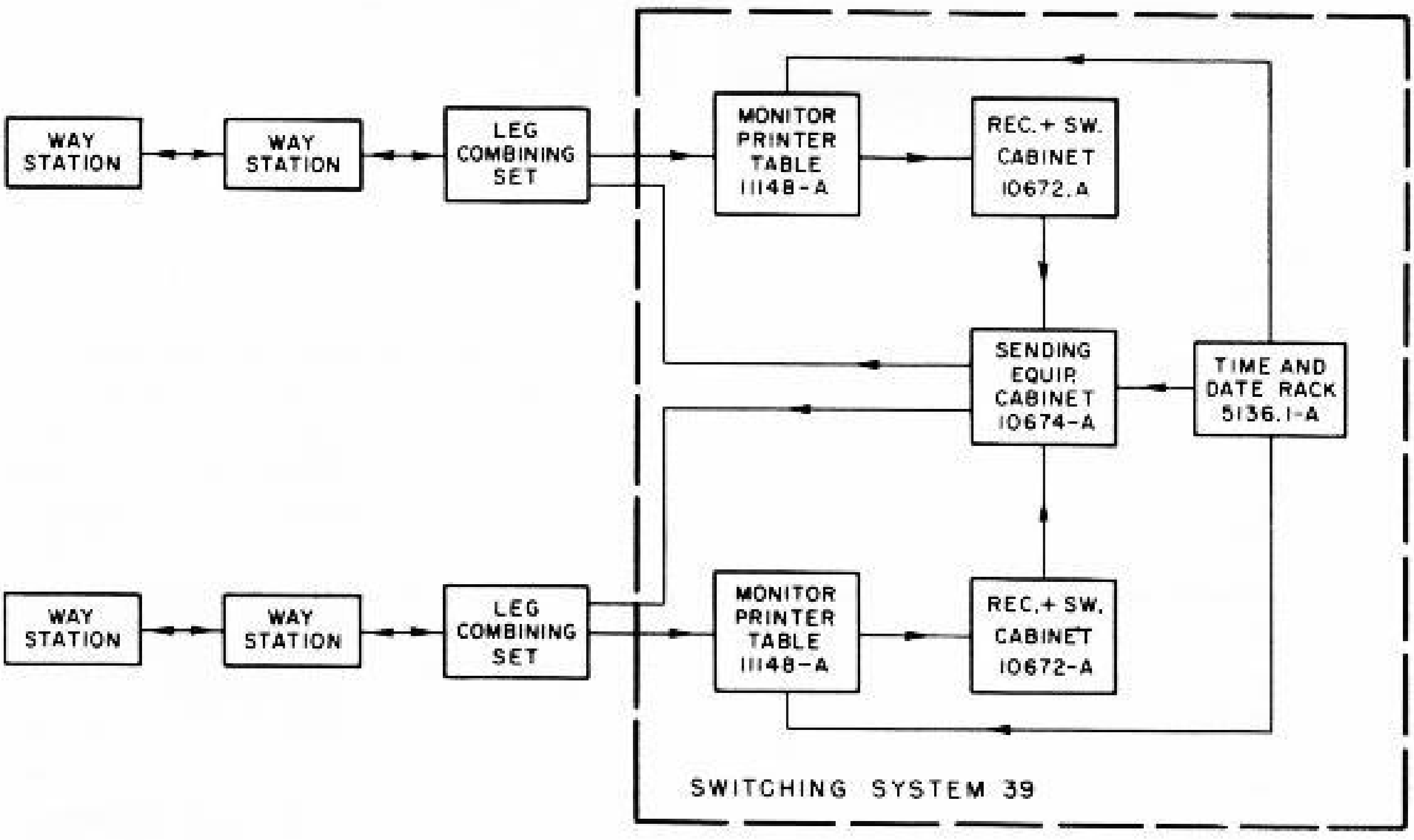


Figure 5. Flow Chart for Switching System—Plan 39

the possibility of overlining on the page printers becomes quite prevelant. Therefore, as a message is transmitted from the system the characters are counted. An automatic "carriage return" line feed is inserted after a count of seventy characters for a line, or on the reception of a "space" character after a count of fifty-eight characters for a line. This feature eliminates the possibility of overlining.

The monitor printers, themselves, are protected against overlining. They are arranged to automatically carriage-return, line feed after a count of approximately seventy characters for a line.

Special Features of Plan 39

Since the main purpose of the Plan 39 switching system is to speed up the interchange of test and dispatching traffic, the probabilities of system tie-ups had to be considered. Certain features were incorporated into the system to guard against possible causes of system tie-ups, e.g., incorrectly addresed messages, apparatus failures, and line circuit failures.

- *Automatic Switching to Spillover of Incorrectly Addressed Messages:* If a message should enter the system with an incorrect routing sequence, the system will not recognize the routing characters and will automatically switch the message to a spillover position. The "00" designated operating position is utilized as the spillover position. The message is then pushbuttoned to its proper destination. The purpose of this feature is to move the incorrectly addressed message out of the "operate" position, so that other messages being received by that position may be switched without delay.

  Should a message be received without any routing sequence, an "alarm" condition will be initiated. In this case, since all operate positions are provided with pushbutton panels, the message can be manually switched to its intended destination, or to the spillover position for further processing.
- *Close Out Switches and Line Condition Lamps:* Closeout switches and line condition lamps for all the sending circuits, are located on the sending equipment cabinets. It is at the sending equipment cabinets that the condition of each line can be checked, and the transmission to each line can be controlled. Should a line circuit failure occur, an alarm condition will be initiated, and the line condition lamp for the line circuit will flash. In this situation, the associated line close-out switch will be thrown to its close-out position. Then, if a message destined for a closed-out line enters the system it will be switched automatically to the spillover position. Thus, such messages will not hold up the automatic switching of any succeeding message.
- *Transmission Protection On Line Circuit Failures:* If a message is in the process of being transmitted to a particular line on which a circuit failure occurs, the transmission of that message will be automatically stopped. This message will then be handled manually.
- *Protection For Type 28 Monitor Printer:* The Type 28 Monitor Printers, which control the flow of traffic into the system, have also been protected. Should the ac power to a particular monitor printer fail, or should the monitor printer be removed for maintenance purposes, all way-station traffic on that line which would be recorded by the associated "operate" position will then be handled manually.
- *Line Spacing Between Messages:* To conserve the amount of paper used by the monitor-printer, the line feeding mechanism of the monitor printer will be interrupted after two sequential line feed characters are received. The reception of a "carriage return" character will allow the line feeding mechanism to function again. Therefore, the line spacing between message texts will be limited to two lines.
- *Visual Traffic Indicators:* The pushbutton panel at the operating position also provides visual traffic in-

dicators in addition to switching facilities. Associated with each pushbutton are two lights; one located on each pushbutton, and one located under each pushbutton. When glowing, the light on the pushbutton indicates the line to which the distributor-transmitter of the position is connected. When the light under the pushbutton glows, it indicates that the line is being used by a way-station on that line, or that a message is being sent out on that line from the Center. Since some of the busier way-stations may be reached by more than one line circuit, the flow of traffic can be speeded up by manually switching messages to alternate circuits. The traffic indicator lights become quite useful in such situations.

- *Circuit Tie-Up Release Control:* In situations where traffic from the Center must be sent immediately, a "seize tie-up release" pushbutton is provided. Each send circuit in the Center has its own "seize tie-up release" pushbutton. When depressed these pushbuttons, will release the seize circuit for the associated line circuit. An operate position, attempting to seize the particular circuit, will seize the circuit and begin to send, regardless of any way-station which may have been using the line circuit.
- *Stop Traffic Control:* Traffic from the center may also be interrputed or stopped at any time. The close-out switches for the line circuits, when rotated to their "special" or "standby" position, will stop, immediately, any transmission from the Center to that line.
- *Time and Date:* Time and date is also included as a feature of Switching System Plan 39. On all traffic originated by the way-stations connected to Switching System 39, the time and date will automatically be inserted at the end of each message. The time and date, besides indicating when the message was transmitted, also indicates an acknowledgement of receipt of message.

Conclusion

With the expansion of Western Union's services and increases in transmission speeds, consideration must be given to improvements in the facilities for the dispatcher. The rapid interchange and automatic handling of messages by means of Switching System Plan 39 allows the dispatcher to perform his functions more efficiently.

Mr. Ronald J. Duswalt, Project Engineer in the office of the Telegraph Equipment Engineer has been responsible for solid-state circuit design for telegraph apparatus.

He joined Western Union in 1957 immediately after receiving his Degree in Electrical Engineering, from Pratt Institute.

Upon joining Western Union he was assigned to the Research and Engineering Department where his work has been basically on Reperforator Switching Systems for Public Message handling. His more recent achievements include the circuit design and testing of Switching System-Plan 39 and the Circuit Design for the Western Union Data Card Transmitter 11313.

T. J. O'SULLIVAN, Project Engineer, TELEX Division-R & E Department

The TW56-WU TELEX Concentrator

In a nationwide circuit switching network, the extension of services to small cities with only a few customers is usually an economic problem because of the cost of line facilities. The TW56-WU TELEX Concentrator solved this problem in Westner Union's U.S. TELEX Network by providing circuitry for sharing five trunks among twenty customers. The trunks are connected to one of the switching centers of the TELEX Network. Thus, the TW56 reduces the line facilities, required to connect a small city to a switching center, by a factor of four.

Another function of the TW56 is to serve as an interim means of introducing TELEX service in areas of potential growth. When the number of subscribers or customers exceeds the capacity of the TW56, a switching center will replace the concentrator, thus releasing it for another city.

The TW56 In The U. S. Telex Network

Western Union's U.S. TELEX Network is an automatic dial teleprinter exchange system. The TW56-WU TELEX Concentrator is a two-rack unit that serves as a sub-district exchange in the network.

The TW56 is connected to a switching center of the network that serves as a "parent" exchange for the concentrator. In W.U.'s U.S. TELEX Network, these parent exchanges are equipped with either a TWM2 switching system[1,3] or a TW39-WU switching system[2,3]. (The references cited above describe the operation of these systems.)

The TW56 sub-district is the smallest exchange in the U.S. TELEX Network. However, by extending TELEX service to smaller American cities, it allows the network to provide a wide geographical coverage of the United States. Over one hundred American cities are meshed with Western Union's TELEX Network, with seventy cities connected via TW56 Concentrators.

Development Of The TW56

Early concentrators, used in European TELEX Systems, were essentially cut-down versions of the TW39 system. These were wasteful of equipment when used in areas with only a small number of subscribers. Therefore, Siemens and Halske A. G. in co-operation with the German Federal Post designed the TW56 Concentrator to terminate a maximum of twenty subscribers[3].

The Single Rack TW56

The TW56 was a single-rack unit, that connected 20 subscribers over five shared trunks to a parent exchange, where most of the switching was done. When Canada inaugurated its TELEX service in July 1957, a modified TW56 Concentrator was made an integral part of its network[4]. The Canadian TW56 was investigated by Western Union engineers for its possible use in the U.S. TELEX Network. However, additional modifications were required, resulting in a new unit, the Single-Rack TW56-WU, shown in Figure 1.

The Single-Rack TW56-WU

Twenty Single-Rack TW56-WU Concentrators introduced TELEX service to American cities during the initial growth stages of the U.S. TELEX Network. However, a limiting factor in using this concentrator was the number of tariff points. It is necessary to have one tariff point per TELEX exchange in order to properly evaluate the charges for calls to each city in the network. There were only 300 tariff points available in the Single-Rack TW56-WU. This limitation did not accommodate the expanding U.S. TELEX Network. Therefore, a new concentrator was required.

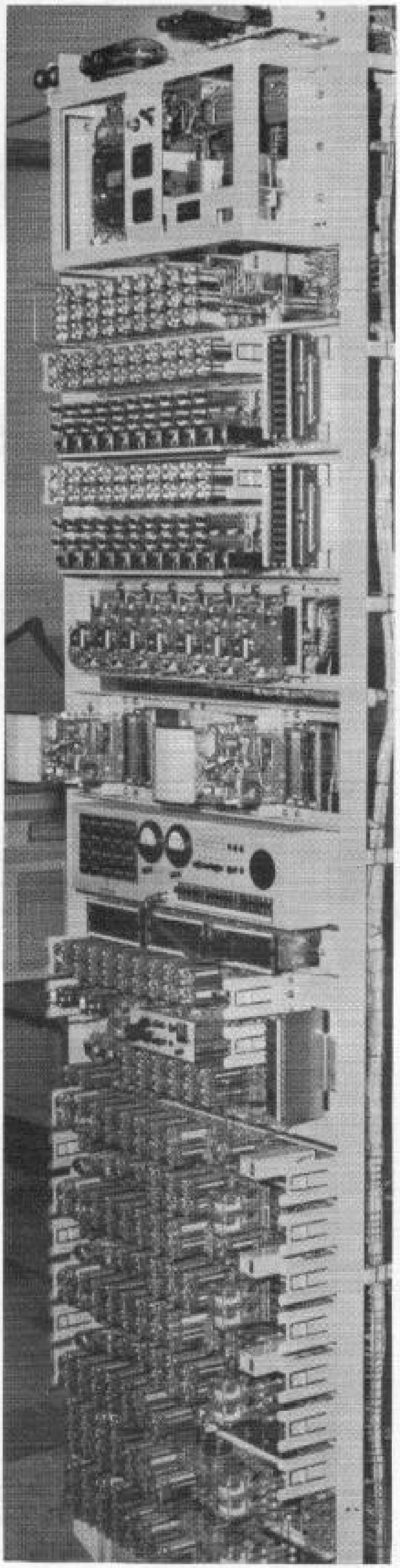


Figure 1. Single-Rack TW56-WU Concentrator

The Two-Rack TW56-WU

Siemens and Halske designed a concentrator to meet the unique needs of Western Union—the Two-Rack TW56-WU TELEX Concentrator shown, in Figure 2. The rack on the left, designated "Rack A," contains the switching circuitry. The rack on the right, designated "Rack B," contains the zoning circuitry. There are 900 tariff points available on the "B" Rack. As with other versions of the TW56, this unit connects 20 subscribers over five shared trunks to a parent exchange. The first two-rack unit was installed in December 1961; installation of these units will continue through 1963.

Functions Of The TW56

There are two main uses for the TW56-WU Concentrator. Its primary function is to provide TELEX service for small cities with less than 20 subscribers. A second function is to serve as the interim means for introducing TELEX service quickly and economically to areas of potentially large subscriber growth. Two outstanding examples of the TW56's latter function were: Phase III of the U.S. TELEX Expansion Program and Western Union International's TELEX Service.

Phase 3—U. S. Telex Program

On May 1, 1961, the third phase of Western Union's TELEX Expansion Program expanded the U.S. TELEX Network to include 23 of America's largest cities. As shown in Figure 3, seventeen of these cities were connected to the network by TW56 Concentrators. The seventeen TW56 cities gave the network a broad geographical coverage which quickly attracted customers.

Automatic, fast and efficient,—TELEX was well received in the TW56 cities. As more customers applied for service, the concentrators were replaced by TW39-WU or TWM2 exchanges. The removed TW56's were then installed in other non-TELEX cities, expanding the network even further.

W. U. International

Overseas TELEX service via W.U. International began in the Summer of 1960,

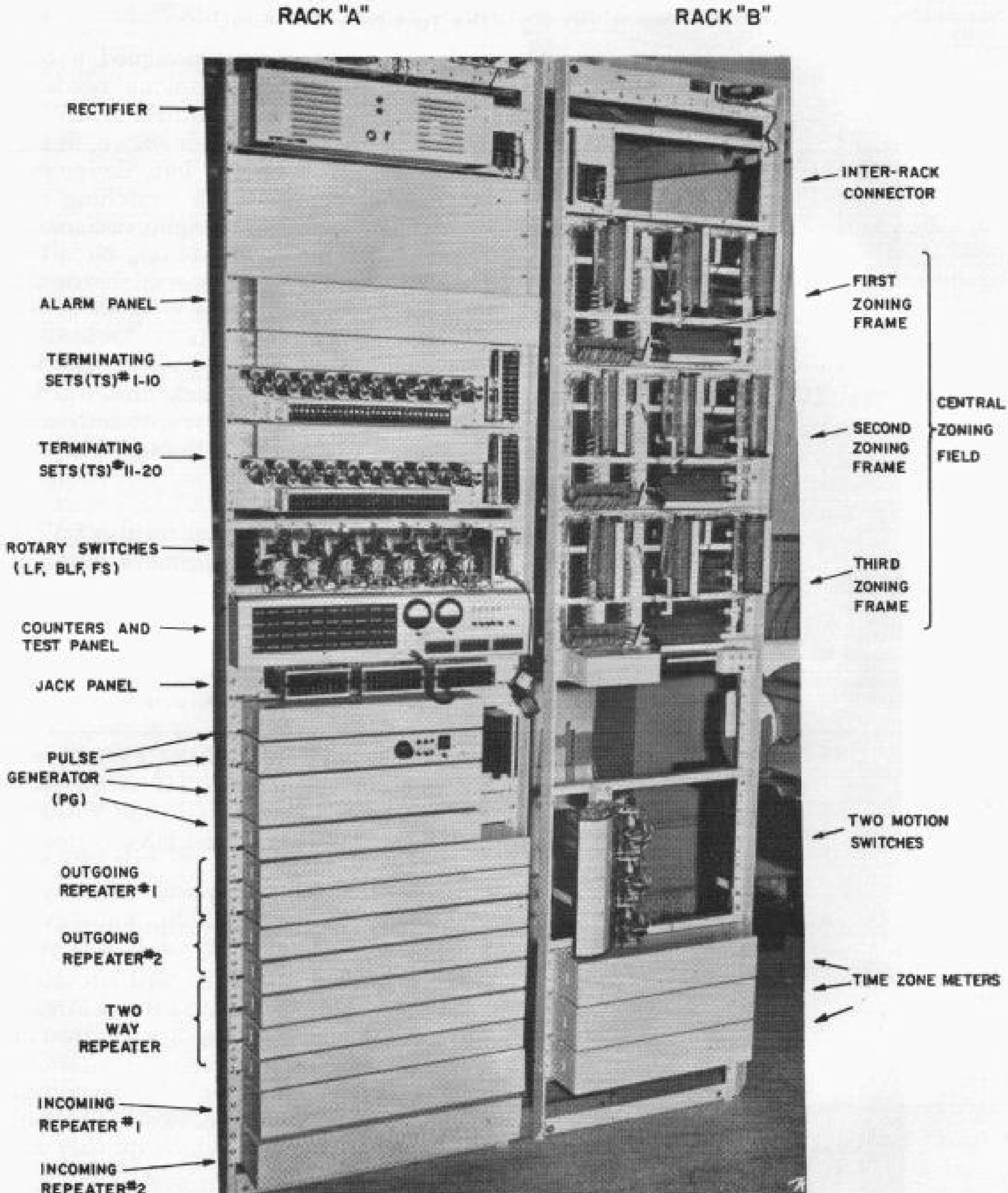


Figure 2. The Two-Rack TW56-WU TELEX Concentrator

when a TW56 was used to switch 20 customers to London and Paris. A second TW56 Concentrator was soon added to increase the switching facilities for international calls. The service proved so popular that the concentrators couldn't handle the load, therefore, they were replaced by a TW39 exchange. In the near future, a TWM exchange will handle this service, first introduced via concentrators.

The TW56 In Telex Systems

The theoretical network, shown in Figure 4, illustrates the functions of the TW56 in TELEX systems. There are four junction exchanges, A, B, C, D, and all the sub districts are TW56 Concentrators. All four junction exchanges are directly connected to one another and every inter-junction call must be routed through these exchanges.

The TW56—A Satellite

The concentrators in Figure 4 are shown connected to both district and junction exchanges. These serve as "parent" exchanges for the concentrators and contain the switching circuitry to route calls to and from concentrator subscribers. Because of this dependence on the parent exchange for switching capability, the concentrator is considered a "satellite" of the exchange to which it is connected.

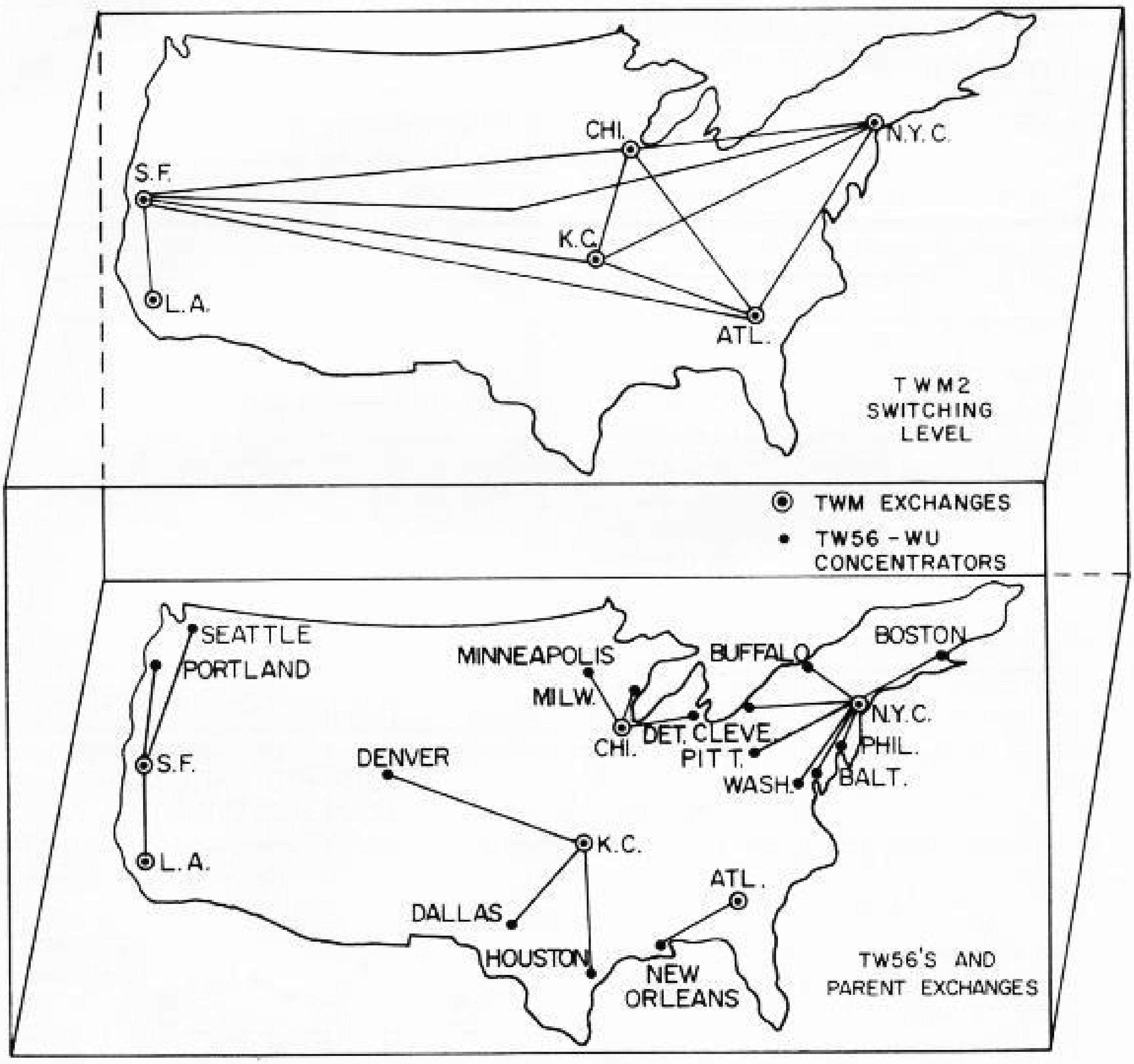


Figure 3. Phase III—May 1, 1962 TELEX Cut-Over

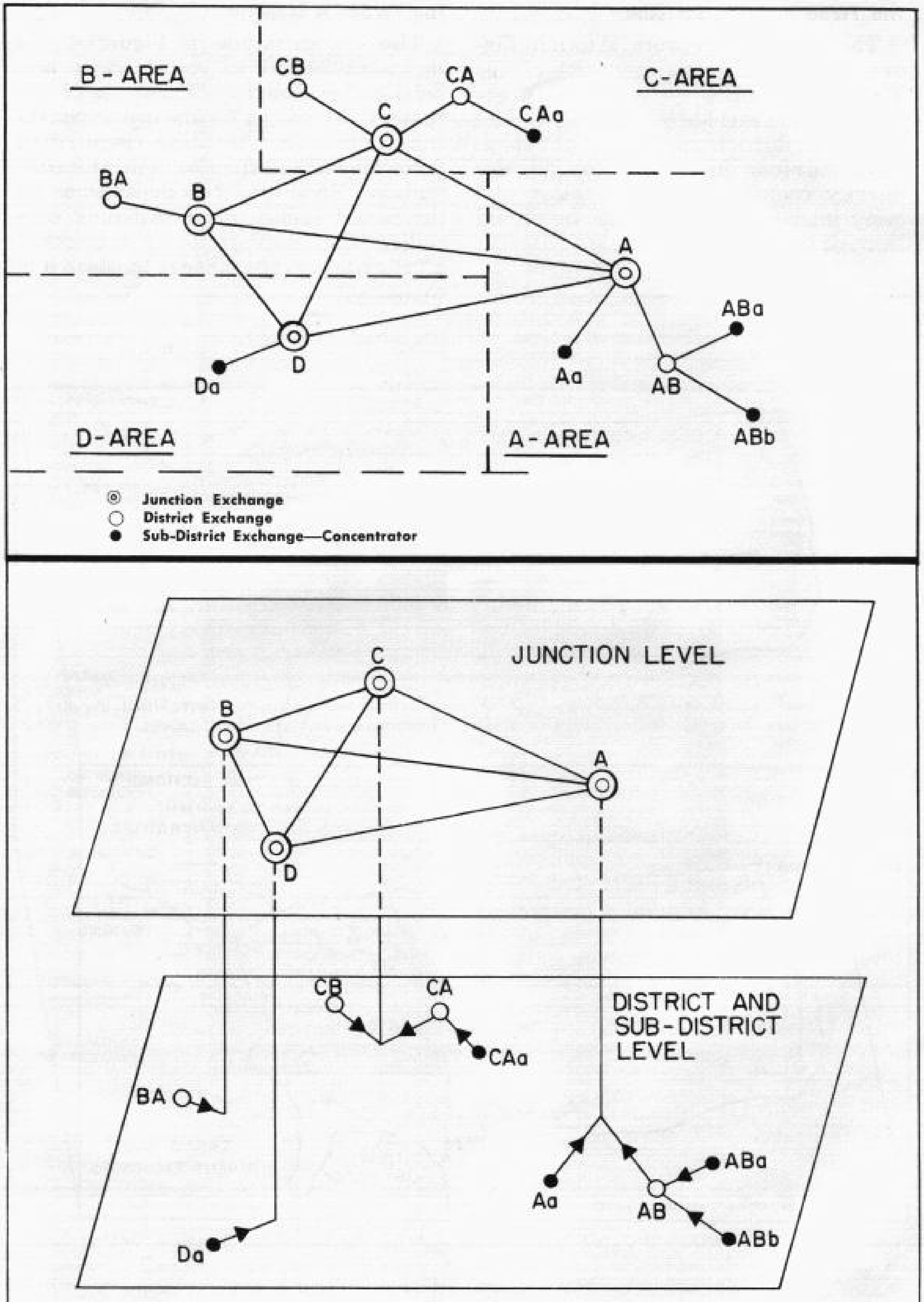


Figure 4. A Theoretical TELEX System

Junction Parent Exchange

As shown in Figure 4, a concentrator is located in city Aa and is directly connected to the junction exchange in city A. All calls from subscribers in city Aa to other TELEX exchanges in the A-Area must be routed into the junction exchange in city A. From there, they are switched to the desired city in the A-Area.

District Parent Exchange

City CAa is an example of a concentrator connected as a sub-district of a district exchange. The district exchange in city CA serves as the parent exchange for the TW56 in city CAa. Calls from CAa subscribers to subscribers in city CA are routed and switched via the CA exchange; such calls are not routed to the junction exchange at city C because they are intra-district calls. All intra-junction calls from CAa subscribers to subscribers outside the CA district are routed through the CA district exchange to the junction exchange in city C. There, the call is either terminated to a subscriber in city C or switched to city CB, depending on the location of the called subscriber.

TW56 Subscribers

The TW56 Concentrator can terminate 20 subscribers. These can be either local or long distance subscribers. Local subscribers are connected via a make-break loop with a current of 60 ma. in the seized condition. Long distance subscribers are connected to the concentrator via two polar legs.

Basically, each subscriber has a TELEX remote control unit (RCU) and a teleprinter. The RCU is used to initiate and disconnect TELEX calls, while the teleprinter records transmission for each call.

Collective Number Subscribers

TW56 subscribers with a large volume of TELEX business can be connected as Collective Number Subcribers. These subscribers have more than one teleprinter with the same TELEX call number. Thus, if a Collective Number subscriber were making a call and an incoming call arrived, it would be connected to a second (or third) teleprinter on his premises. The main function of the additional printer is to receive overflow incoming calls from the first. However, outgoing calls can be made from all printers and each can be dialed individually via its own TELEX call number. This arrangement is very advantageous in large plants.

Description Of TW56 Equipment

The tariff or rate metering circuitry in the Two-Rack TW56-WU TELEX Concentrator is the main difference between this and earlier models. This circuitry is located on Rack B, shown to the right in Figure 2. It consists of three two-motion switches, three time zone meters (TZM's) and a central zoning field, composed of three zoning frames. Rack B is joined electrically to Rack A by three patch cords that connect sockets at the top of each rack.

The concentrator's trunks and subscribers are terminated on Rack A, shown on the left in Figure 2. The twenty TW56 subscribers are divided into two decades. Subscribers 1-10 are connected to the upper panel of Terminating Sets (TS's). Subscribers 11-20 are connected to the lower panel of TS's. Each subscriber has a separate TS. Rack A also contains power, alarm and switching circuitry, plus a Pulse Generator (PG) which supplies timed pulses for alarms and rate metering.

TW56 Trunks

The five TW56 trunks are connected to repeaters on the bottom half of Rack A. Two trunks can be seized only in the inbound direction (from the parent exchange). These are connected to Incoming Repeaters. Two trunks can be seized only in the outbound direction (from TW56 subscribers initiating calls). These are connected to Outgoing Repeaters. The final trunk can be seized in either direction and is connected to the Two-Way Repeater.

Each Outgoing and Two-Way Repeater is associated with a TZM and a two-motion switch (TMS) on Rack B. The TZM and the TMS determine the tariff or rate metering on all calls initiated by TW56 subscribers.

Trunk Versatility

The normal arrangement of two outbound trunks, two inbound trunks and one two-way trunk is not mandatory for the TW56. Each Outgoing Repeater is paired with an Incoming Repeater. Each pair can easily be strapped to form a Two-Way Repeater. Thus, the TW56 can meet limitations on trunking facilities by providing three two-way trunks or one outbound, one inbound and two two-way trunks.

Operation—Outgoing Calls

To initiate a call, a TW56 subscriber depresses the START pushbutton on his remote control unit (RCU). This seizes his Terminating Set (TS) at the concentrator, as shown in Figure 5.

An allotter circuit from the TS looks for an idle outgoing trunk. The allotter attempts to seize Outgoing Repeater No. 1, Outgoing Repeater No. 2, and the Two-Way Repeater in that order. If all three repeaters are tied up with other calls, a busy signal from the Alarm Panel disconnects the calling subscriber.

When the TS seizes a repeater, a line finder rotary switch (LF) associated with the repeater hunts for the calling subscriber. After the LF locates the subscriber, the repeater signals the parent

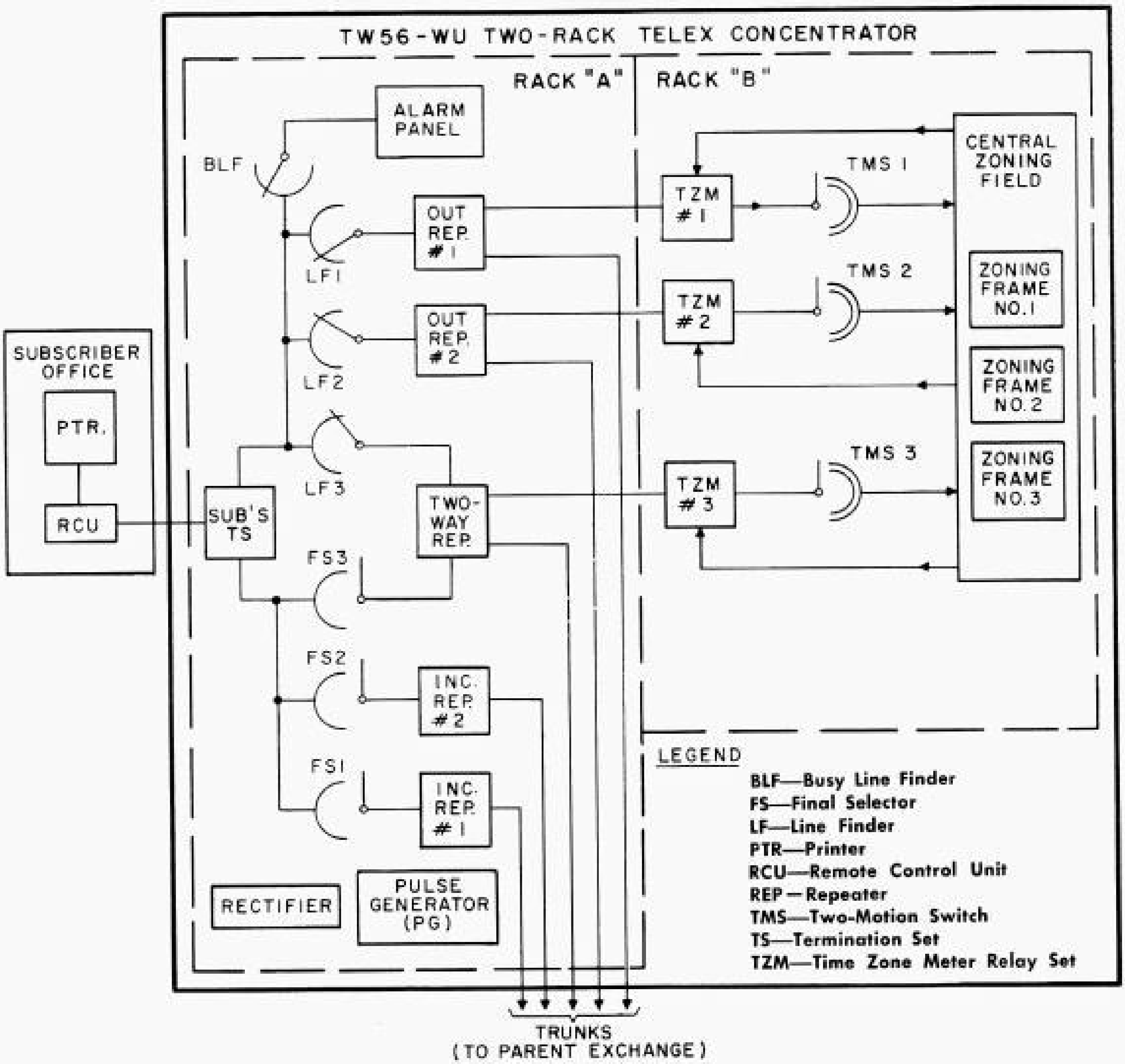


Figure 5. TW56-WU Block Diagram

exchange that a call has been initiated.

Trunk Seizure — Before the repeater had been seized, steady positive battery (Start Polarity) was applied on its send (forward signaling path) and receive (backward signaling path) legs to the parent exchange. When seized, the repeater applies steady negative battery (Stop Polarity) on its send leg. This signals that a call has been initiated and constitutes seizure of the trunk from the TW56 repeater to the parent exchange.

Proceed-to-Dial Signal—A short negative pulse is returned on the repeater's receive leg from the parent exchange. This is a "proceed-to-dial" signal. The repeater sends this to the calling subscriber, indicating that he may dial the TELEX call number desired.

Dialing — A TELEX call number consists of either six or seven digits. Six-digit numbers are shown as "OXXXXX" and seven as "OXXXXXX." (Zero is always the first digit.) When the TW56 is connected to a TW39-WU parent exchange, intra-district calls are designated as "local calls." A TW56 subscriber making a local call dials only the last three digits of a six-digit number, or the last four digits of a seven-digit number. All other calls are treated as "long-distance" calls, requiring the subscriber to dial the full number.

The repeater transmits the dial digits to the parent exchange as polar signals on its send leg. (The dial digits are also received by the Time Zone Meter associated with the repeater. See the section on "Rate Metering.") The call is routed by the parent exchange through the network to the exchange of the called subscriber.

Connection — When the connection is completed, steady negative battery is applied to the receive leg of the TW56 repeater. This is the "call-connected" signal, indicating an established connection to the called subscriber. In turn, the repeater sends a "call-connected" signal to the TW56 subscriber, which turns on his teleprinter.

Communication & Disconnect—As soon as his teleprinter is turned on, the TW56 subscriber can communicate with the called subscriber. This communication is made on a half-duplex basis, i.e. only one subscriber at a time can transmit intelligence. When the call is completed, the connection is terminated by depressing the STOP pushbutton on the RCU. Either the calling or the called subscriber can disconnect the call.

Operation—Incoming Calls

When a long distance call is made to a TW56 subscriber, the first four (OXXX) or five (OXXXX) digits switch the call to the parent exchange. Then the parent exchange applies steady negative battery to the receive leg of an Incoming or Two-Way Repeater. The repeater returns a short negative pulse on its send leg. This is a revertive pulse or trunk checking signal to acknowledge that the repeater is in proper operating condition. The parent exchange then transmits the last two dial digits, identifying the TW56 subscriber being called.

First Digit Received—The first received by the TW56 repeater must be either "1" or "2." This is required because of the TELEX call numbers assigned to concentrator subscribers. The first ten subscribers have a general TELEX call number of "OXXX1X," or "OXXXX1X," depending on whether they have a six or seven-digit number. The second ten subscribers have a number of "OXXX2X" or "OXXXX2X." The first received digit positions the final selector rotary switch (FS) associated with the repeater to the subscriber decade containing the called subscriber.

Second Digit & Communication — The second digit positions the FS to the switch outlet wired to the called subscriber's Terminating Set, thus seizing it. The TS seizes the subscriber's Remote Control

Unit, turning on his teleprinter. A "Call-Connected" signal of steady negative battery is then sent to the parent exchange via the repeater's send leg. Communication between the two subscribers can now begin, similar to that described for outgoing calls.

Rate Metering

A Time Zone Meter (TZM), associated with each outgoing and two-way repeater, determines the rate at which a subscriber is billed for the duration of a call. One of eighteen pulse rates is selected by the TZM and the calling subscriber's pulse rates is recorded or metered on his counter circuitry at the concentrator.

Local Calls

On Local Calls, the TZM evaluates only the first digit dialed by the calling subscriber. This digit will be other than a "O." As shown in Figure 6, the digit is sent to the TZM from its associated repeater. The TZM local-call circuitry determines if the call is a chargeable local call or a free call to a test or information position. "Free" calls cost the subscriber nothing.

A chargeable local call is recognized by the TZM. Evaluation Circuitry and the pulse rate for local calls is selected from the 18 pulse rates supplied from the Pulse Generator. Negative pulses are sent from the TZM via the repeater and a level of the line finder switch, after the repeater receives a "Call-Connected" signal from the "parent" exchange. These pulses activate the subscriber's counter circuitry for the duration of the call. When the call is disconnected, the repeater breaks the connection to the subscriber's pulse circuitry and the TZM is no longer seized by the repeater.

Long Distance Calls

On Long Distance Calls, the TZM evaluates the first four digits dialed by the calling subcriber. The first digit is always "O," identifying this as a long distance call. The second digit of a TELEX call number distinguishes the junction area in which the called subscriber is located. This second digit also indicates one of the two criteria required by the TZM—Evaluation Circuitry for determining the pulse rate applied for a long distance call.

The third digit represents the district area of the called subscriber. The fourth digit represents the called subscriber's sub-district. The 3rd and 4th digits are received by the TZM and position a two-motion switch (TMS), connected to the TZM as shown in Figure 6. No further digits are accepted by the TZM which now attempts to seize the Central Zoning Field.

Central Zoning Field

The Central Zoning Field is accessible to all three TZM's but only one can seize it at a time. It is composed of three zoning frames. Three hundred inputs to each zoning frame are wired, in parallel, to the 300 studs of each two-motion switch. There are 20 gating circuits in each zoning frame.

When the TMS is positioned, its three wipers each rest on a stud. However, the 2nd Digit Evaluation in the TZM selected one of the wipers for the path to seize the Central Zoning Field. As shown in Figure 6, there is now a path from the TZM, via the wiper and stud of the two-motion switch to one input in each zoning frame.

The input is connected through a diode to a program terminal. There are 300 program terminals in each zoning frame and a total of 900 in the entire Central Zoning Field. The program terminals each represent a unique tariff point determined by the first four digits of a TELEX call number. At the time or installation,

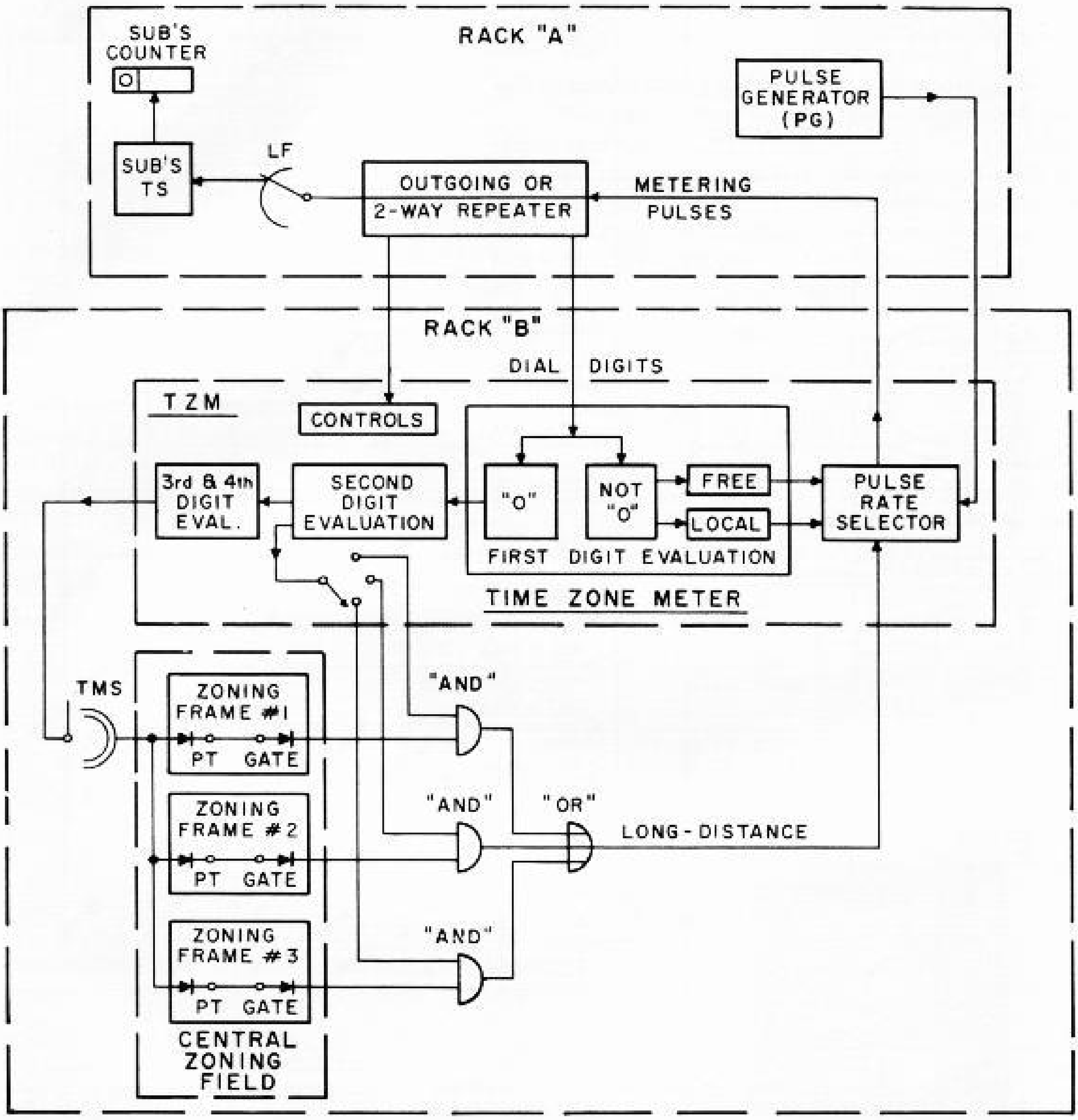
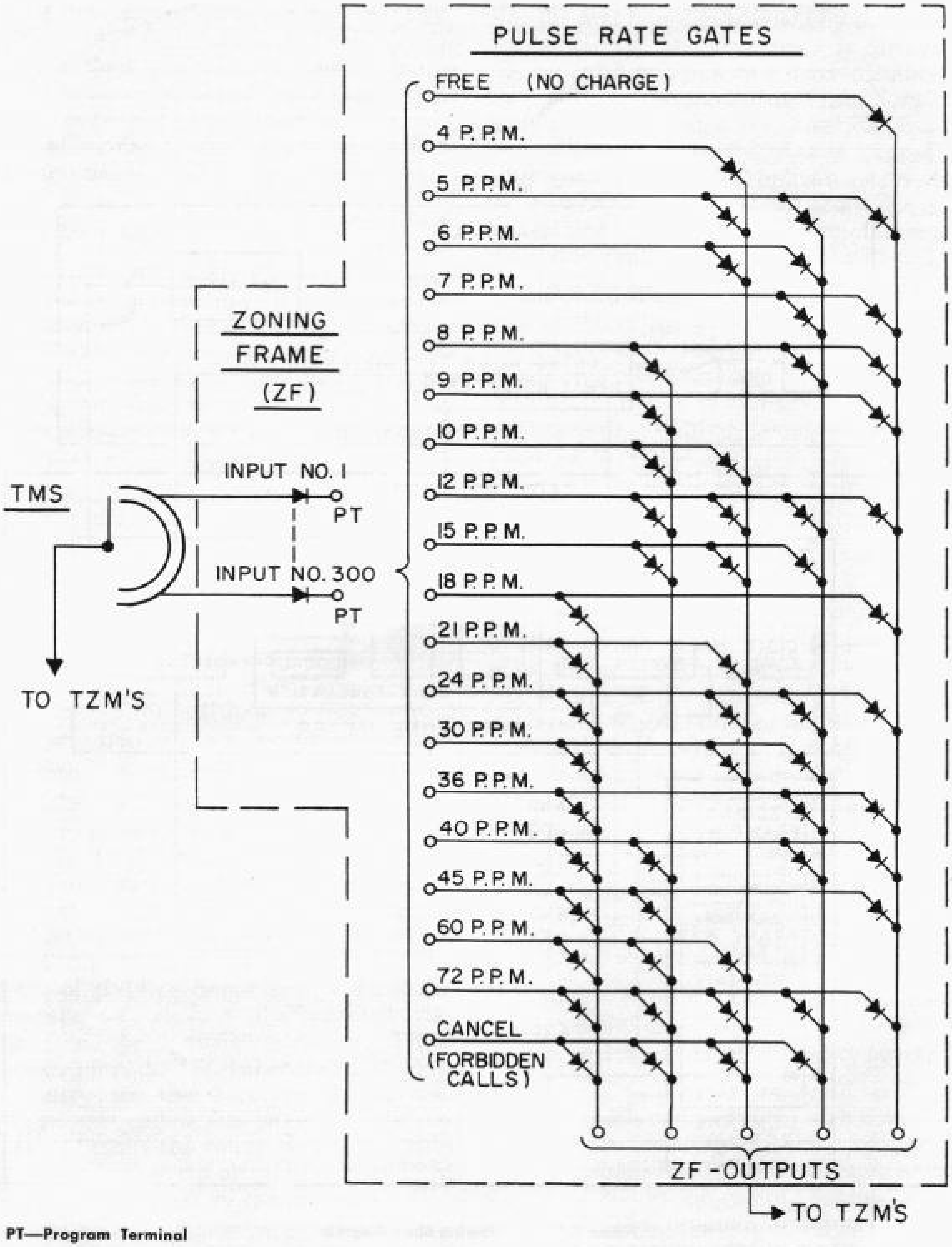


Figure 6. Rate Metering Block Diagram



PT—Program Terminal

Figure 7. Gating Circuits in a Zoning Frame

these terminals were strapped to gating circuits in each zoning frame, as shown in Figure 7, representing 18 different pulse rates, one "free"-call gate and one "forbidden"-call gate for cancelling restricted calls.

When a TZM seizes the Central Zoning Field there are three possible paths through it as shown in Figure 6. The 2nd Digit Evaluation determines which zoning frame supplies the input to the TZM Evaluation Circuitry. This then selects the pulse rate for the call. After the parent exchange sends a "Call-Connected" signal, negative pulses at this rate are sent to the calling subscriber's counter circuitry for the duration of the call just as for local calls.

Tariff Programming

Proper programming of the Central Zoning Field is essential for rate metering in the concentrator. The majority of this programming is accomplished when the TW56 is initially installed. All program terminals are then strapped to the appropriate gating circuits in each zoning frame. As new cities are later added to the network, it is simply a matter of strapping to include them in the tariff program of the TW56.

Conclusion

The TW56-WU TELEX Concentrator links smaller American cities to the district and junction exchanges of Western Union's U. S. TELEX Network. It primarily provides the means of economically meshing cities having up to 19 subscribers into the U. S. Network. It also provides an interim means of introducing TELEX to cities where the potential is expected to eventually require a district or junction exchange.

References

1. "TELEX IN THE U.S.A.," PHILIP R. EASTERLIN, presented at the Winter General Meeting of the AIEE in New York, (W. U. Technical Review, Jan. 1962).
2. "TELEX in New York," PHILIP R. EASTERLIN, AIEE "Transactions Paper 59-37," "Electrical Engineering," July 1959, pp. 742-748. (W.U. Technical Review, Apr. 1959).
3. "Teleprinter Switching," EHRHARD A. ROSSBERG and HELMUT E. KORTA, published by D. Van Nostrand Company, Inc., Princeton, New Jersey.
4. "TELEX—A New Telegraph Service for Canada," C. J. COLUMBO, Canadian Pacific Railway Company CP 57-830, presented at the Summer General Meeting of the AIEE in Montreal, June 1957, (W.U. Technical Review, Jan. 1958).

Mr. T. J. O'Sullivan has been a member of the R&E TELEX Division since its organization in March, 1960. He has been concerned with the applied engineering aspects of the TW56-WU TELEX Concentrator and the tariff circuitry for the TW56 and TW39 TELEX Systems. Prior to that, he assisted in the first Western Union TELEX installation at New York City in 1958.

After joining Western Union in 1955, he was assigned to the Apparatus Engineer's Section. He assisted in the development of regenerative repeaters and small office reperforation equipment and apparatus associated with Reperforator Switching. He also assisted in the development of Switching Systems Plan 55, Plan 57 and Plan 38.

Mr. O'Sullivan received his B.E.E. degree from Manhattan College and is a member of the I.E.E.E.

K. M. Jockers—Senior Project Engineer, TELEX Division-R & E Department

Type 600

Automatic Four-Wire Switching System

An automatic switching system for point-to-point facsimile leases was installed for the National Aeronautics and Space Administration at Marshall Space Flight Center, in the New Orleans Western Union Office, in April 1963. This system, known as the TYPE 600 Automatic Four-Wire Switching System, is a special application of the standard Western Union TELEX TWM2 Equipment. The first exchange in this system links 43 NASA stations in locations such as St. Louis, Detroit, Seattle, Huntsville, Alabama and Cape Canaveral and has been equipped to facilitate rapid growth as needed. The new system is capable of exchanging information between all stations via voice and facsimile as well as data in digital form, at speeds up to 2400 baud.

This is the first automatic, high-speed, "voice-coordinated" exchange network for the rapid transmission of copies of documents, drawings and administrative information between NASA installations. The Western Union system was engineered so that each station may be automatically connected to any other station in the network and can transmit all types of data in digital and facsimile form. Through the alternate voice facility in the system, coordinated discussion of the graphic information is also provided, as shown in Figure 2.

Each year we recognize an increasing demand from government and industry for versatile and reliable highspeed data communications equipment. Recent developments in data terminal equipment and centralized computers prompted Western Union to investigate many ways of fulfilling customer data requirements. One such investigation has led to the use of Western Union TELEX TWM2 equipment in establishing a four-wire data switching ssytem. This system has been designated the Type 600 Automatic Four-Wire Switching System.

Application of TWM2 Equipment

The switching equipment in a TWM2 Exchange uses a motor-driven switch, similar to those employed in the telephone central office equipment. The unique qualities of this switch make possible its application in a four-wire data communications system.

The switch has sixteen wipers, as shown in Figure 1. The first group of eight wipers are physically 180 degrees out of phase with the second group of eight wipers. Since the stator has 56 studs in each level, the switch can be arranged to be an 8-level, 112-point switch. In the TELEX TWM2 exchanges, this switch is electrically arranged to be a 4-level, 224-point switch.

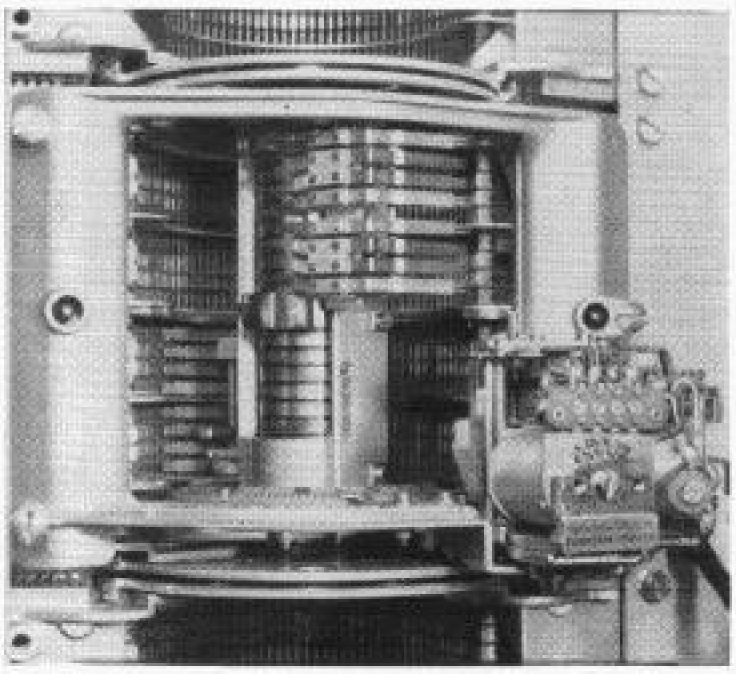


Figure 1. Motor Driven Switch for Four-Wire Data Communications.

While four wipers are being used to designate a single teleprinter circuit path, the other group of four wipers, which are physically in line, are disconnected from another single teleprinter circuit path. In applying this switch to four-wire data communications, four wipers are used to set up the single teleprinter circuit, which henceforth shall be designated the "signalling channel" and the other four wipers, which are in line, are used to simultaneously establish the "data channel."

Four of the eight wipers which are used to establish separate "Signalling" and "Data" channels have two unique qualities. First, they do not wipe over the stator, but are pressed on to the stator studs once the switch has stopped rotating; therefore they are called "press-on" wipers. Second, these wipers are equipped with noble metal contacts, thus making them applicable to low voltage circuits. For these two reasons the press-on wipers are assigned to the "data channel."

The "signalling channel" contains polar relays, and is capable of repeating digital transmission up to 150-baud. This channel uses dial pulse information for establishing a connection, recognizes busy and disconnect signals, and readily lends itself to the transmission of teleprinter signals.

The "data channel" is practically independent of the modulation rate because it is cut through the exchange on a metallic basis without having any external impedance imposed on it. There are many factors that limit the transmission rate through the exchange, such as length of cable runs, shielding, method of routing cables, and the physical spacing between the stator studs and between wiper arms. All these factors can be improved upon in order to obtain the required rate, except the physical spacing between the stator studs and between the wiper arms. However, the spacing between the wiper arms is most critical. Tests conducted at 16 kc have proven satisfactory. Higher transmission rates, although not tested, have been analytically calculated to be in excess of 16 kc.

In general, the simultaneous establishment of the "signalling channel" and the "data channel" in one connection between two subscribers readily lends itself to the use of teleprinter co-ordination of the data transmission on an attended or unattended basis. If required, however, the "signalling channel" may be used only for establishing and maintaining a connection, while the data path is used for alternate voice co-ordinated data.

NASA Requirements

In the latter part of 1962 the National Aeronautics and Space Administration requested Western Union to terminate its point-to-point alternate voice-facsimile leases in an automatic exchange. The rapid expansion of NASA installations has made it necessary to allow transmission of documents, drawings and administrative matters between all subscriber points. NASA also placed a requirement that the exchange be capable of handling data transmission speeds up to 2400 bauds.

Initially, each subscriber's station will be equipped with facsimile transmitter recorder equipment operating at 360 rpm, and a telephone for alternate voice co-ordination, as shown in Figure 2.

These requirements, plus the flexibility required for the expected growth of the NASA Communications System led Western Union to recommend the Type 600 Automatic Four-Wire Switching System.

Figure 2. Out-Station Equipment for Alternate-Voice Coordination.

System Approach

Before going into the specific exchange arrangement provided for NASA, a more general exchange configuration will be described. For clarity, a step-by-step procedure in establishing a connection between two subscribers in different exchanges will be developed.

Figure 3 illustrates a typical two-exchange arrangement of the Type 600 Automatic Four-Wire Switching System. For example, the subscriber "234," from Exchange A, in extending a connection to subscriber "354," from Exchange B, first depresses the "START" button on his Remote Control Unit (RCU). This results in a seizure of his Terminating Set (TS) over the "signalling channel." Seizure of the TS initiates a request for an idle Input Set (VUS) and in turn the VUS requests an idle Dial Code Translator (WU). The seized WU then positions its line finder switch (AS/WU) to the requesting VUS and also the VUS's line finder switch (AS/VUS) to the requesting TS. Upon positioning the AS/VUS, the WU sends a proceed-to-dial signal to subscriber "234," which lights the "Dial" lamp on the RCU. At this time the "signalling channel" is connected to the WU and the "data channel" is extended from the subscriber's Modem (Modulation and Demodulation Unit) over a four-wire voice-band to the wipers of the First Group Selector (IGS).

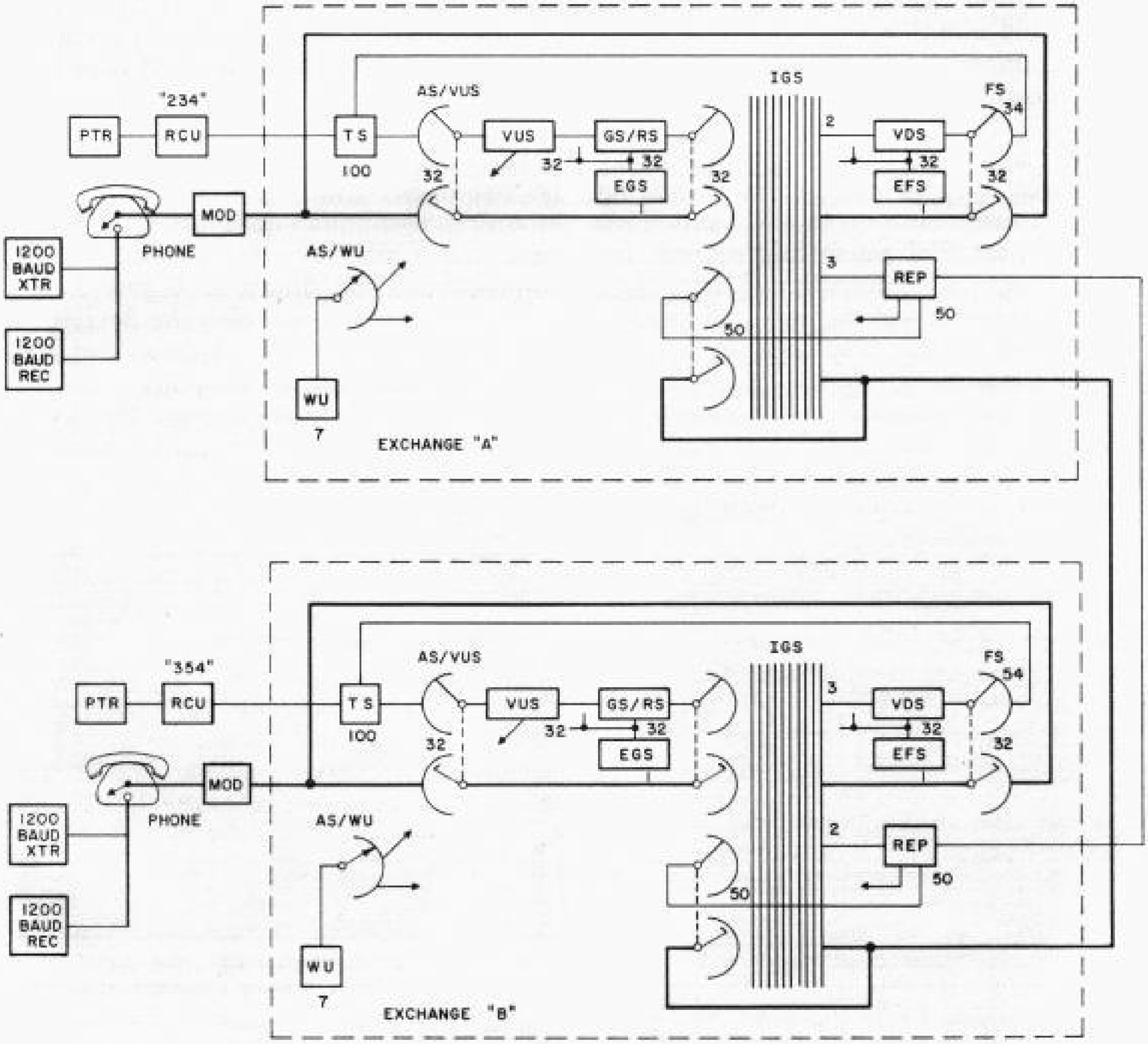


Figure 3. Type 600 Automatic 4-Wire Switching System for Typical Two-Exchange System.

The subscriber now dials the digit, 3, which is received serially by the WU, and stored as a four-unit code by the operated or released combination of four relays.

The VUS is physically connected to a Group Selector Relay Set (GS/RS) and a IGS switch. After the WU has stored the four-unit code representation of the digit, 3, plus the criteria that it is connected to a VUS, the WU seizes a Group Selector Marking Unit (EGS). The four-unit code information is then transferred to the EGS, and the EGS moves the IGS switch to seize an idle output in the third level. When this has been accomplished, the EGS disconnects.

In this case the idle output in the third level is a Two-Way Trunk Repeater (REP). This REP A is connected to a REP in Exchange B over a teleprinter channel; the seizure of REP A causes it to seize the REP B. A return pulse indication signifies that this seizure has been completed, and that the trunk facilities are good in both the send and receive directions.

The REP B now initiates a request for an idle WU in Exchange B, and the seized WU positions its AS/WU to the requesting REP B. The WU recognizes that it is connected to a REP B; therefore it positions the IGS associated with REP B, through an EGS, to an idle output in the 3-level. The WU also sends a return pulse indication to the WU in Exchange A. This signifies to the WU in Exchange A that it should send any stored dial digits, excluding the 3, to the WU in Exchange B and disconnect itself from the circuit. If the the next two dial digits have not been received by the WU in Exchange A, then they will be sent directly from the calling subscriber to the WU in Exchange B.

In Exchange B, the WU recognizes that the IGS has positioned itself to an Output Set (VDS); therefore two digits must be placed into storage before the Final Selector Switch (FS) can be positioned, through a Final Selector Marking Unit (EFS), to the requested TS. When the remaining digits "54" are received and placed in storage, the EFS is seized, and the four-unit code representation of "54" is presented to the EFS for positioning the FS to the proper TS.

On the seizure of the "54" TS, the "CONN" lamp lights up on the called subscriber's RCU, and his teleprinter's motor is turned on. This seizure also results in a signal being sent back to the calling subscriber's RCU, which lights his "CONN" lamp and turns his teleprinter's motor "on."

At this time the calling subscriber's teleprinter is connected to the called subscriber's teleprinter through the "signalling channel." Concurrently, with the setting up of the "signalling channel" the Modem of the calling subscriber is connected on a four-wire voice-band basis through the AS/VUS and IGS, in Exchange A, the IGS and FS in Exchange B, to the called subscriber's Modem.

As indicated in Figure 3, the "data channel" can now be used for data transmission requiring a four-wire voice-band; and the "signalling channel" can be used for simultaneous co-ordination by the teleprinter.

At the conclusion of the transmission, the circuit is released by depressing the "STOP" button on the RCU at either called or calling subscribers' station.

In this general system arrangement it will be noted that certain proportions of units of equipment to the number of subscribers have been indicated. For example, the group of 100 subscribers in Exchange A are equipped with 32 VUS Units; therefore only 32 connections can be initiated from this group of subscribers. This same group of 100 subscribers can receive only 32 calls; this limit is due to the assigned 32 VDS Units. Also, at one given time, only seven calls can be processed through Exchange A, because there are only seven WU's. All these figures are variable, and are strictly dependent upon the traffic load offered to the exchange, the average length of connection, and the grade of service required by the customer. Standard TWM2 traffic evaluation techniques are employed in order to vary the equipment ratio to meet the customer's requirements.

NASA's Present System

The present installation of the Type 600 Automatic Four-Wire Switching System, shown in Figure 4, consists of only one exchange; therefore, the exchange does not require Trunk Repeaters or Group Selectors. Each Input Set (VUS) is connected directly to an Output Set (VDS). The exchange has a subscriber capacity of 50, two Dial Code Translators and fourteen VUS/VDS Units.

The step-by-step procedure in making a connection is identical to the one described for the general system approach with the following exceptions:

After the "proceed-to-dial" signal is sent, the WU recognizes that it is connected to a VUS/VDS Unit; therefore, on the receipt of two dial digits, the FS is positioned to the called subscriber's TS. Also, since there is no teleprinter on the "signalling channel," a lighted "CONN" lamp signifies that the "data channel" has been cut through. The phone can then be used to ring the called subscriber and co-ordinate the transmission of the facsimile copy.

A test position, equipped like the subscriber's station, is also provided at the exchange. This test position is equipped to perform routine facility checks, and to provide immediate subscriber assistance. The facility checks can be made without assistance from the subscriber's station, because in the idle condition the voiceband is "busted back" to the exchange. Also, in the idle condition the subscriber's terminal equipment is "busted back" so that a local check can be made on the performance of the facsimile equipment.

Transmission Features

The "data channels" provided for NASA are normally available voice channels. The key to the ability to operate 360 rpm facsimile over these channels is the principle of vestigial sideband transmission, and the conditioning of the facilities to reduce amplitude and delay distortion.

When a carrier frequency is modulated by a signal frequency, two sidebands are produced, one of them the sum of the carrier and signal frequencies, and the other the difference between the carrier

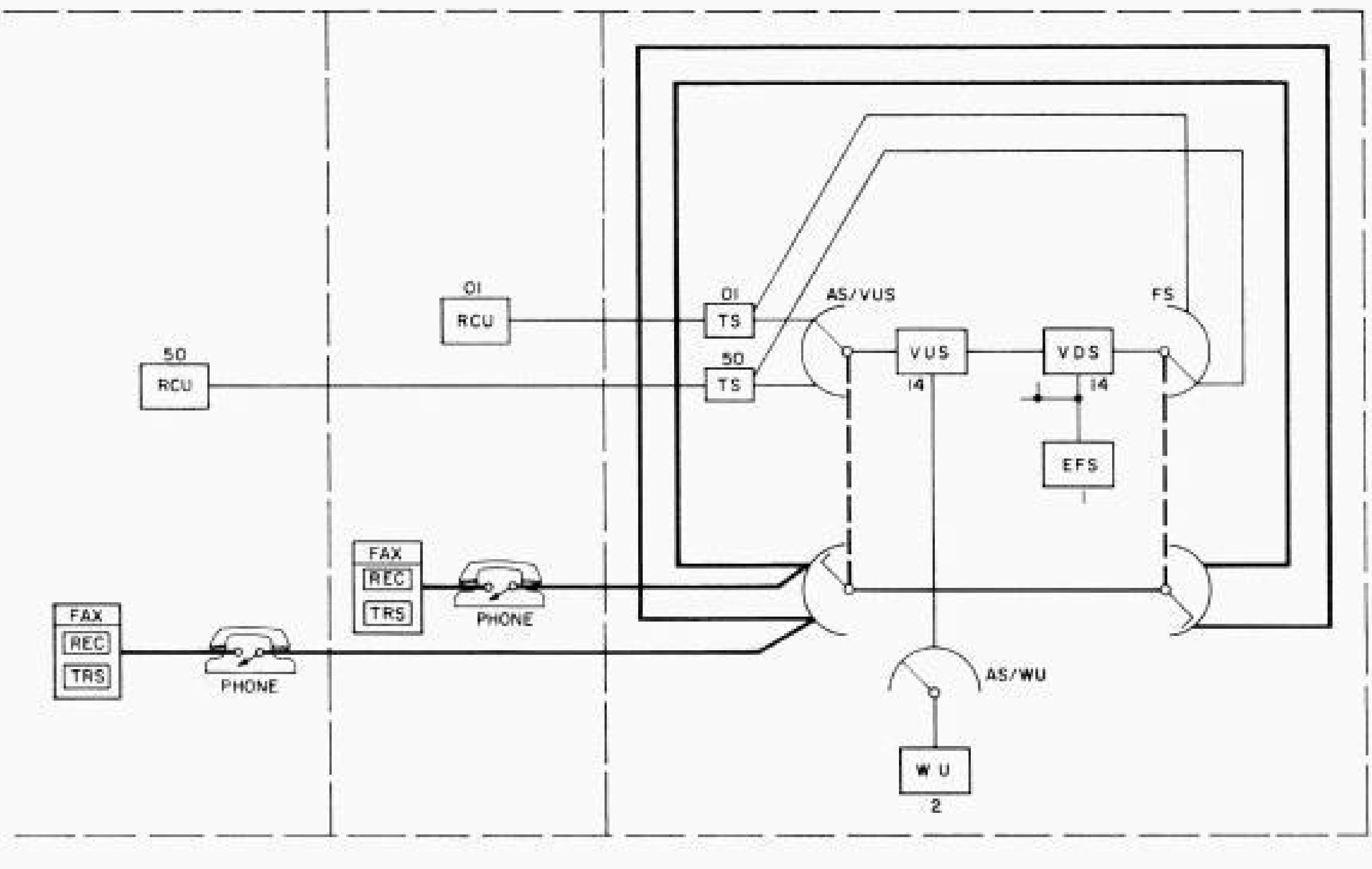


Figure 4. NASA Installation—Single Exchange System.

and signal frequencies. All the information necessary to determine the signal is contained in either of these two sidebands. However, to transmit both sidebands of a 360 rpm facsimile system would require premium facilities of greater band-width than the conventional voice channels. Because of filter design problems, single sideband operation of facsimile circuits is impractical. The vestigial sideband filter associated with each facsimile transmitter permits the transmission of one complete sideband (lower) together with the carrier and a small portion of the other sideband (upper). Although this type of transmission is subject to some loss in copy quality, proper conditioning of the facilities does produce excellent results.

Distortion and Noise Requirement

Facility conditioning for the NASA circuits included equalization for amplitude and delay distortion. All the present outstations are terminated in a single exchange at New Orleans. Provision has been made for additional exchanges. Since any outstation has the capability of being connected with any other outstation in the network such as Seattle to Cape Canaveral, amplitude and delay characteristics of the individual circuits had to be held to very close limits.

Each circuit was equalized for amplitude and delay in each direction between the outstation and the exchange. Because of long loaded cable facilities between some outstations and Western

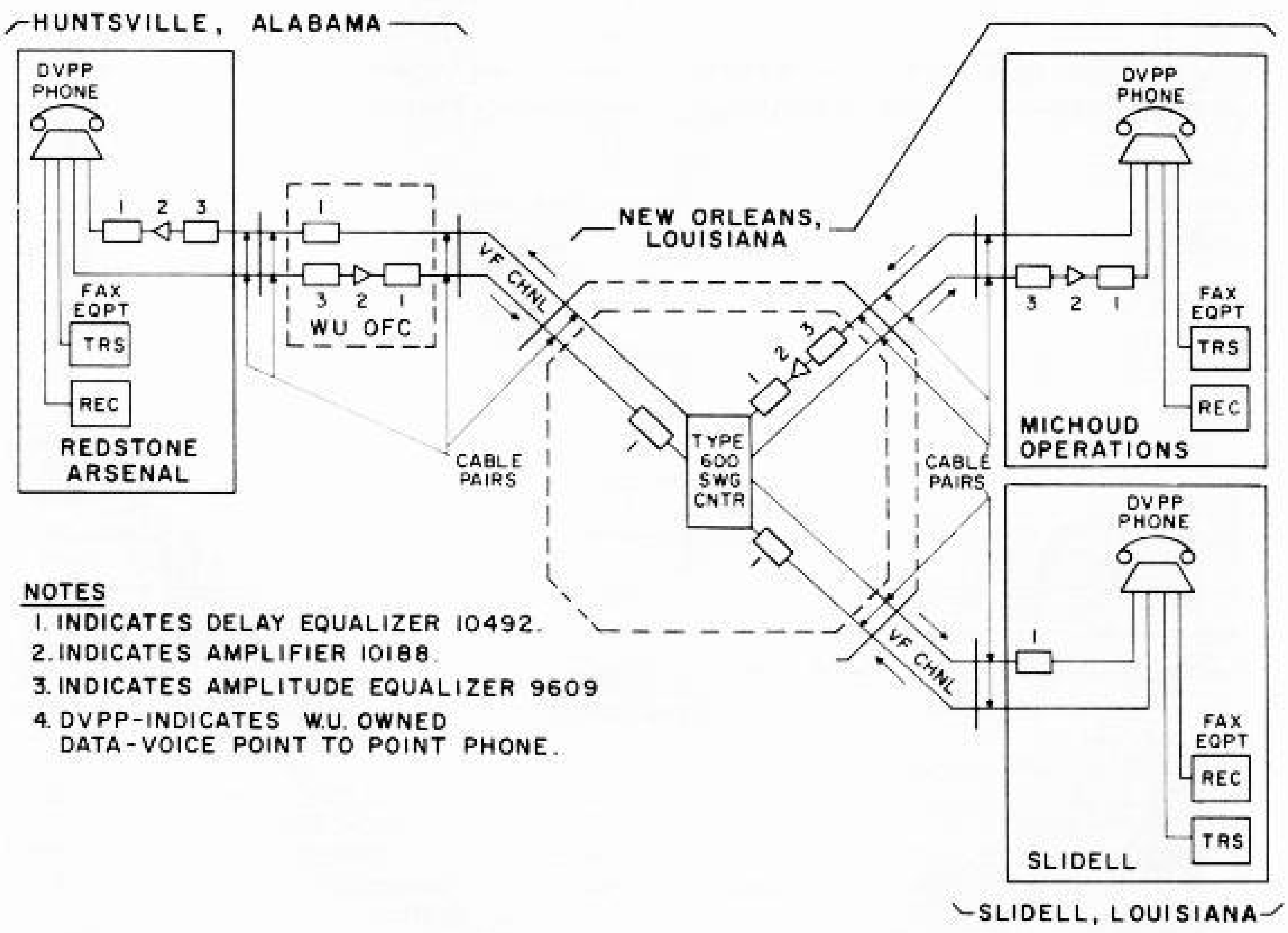


Figure 5. Facility Conditioning Equipment for Three NASA Stations.

Union offices, where the voice channels terminated, it was found necessary to equalize the cable pairs as well as the voice channels. The equalization between each outstation and the exchange was limited to ±1 db between 800 and 3000 cycles per second for amplitude, and to 125 microseconds in the same frequency range for delay distortion. These stringent limits between outstations and the exchange restricts the overall amplitude and delay characteristics on an outstation-to-outstation basis to ±3 db and ±250 microseconds respectively.

Standard Amplitude Equalizers Type 9609, Delay Equalizers Type 10492 and Amplifiers Type 10188 or 8288 were used to condition the cable pairs, and voice grade channels in this network.

Since each circuit is arranged for voice coordination, a signal-to-noise ratio of 40 db was achieved. This is higher than that required for facsimile transmission alone.

Figure 5 illustrates the facility conditioning equipment used for three specific NASA stations, namely Huntsville, Alabama, New Orleans and Slidell, Louisiana.

Summary

The Type 600 Automatic Four-Wire Switching System satisfies NASA's need for a reliable and versatile data communications complex. Several of the 38 stations presently in operation required circuits for 2400-baud magnetic tape transmission, and special subscriber's station arrangements.

The potential NASA data communications expansion will undoubtedly require extensive systems growth and much variation. Since the Type 600 Switching System is an application of standard TWM2 Equipment, and the Plant Department's maintenance and installation personnel are thoroughly trained in the use of this equipment, the future needs of NASA can readily be met.

Acknowledgement

The author wishes to acknowledge the assistance of A. E. Rodgers, Senior Engineer, Transmission Group, for his contributions to this paper. Material for the sections entitled "Transmission Features" and "Distortion and Noise Requirements" were supplied by him.

Kenneth M. Jockers, Senior Project Engineer in the Research and Engineering Department, is presently assigned to the Project Manager—TELEX Division, where he is in charge of a group entitled "Special Switching Arrangements." In this capacity he is concerned with circuit switching system concepts; engineering problems associated with TWM2 Equipment and its application.

Mr. Jockers joined Western Union in 1954 and was assigned to the Patron Systems Engineer. He was involved in the design and development of Data Processing System 201, and the conversion of Plan 51.3 for operation with Plan 55.

In 1955 he was called to active duty for two years as an Officer in the Army's Corps of Engineers.

Upon returning to Western Union in 1959, Mr. Jockers participated in the design, development, installation and testing of Switching Systems 57 and 59. In 1960 he joined the staff of the Project Manager—TELEX.

Mr. Jockers received a Bachelor of Electrical Engineering Degree from The Polytechnic Institute of Brooklyn in 1954.

DISPLAY AT 17th ANNUAL CONVENTION ARMED FORCES COMMUNICATIONS AND ELECTRONIC ASSOCIATION

Two of Western Union's latest advances in tele-communications were shown at the AFCEA Convention in Washington, D.C. on June 4 thru 6, 1963.

The DATA Card Transmitter designed for alpha and numeric data transmission is operated on the left by Mr. R. J. Duswalt of the R&E Department. EDAC, the Error Detection and Control system on the right, is operated by Mr. G. L. McFatter, Operating Department and Mr. Mario Merola (extreme right) of the R&E Department.

Patents Recently Issued to Western Union

Electronic Start-Stop Regenerative Repeater

H. F. Wilder, R. K. Lewis

3,073,898—January 15, 1963

An electronic start-stop regenerative repeater in which receipt of the incoming start pulse releases two oscillators in phase, the frequency of the first being equal to the baud rate and that of the second differing by one cycle per character so that at the end of the character the oscillator outputs are again in phase. The second phase coincidence serves to stop both oscillators in readiness for the next following character. As illustrated, triode LC type oscillators energize respective square wave generators for use in the phase coincidence device, and a polar retransmitting relay is employed.

Vestigial Sideband Transmission

E. S. Grimes

3,083,337—March 26, 1963

A system of neutralizing the normal carrier envelope distortion present in vestigial sideband signals at 100 percent modulation. It is shown that a distorted single side band carrier envelope can be restored to a replica of the initial transmitter double side band envelope by a process of frequency translation, filtering and detection in the course of which the signal is inverted and passed through a compensating vestigial side band filter. It is also developed that the instantaneous sum of three or more higher order voltage vectors introduced in the proper direction of rotation can neutralize the single vector representing the original envelope distortion. In this double vestigial network system, one network at the transmitter and one network at the receiver, the envelope distortion generated by the first network is neutralized by the second network so that the output envelope is a replica of the original double side band envelope at the transmitter. The system is designed to transmit facsimile signals over a voice band at a maximum speed of 2400 cycles on a 2900 cycle carrier.

Automatic Telegraph Switching System

J. E. De Turk, W. G. Brown,
R. J. McReynolds, R. L. Snyder,
L. Fulkerson

3,087,010—April 23, 1963

A stored program controlled electronic switching system comprised of five major units: an input system for converting the different pulse rates of incoming channels to the common high speed internal rate; a storage system including a magnetic drum and supplemental storage for storing in-transit messages and programmed instructions; a message processor for conducting the transfer and processing operations incidental to switching messages cross-office and maintaining a steady flow of messages to the output system; an output system to retransmit the messages at the appropriate line speed rates and select way stations, and a supervisory system for monitoring the operation of the center. A prominent element of the drum is the "precessor" associated respectively with the input and output rate converters for advancing the message material into and out of the storage bins preceding and following the message processor.

Book Review

Optical Character Recognition edited by Fischer, Pollock, Radack and Stevens published by Spartan Books 1962 (412 pages)

This book contains the proceedings of a Symposium on Optical Character Recognition held in Washington during January, 1962. These proceedings include oral presentations, formal papers, or abstracts and discussions made available through the courtesy of authors and panelists.

The Symposium brought together equipment specialists and scientists engaged in research or development in the field to explore, for mutual benefit, the present state of the art of optical character recognition, and implications of current research trends.

Areas covered include, for the most part, descriptions of equipment already delivered or in use. Trends in character recognition research are exemplified by the application of mathematical techniques to determine the invariant features of character patterns which involve large or unusual vocabularies of characters such as handwritten material. Also included are discussions of operational requirements and the need for the development of realistic performance specifications related to techniques that are now available and the need to direct research and development efforts to the meeting of requirements actually encountered in data processing operations.

—R. C. Albert

Western Union Engineers
deliver papers at
Spring Joint Computer Conference

Two engineers from the Research and Engineering Department delivered papers at the 1963 Spring Joint Conference, on May 22, 1963.

The paper entitled "Error Detection Correction and Control," by Mr. Robert Steeneck was based on an article by the same title and author which appeared in the July 1962 issue of the Western Union TECHNICAL REVIEW. Here he amplified the original article and emphasized the fact that transmission faults are not usually the main source of error in land line communications. He also pointed out Western Union's contribution to the art of error detection and control in its development of the EDAC system and the Data Card Transmitter which automates the collection of data at the source. Mr. Steeneck indicated that "as the trend toward automated preparation of data increases and as more computers are made to talk to other computers, there will be more need for error control techniques that are also automatic in their function."

The second paper entitled "Automatic Recording Machine for Telegraph Service" by W. D. Buckingham described the low-cost optical character reader, recently developed at the Water Mill Laboratories. This paper stressed the need for a reader which was compatible with telegraph network speeds. In the past, optical character reader research has emphasized the development of high-speed, costly readers, capable of handling large quantities of information at input speeds required for data processing and computer systems. The Western Union Optical Character Reader, Type 11343-A, automatically reads messages, stored in a magazine, at a rate of 16.2 characters per second, or 162 words per minute. It converts them into five-unit code punched tape form. The message reader, now in the experimental stage, is expected to have wide application in private wire service as well. An article on the Western Union Optical Character Reader is planned for a future issue of the Western Union TECHNICAL REVIEW when the design of the machine is finalized and results of tests are completed.

Printed Circuit Cards
Digital Switching Circuits
Solid State Logic

Gold, M. H.: Standard Circuit Cards for Data Switching Circuits
Western Union TECHNICAL REVIEW, Vol. 17, No. 3 (July 1963). pp 94 to 103

Standardization of printed circuit cards for use in digital switching systems has minimized maintenance costs and reduced obsolescence. Six standard circuit cards designed at Western Union are discussed in this article and some of their applications in component and system design are described.

Switching Systems
Dispatching Techniques
Test Facilities

Duswalt, R. J.: Automatic Switching System—Plan 39 Theory and Design

Western Union TECHNICAL REVIEW, Vol. 17, No. 3 (July 1963). pp 104 to 109

Automatic Switching System Plan 39 was designed to speed up the interchange of test and dispatching traffic at the dispatching center. This article summarizes the requirements of the system, the characteristics of the circuits and the operation of the equipment.

This system permits more efficient use of the dispatcher's function.

Line-Switching
Switching Systems
TELEX

O'Sullivan, T. J.: The TW56-WU TELEX Concentrator

Western Union TECHNICAL REVIEW, Vol. 17, No. 3 (July 1963) pp 110 to 121

The TW56-WU TELEX Concentrator makes it possible to provide TELEX service to small cities having less than 20 subscribers.

This article describes the early development of the unit, its operation and its application in international as well as national circuit switching networks.

Automatic Switching System
Voice Data Facsimile

Jockers, K. M.: Type 600 Automatic Four-Wire Switching System

Western Union TECHNICAL REVIEW, Vol. 17, No. 3 (July 1963) pp 122 to 128

This article describes the installation and operation of the Type 600 Automatic Four-Wire Switching System for the National Aeronautics and Space Administration (NASA). The system is an application of TELEX TWM2 equipment.

This is the first automatic high-speed, voice-coordinated exchange network for rapid transmission of facsimile copies between NASA installations. It's a common-control register type system which is capable of extensive expansion and flexibility.

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