WESTERN UNION
Technical Review

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Telex in New York

Telex *(teleprinter exchange)* services are furnished by telegraph organizations in Europe, Africa, South America and the Far East. Western Union's New York Telex service with Canada has been in operation with direct distance dialing through automatic exchanges for about a year. Now customers in Chicago, San Francisco, Los Angeles and some 40 other cities are scheduled to have this service as rapidly as equipment can be provided.

An automatic dial teleprinter exchange service placed in operation on May 21, 1958 by Western Union, enables its subscribers in New York City to obtain direct send and receive teleprinter connections, in a matter of seconds, to over 1500 subscribers throughout Canada.

Internationally known as "Telex," the exchange in New York is linked by a number of carrier telegraph channels to the Montreal exchange of the Canadian Telex network. The Canadian Telex service, comprising over 100,000 miles of telegraph trunk facilities, was placed in operation in July 1957, jointly by the Canadian Pacific and Canadian National Telegraph Companies and its operation has been described in a previous paper.[1]

The new service also incorporates an automatic answer-back feature which confirms that the proper dial connection has been made and that transmission—even to unattended stations—is being correctly received by the distant teleprinter. The same subscriber equipment also can be used to connect to the Western Union land-line or cable office for sending and receiving public message traffic.

Photo H-2286-A

Figure 1. Telex subscriber set

SUBSCRIBER SET

The Telex subscriber set consists of a console-mounted Type 15 teleprinter and an associated remote control (dial) unit shown in Figure 1. A call is made simply by depressing a start button, dialing a 5- or 6-digit subscriber number, and the connection is made immediately after the last digit has been dialed which is indicated by having the teleprinter motor and an operate lamp turned on. The connection can be terminated from either end by depressing a stop button which turns the equipment off. If the called subscriber is already engaged, a busy signal is returned which cuts the calling subscriber's equipment on for about one second, and then off again.

Answer-Back Feature

The teleprinter keyboard in the subscriber set is equipped with an answer-back unit, a close-up of which is shown in

A paper presented before the Winter General Meeting of the American Institute of Electrical Engineers in New York, N. Y., February 1959.

Figure 2. This device is a cylindrical drum associated with the keyboard which can be coded to transmit an answer-back sequence of 19 characters, 14 of which can be used to identify the subscriber's name and city as listed in the Telex directory.

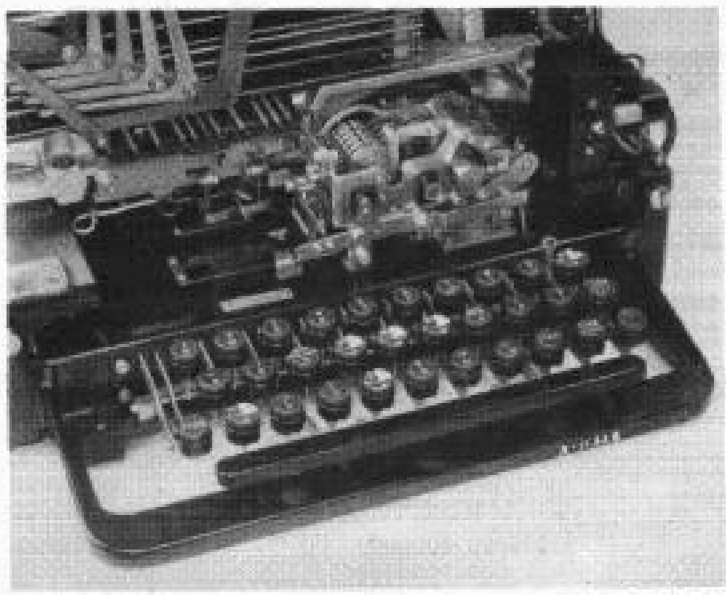


Photo R-11,228

Figure 2. Answer-back unit installed on keyboard of Type 15 Teleprinter

The unit is remotely actuated by the WHO ARE YOU signal (upper-case D) sent from the distant end, or it can be triggered locally by depressing an associated HERE IS key.

In normal operation, the calling subscriber initiates the exchange of answer-back sequences after a dial connection is established by transmitting the WHO ARE YOU signal, receiving the answer-back from the distant teleprinter, and then depressing the HERE IS key to identify himself to the called subscriber. An exchange of answer-backs also may be initiated at any time during transmission to verify continuity in reception or as an over-all acknowledgment just prior to terminating a call. The answer-back, along with a paper-out protective circuit which prevents a connection being made to a subscriber's teleprinter having low paper, provides a high degree of reliability for Telex connections to unattended subscriber stations.

Subscriber Set with Local Tape Function

For Telex subscribers who require the additional operating facility of preparing, transmitting or receiving on a 5-channel perforated tape, a special type of subscriber set is provided. This set, as shown in Figure 3, is equipped with a Siemens Model 100 pageprinter which has a built-in reperforator and transmitter-distributor attachment. A special Type "L" remote control unit is provided which allows the printer equipment to be used in an "off-line" manner for the advance preparation of tape. In the event of an incoming Telex call, the subscriber set is automatically switched "on-line" after a warning signal. Specifically, the set provides the following operation:

1. Off-line operation when idle, enabling keyboard to be used for preparation of tape from reperforator attachment along with a printed monitor copy.
2. After a connection is established, transmission may be from either the keyboard or by tape fed through the transmitter-distributor. Outbound as well as inbound transmission is again recorded on the pageprinter and the reperforator attachment may be used simultaneously to produce another tape.

The pageprinter used in this set also contains a two-color ribbon feature which automatically prints the outgoing transmission from the keyboard and the incoming transmission in different colors. This is very useful when a two-way Telex conversation is later transcribed or read by other parties.

CANADIAN TELEX NETWORK

The layout of the Canadian Telex network and the interconnection to the New York Telex exchange are shown in Figure 4. The network is divided into three areas, centralized around a junction exchange in each area. These are Area 01, Montreal; Area 02, Toronto, and Area 03, Winnipeg. Other exchanges such as New York (015) are designated as district exchanges and are assigned three digits; the first two represent the junction area and the third denotes the district exchange within that area. The subexchange, which is usually in a city nearby to the district exchange, functions as an integral part of its respective district exchange by the assignment of a different fourth digit. For example, 036 designates the Vancouver, B. C., district exchange and 0366 switches a call through to a subexchange located at Victoria, B. C.

Photo R-11,319

Figure 3. Subscriber set with local tape function

Local subscribers connected to the various junction and district exchanges are assigned either 5- or 6-digit dial numbers such as 03-564 for a Winnipeg subscriber or 015-222 for a New York subscriber. The digits on the right side of the dash denote the local number which is dialed to reach another subscriber who is terminated in the same junction or district exchange as the calling subscriber. For long-distance connections—calls to subscribers terminated by other junction or district exchanges—the complete number of digits, i.e., 03-564, must be dialed.

While the Telex exchange equipment used in Canada and New York City employs the step-by-step principle and completes the connection as soon as the last digit has been dialed, it does impose certain restrictions on the routing of calls over trunk circuits. For example, the system does not normally employ registers for storing the dial digits and selecting alternate routes for calls when all trunks are busy or faulted. Therefore, each long-distance call between two exchanges, excluding the subexchange, is given a *predetermined* route through one or more junction exchanges. For example, a New York call to Vancouver is routed New York-Montreal-Winnipeg-Vancouver and could not be passed through an additional Telex exchange such as Montreal-Toronto-Winnipeg, and so forth. Also calls between local subscribers in subexchanges must be handled through the respective district exchange.

HOW A TELEX CONNECTION IS ESTABLISHED

Before describing the technical functions of the switching equipment in the Telex exchange, a description will be given of the various steps which take place

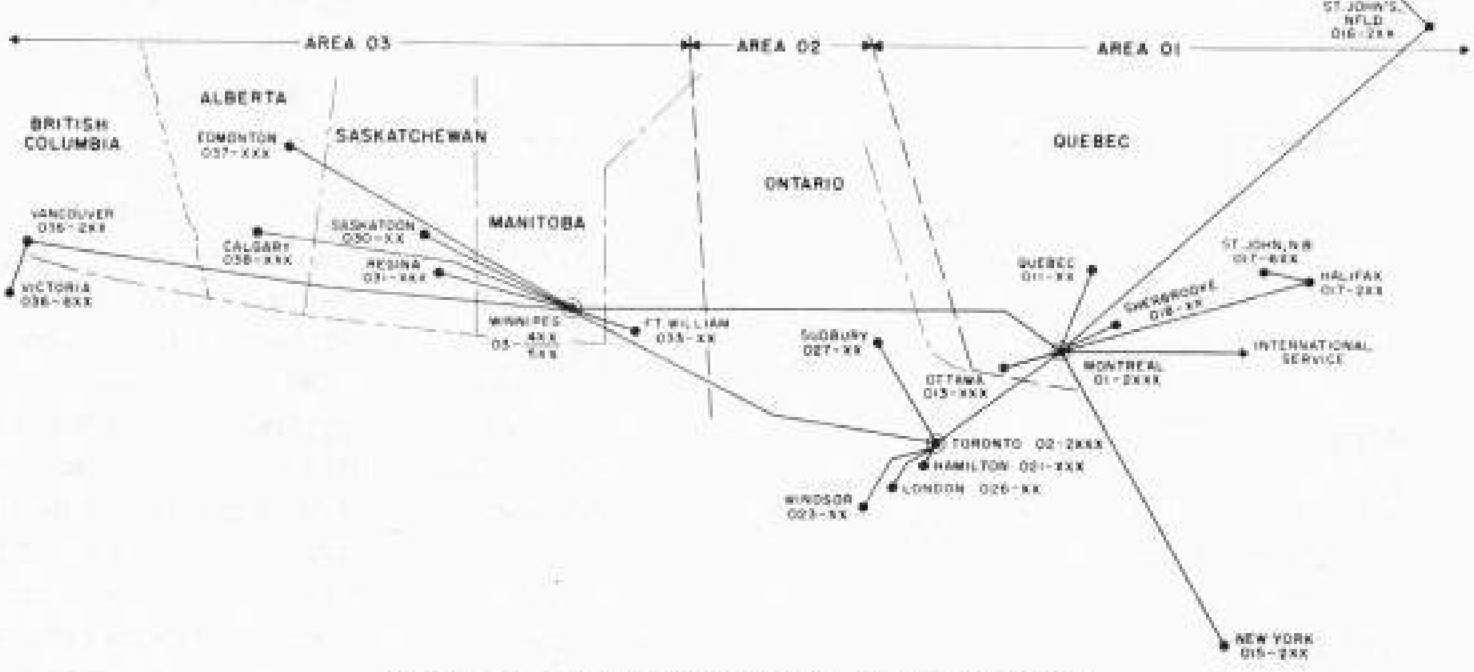


Figure 4. Exchange layout of Canadian Telex network

in establishing a long-distance Telex connection. A typical call would be where a New York subscriber dials 036-292 to reach a subscriber in Vancouver, B. C. The connection through the group selector switches and repeater equipment in the various Telex exchanges for such a call is illustrated in simplified form in Figure 5.

When not in use, the teleprinter motor in the subscriber set is turned off and the dial on the remote control unit is locked. To initiate a call, the New York subscriber depresses a start button which causes the subscriber's preselector switch in the Telex exchange to seize an idle group selector switch. Almost instantly, the exchange equipment returns a go-ahead dial signal to the subscriber, unlocking the dial and bringing up a white

tends the circuit in a similar manner from Winnipeg to Vancouver. The last three digits, 292, are utilized in the Vancouver exchange to set the group selector and final selector switches to the called subscriber.

Upon completion of the connection—requiring about seven or eight seconds—the teleprinter motor and a red operate lamp on the Vancouver subscriber set are turned on. As this occurs, a free-line signal is returned to the New York subscriber, also turning on the teleprinter motor and operate lamp to indicate that a connection has been established.

At this time an exchange of answer-back codes is initiated by the *calling* (New York) subscriber to insure that the proper automatic connection has been made and

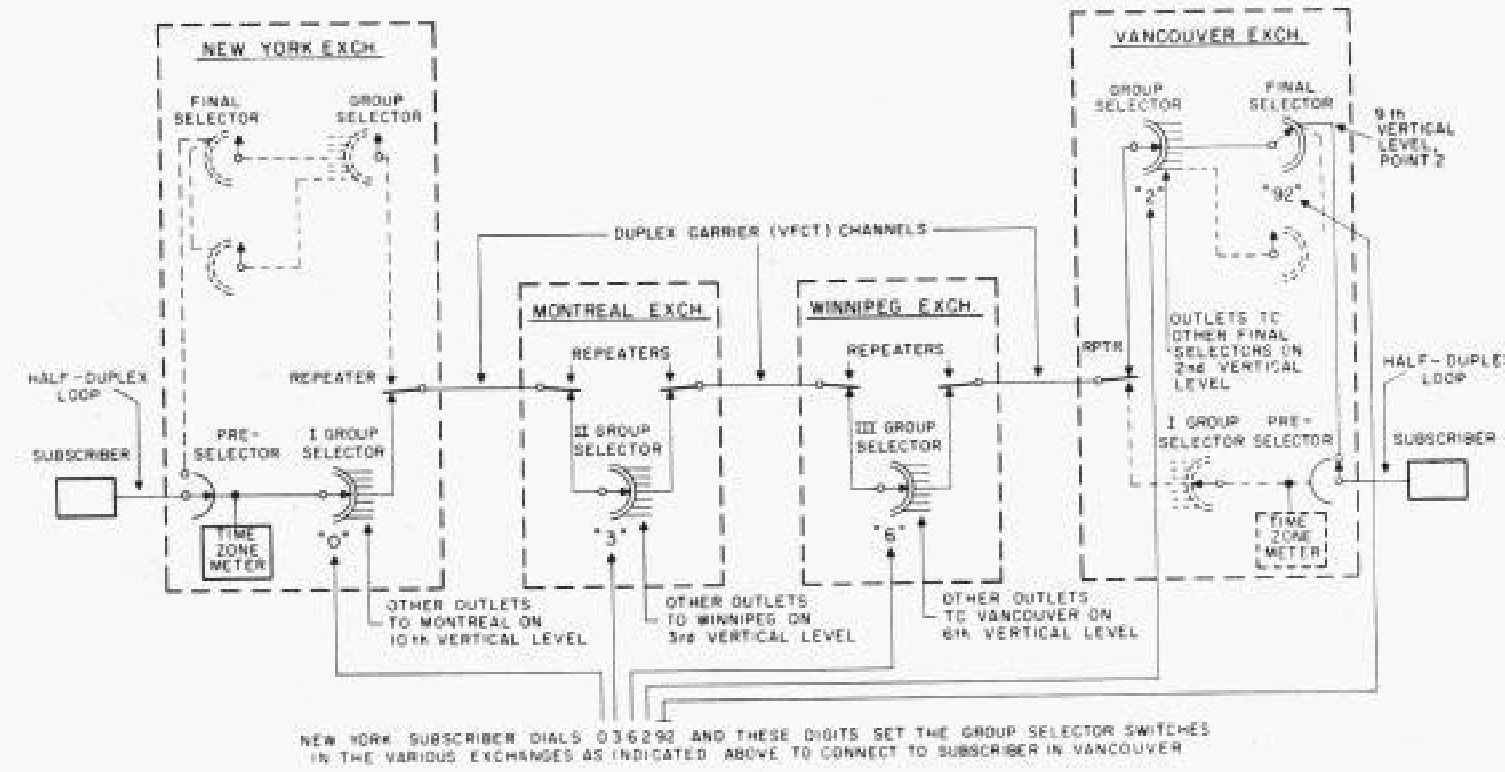


Figure 5. Build-up of connection through several Telex exchanges

visual indicator on the remote control unit.

The subscriber dials 036-292. While these digits are being dialed, the circuit is progressively built up through the various exchanges to Vancouver. For example, 0 causes the first group selector switch in the New York exchange to select a trunk to Montreal; 3 actuates the second group selector switch in the Montreal exchange to route the call to Winnipeg, and 6 ex-

that the *called* (Vancouver) subscriber's teleprinter is functioning properly. Below is a typical operating sequence which shows how the answer-back feature is used at the beginning and end of a Telex connection. Shown in parentheses are the control character which triggers the distant subscriber's answer-back unit, and the symbols for the teleprinter nonprinting functions, i.e., ← carriage return, ≡ line feed, ↑ figure shift, ↓ unshift.

Description of Operating Sequence		Characters Received by Both Teleprinters
WHO ARE YOU (Sent by calling sub)	(↑D)	
ANSWER-BACK (Sent automatically by called sub)	(←≡↓)	SCOTIA BANK VCR (←≡)
HERE IS (Sent by calling sub)	(←≡↓)	CHASE BANK NYK (←≡)
(Telex message or two-way teleprinter conversation)		
WHO ARE YOU (Sent by calling sub prior to disconnecting)	(↑D)	
ACKNOWLEDGMENT (Sent automatically by called sub)	(←≡↓)	SCOTIA BANK VCR (←≡)

Without respect to the originator of a Telex call, the subscriber at either end of the circuit may terminate the connection at any time by depressing the stop key on the remote control unit. When this occurs, the trunk circuits through the several exchanges are released sequentially, beginning at the exchange of the originating or calling subscriber. This turns off the teleprinter motor and operate lamp on both subscriber sets, making them available for initiating or receiving other connections.

Busy Signal

When a subscriber is dialed who is already engaged in a connection, a busy signal will be returned which momentarily turns on and off the teleprinter motor and operate lamp of the calling subscriber and relocks the dial. Also a subscriber may receive a busy signal before completing the dialing sequence when trunk circuits are busy or faulted between two exchanges. By dialing more slowly than normal, it is possible to identify the blocked trunk section. For example, if a busy signal is returned after the first three digits 036 have been dialed, it would indicate a shortage of trunk facilities between Winnipeg and Vancouver, and so forth.

Subscriber Set Out Of Service

If a subscriber is dialed whose equipment or connection to the exchange is faulted—or where the paper roll is too low and needs replacing—neither a busy (which could be misleading) nor a free-line signal is returned and therefore the subscriber set receives no response to the dial sequence. In such cases the calling subscriber is requested to depress the stop key, which cancels the call and recycles the dial unit, enabling him to redial and report the difficulty to supervisory personnel. If the call is not cancelled in this manner, the trunk circuits involved are automatically released after a short period of time.

PUBLIC MESSAGES OVER TELEX

The exchange equipment is arranged so that Telex subscribers can make free calls to the Western Union land-line or cable tie-line sections to send or receive public message traffic. As such connections are established, the subscriber or Western Union initiates an exchange of answer-back codes by following the regular Telex operating procedure. This speeds up the movement of message traffic by eliminating the delay in obtaining acknowledgments.

By dialing 1 or 3, New York subscribers are connected automatically either to one of a group of page receiving-only positions in the land-line tie-line section at 60 Hudson Street, or to similar positions in the new Western Union cable office located at 26 Broadway, New York. The Western Union teleprinters are coded with the WHO ARE YOU following the Telegraph Company answer-back sequence. Therefore, as a subscriber calls in and obtains the Western Union answer-back, his answer-back unit is also triggered automatically to identify the calling subscriber.

Messages or cablegrams destined to the local Telex subscribers are handled from a group of sending-only positions in the tie-line sections of the two Western Union offices. These positions also are equipped with a remote control dial box unit and the operator simply dials the subscriber's number, obtains an answer-back before and after transmission of each message series, and then disconnects.

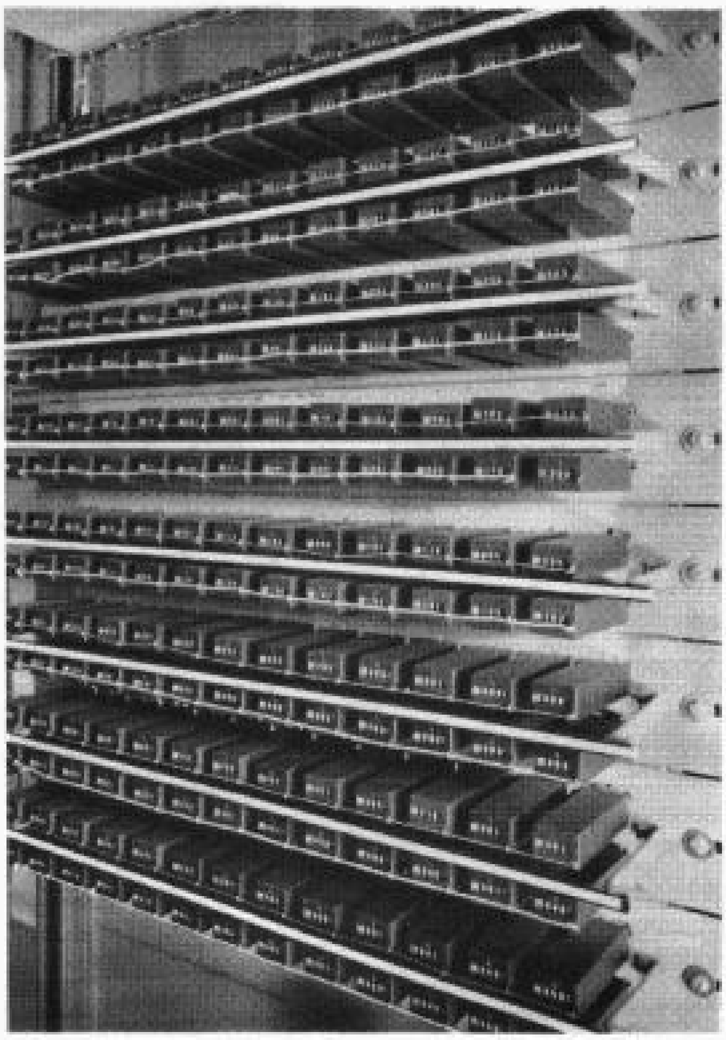


Photo R-11,309

Figure 6. Connection (top) and pulse rate (bottom) counters for New York subscribers

INFORMATION CENTER

An Information Center is located in the tie-line section at 60 Hudson Street which New York subscribers can reach by dialing 9. This center communicates with other information centers in the Canadian exchanges to provide subscribers with current additions or changes in the Telex directory and to exercise general supervisory control over Telex network operations. Canadian exchanges may connect to the New York Information Center by dialing 015-9.

TELEX CHARGES

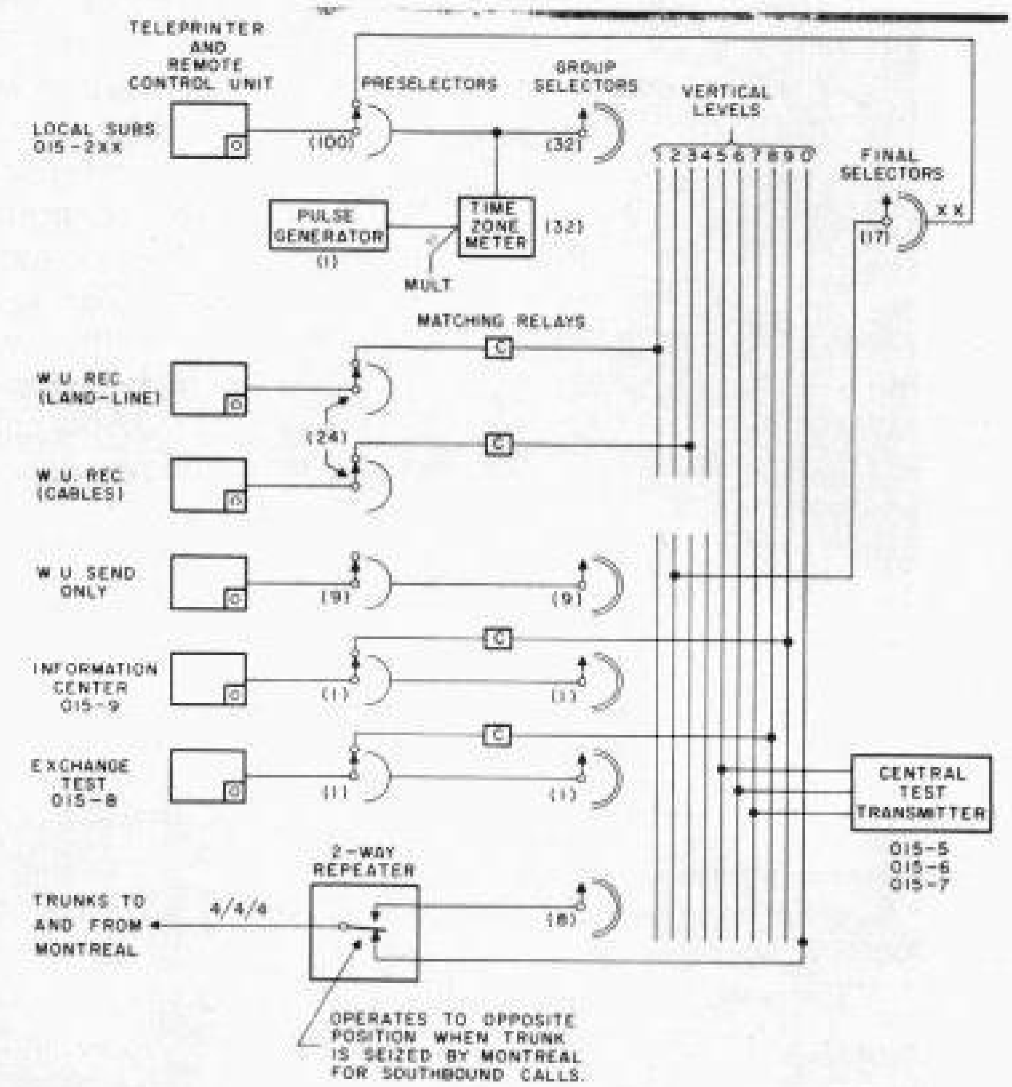
There is no minimum time charge for individual Telex calls between New York City and Canadian subscribers. Instead, there is a flat connection charge of 50 cents for each completed call, plus a particular pulse rate—based on airline mileage—which is applied for the actual time the connection is held intact. The pulse rate, having no relation to the telegraph transmission speed, is expressed in P.P.M. (pulses per minute) and the charge for each pulse is 2-1/2 cents. In addition, there is a $35.00 monthly charge for the subscriber equipment. There is no charge for calls to Western Union other than the regular rate for telegrams or cablegrams.

For example, a pulse rate of 15 P.P.M. is applied for a New York City-Montreal call and 30 P.P.M. for a New York City-Vancouver, B. C., call. Therefore, the connection and pulse rate charge for a 1-minute New York City-Montreal call is $50¢ + (15 \times 2\text{-}1/2¢)$ or 87-1/2¢; for the New York City-Vancouver call it would be $50¢ + (30 \times 2\text{-}1/2¢)$ or $1.25. If these calls were held for a 2-minute period, the charges would be $1.25 and $2.00, respectively. The connection and pulse rate charges are assessed to the calling subscriber on two 5-digit counters individual to each subscriber line and are shown in Figure 6.

TELEX EXCHANGE OPERATION

New York, as well as the exchanges in Canada, is equipped with the Siemens and Halske Company's Type TW-39 automatic teleprinter exchange system, manufactured in Munich, Germany. This system is specially designed for teleprinter exchange service and uses a number of equivalent telephone exchange components such as subscriber bars, preselectors, group selectors, final selectors, repeaters, and so forth.

A simplified theory of the New York exchange layout is shown in Figure 7. The operation of the exchange equipment will be covered by describing the functions which occur for setting up the typical New York City to Vancouver call, previously used in the brief explanation of how a Telex connection is established. The description for a northbound call, outgoing from New York and incoming at Vancouver, also will be typical of southbound calls from various Canadian exchanges to New York City. Photographs of the exchange equipment units also will be referred to at appropriate points throughout the discussion. The multiple wiring and grouping arrangement of the equipment is not essential to a preliminary understanding of the exchange operation and is discussed later.



Note—Figures in parentheses denote the number of exchange units of each type

Figure 7. Theory of New York Telex exchange

Preselectors

Figure 8 shows a group of preselector racks where the loop from each subscriber is terminated. Each subscriber's preselector consists of control equipment located in a subscriber bar and an associated preselector (stepping) switch capable of connecting to any one of ten GS/TZM's (group selectors/time zone meters). Each of the first three preselector racks accommodates 40 local subscribers (or Western Union tie-line positions) which are operated on a loop basis using make-break signalling. A different type of preselector rack, serving 20 long-distance subscribers, has additional control equipment for operating 2-wire polar over physical or carrier facilities for longer distances. In the latter case a d-c converter panel is required at the terminal of the distant subscriber to provide an equivalent termination between the line facilities and the conventional subscriber loop.

When the subscriber's set is idle, a current of about five ma (milliamperes) flows in the loop in a direction to keep the teleprinter motor cut off and the subscriber's remote control (dial) unit locked. As a subscriber initiates a call by depressing the start button on the remote control unit—equivalent to removing a telephone from the hook—the current in the loop is increased to 60 ma. This causes the subscriber's 11-point preselector switch in the exchange to leave its home position and seek connection to any one of ten GS/TZM's which may be idle. If all

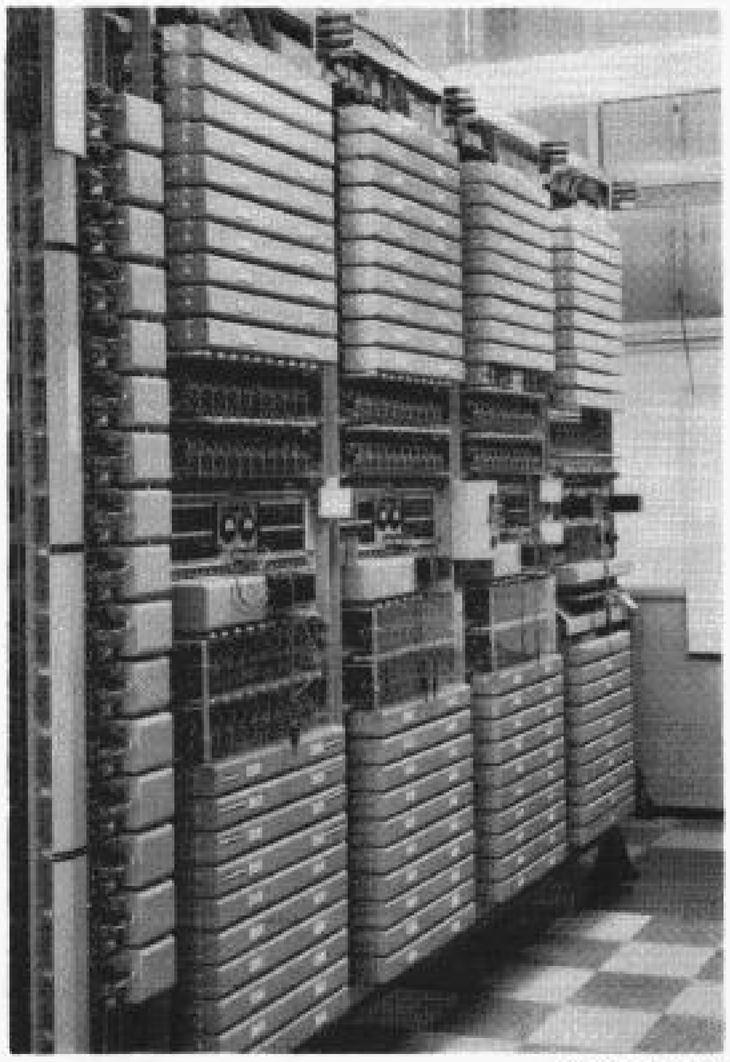


Photo R-11,310

Figure 8. Left to right, one rack of 20 final selectors, three racks of 40 local preselectors and one rack of 20 long-distance preselectors

ten of these units are in use, the preselector switch steps to the 11th point, returns a busy signal to the subscriber, and then restores to its home position.

Group Selector/Time Zone Meter

The New York exchange is equipped with 32 GS/TZM's and Figure 9 shows five of these units per rack, with the group selectors located in the upper section and the five associated time zone meter units mounted below. The group selector is a two-motion decade type (stepping) switch with associated relay controls and the switch, having ten vertical levels (rows) and ten rotary points in each level, provides 100 outlets for three circuits designated as SEND, RECEIVE and TEST, the latter being used for control purposes.

The associated time zone meter is for the purpose of recording, by means of two stepping switches and associated relay controls, the first four dial digits, or less, in order to apply the proper charge for each call. In doing so, the proper metering pulse rate conductor, i.e., 15, 18, 30 P.P.M., is picked up from the pulse generator rack shown in Figure 10 and is passed back over a separate conductor through the preselector switch to the subscriber's two individual connection and pulse rate counters. After the dialing sequence and when a free-line signal has been given to the calling subscriber which indicates a completed call, both counters are stepped on a prepulse and thereafter only the pulse rate counter responds to the metering pulses obtained from the pulse generator rack. The TZM can be strapped to cancel and return a busy signal on certain calls which are to be rejected for special reasons. Also calls to the tie-line or information positions at Western Union are recognized by this unit as free calls, for which neither counter is allowed to operate.

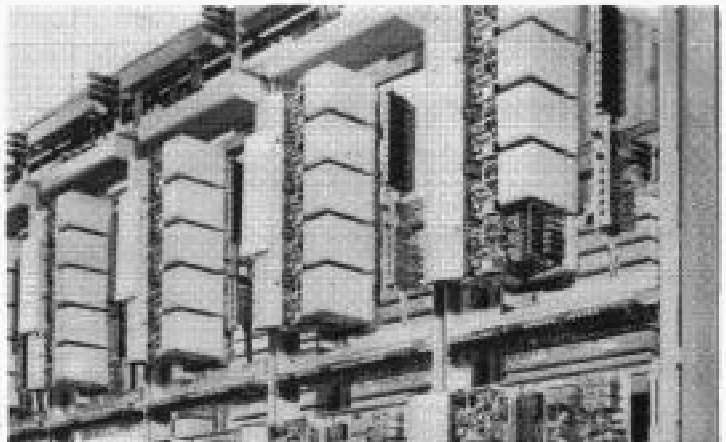


Photo R-11,311

Figure 9. Group selectors/time zone meters

When the subscriber's preselector switch has made connection with an idle GS/TZM—which is almost simultaneous with the release of the start button, a go-ahead dial signal is returned to the subscriber set. This signal is an interruption in the subscriber's loop current for about 25 ms which unlocks the dial unit and brings up a white visual indicator on the remote control unit, providing an indication that dialing can begin.

As the subscriber begins the dialing sequence, the group selector switch in the GS/TZM is operated by the dial pulses of the first digit, which for a long-distance call would be 0, to the 10th level. The switch then free-hunts or self-steps horizontally over the ten rotary points on this level and stops on the first idle point corresponding to an outgoing or two-way trunk repeater to the Montreal exchange. A busy signal also will be returned to the subscriber at this point if all available trunk circuits are in use. Between the dialing time of the first and second digits, the trunk circuit to Montreal is tested by means of a revertive pulse which is described in the following paragraphs on the Telex trunk repeaters.

Telex Trunk Repeaters

The 12 trunk circuits which connect to the Montreal exchange are terminated in three types of repeaters designated as outgoing, two-way and incoming, which are located on a rack shown in Figure 10. The three types of repeaters permit the trunk circuits to Montreal to be operated on a 4/4/4 basis, which denotes the outgoing, two-way and incoming seizure priority for establishing a Telex connection. For example, the four outgoing trunk circuits may be seized only for northbound calls; the four two-way circuits for calls in either direction, and the four incoming circuits for southbound calls only. A jack field with associated controls for testing individual trunk circuits is located in the center of the rack.

In addition to the switching controls for seizure of the trunk circuit, each repeater contains two polar telegraph relays which repeat the telegraph signals and dial pulses on a 2-wire polar basis between similar telegraph relays in the subscriber's preselector located in the exchange and the sending and receiving legs of the carrier channel terminal equipment. When a trunk circuit is unseized, the spacing (positive) polarity is applied in both directions.

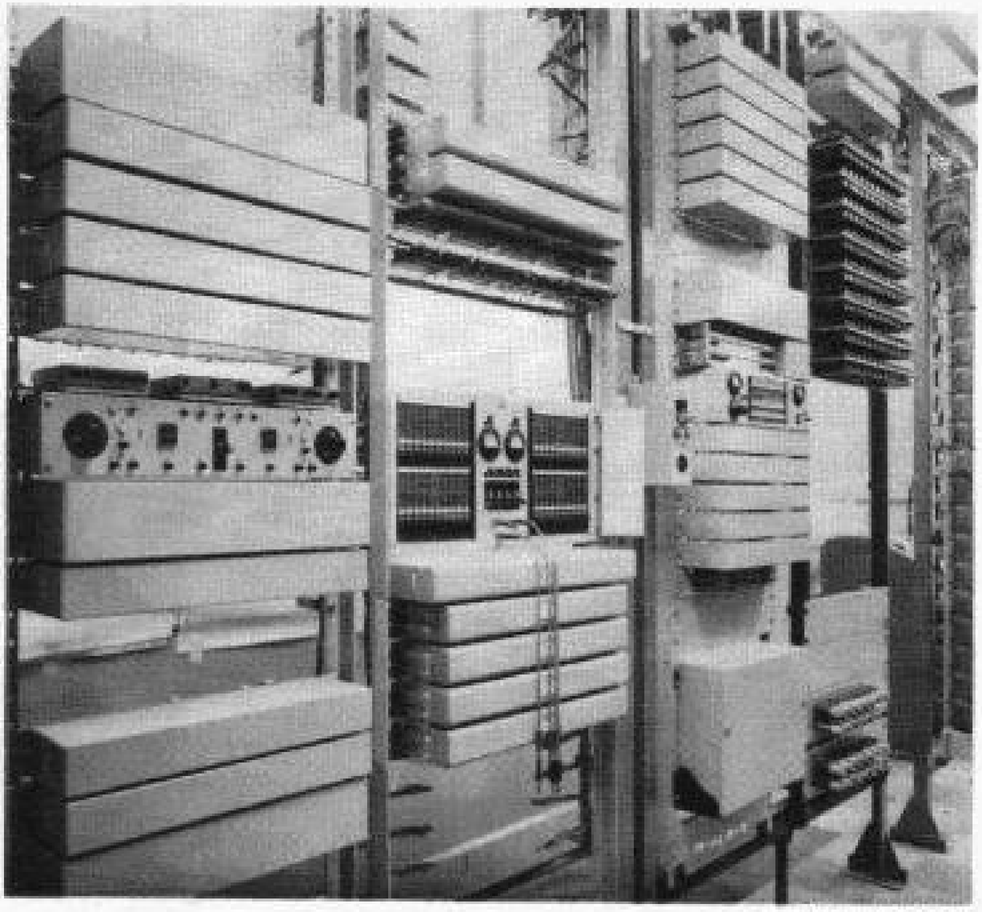


Photo R-11,312

Figure 10. Left to right, pulse generator, trunk repeater and central test transmitter racks

Returning now to the typical northbound call, as the GS/TZM, previously described, stops on the point of an idle outgoing or two-way repeater after the first digit has been dialed, the sending leg of the carrier trunk circuit to Montreal is reversed to the marking (negative) polarity. This seizure signal is received in the Montreal exchange on an incoming or two-way repeater having an associated group selector. If the trunk facility and group selector equipment is in proper working order, the Montreal repeater returns a 25-ms revertive pulse to the New York exchange. Reception of this signal in New York momentarily operates the receiving relay in the Telex repeater to the marking polarity and then back to spacing, verifying circuit and equipment continuity for the reception of dial digits. Failure to properly test a trunk circuit in this manner instantly produces a busy signal to the calling subscriber, removes this particular trunk circuit from service and operates an exchange alarm.

As the second and third digits are dialed by the New York subscriber in the typical 036-292 call to Vancouver, the second digit, 3, sets the group selector at Montreal, as shown in Figure 5, to the third vertical level where it free-hunts seeking an idle outgoing or two-way repeater to Winnipeg. When the connection is made to such a repeater, the trunk circuit between Montreal and Winnipeg likewise is tested by means of the revertive pulse as previously described. Following this the third digit, 6, is used in a similar manner at Winnipeg to extend the call to Vancouver. The call now enters the Vancouver exchange in an incoming or two-way repeater having an assigned group selector, as shown in Figure 11, which is pulsed by the fourth digit, 2, to the second vertical level. Between the dialing time of the fourth and fifth digits, the group selector free-hunts over the points in level 2 and connects to the first idle final selector.

For each 100 subscriber lines in an exchange a rack of 20 final selectors, as shown in Figure 8, is provided for handling incoming calls to this group of subscribers. The final selectors also use the two-motion decade type 100-point stepping switch and associated relay controls but, unlike the group selectors, they do not free-hunt in a horizontal direction. Instead the final selectors are pulsed vertically and then horizontally by the remaining two dial digits to make connection to any one of 100 subscribers served by this rack.

As the group selector seizes an idle final selector and the dial digits 92 are received in the Vancouver exchange, the circuit is extended to the called subscriber's preselector switch. If the Vancouver subscriber is idle, as indicated by the preselector switch being in the home position, the relay controls of the preselector function to reverse the five ma flowing in the loop. This reversal of current actuates the polar motor control equipment in the subscriber's set, which turns on the teleprinter motor, the operate lamp, and also *increases the loop current* to the 60-ma working level.

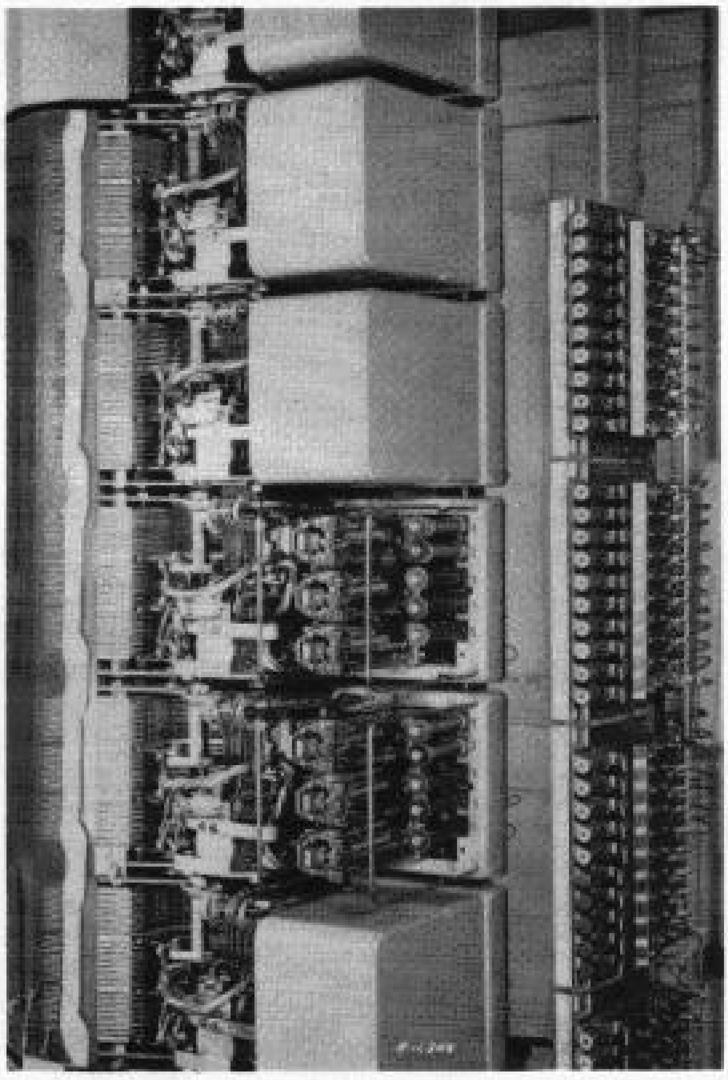


Photo R-11,308

Figure 11. Group selectors associated with incoming trunk repeaters

Provided the loop current has been raised to the working level, the called subscriber's preselector in the Vancouver exchange will now return the free-line signal to the calling subscriber's preselector in the New York exchange. This is a reversal of transmission polarity from spacing to marking in the eastbound direction. As this signal is received at New York the 60-ma current flowing in the calling subscriber's loop is reversed, causing the teleprinter motor and operate lamp to be turned on and the dial unit to be shunted from the loop circuit. As the connection is completed, the calling subscriber's connection and pulse rate counters are stepped one unit by a prepulse and thereafter the associated pulse rate counter begins recording the assigned pulse rate charge for this call. Starting of the calling subscriber's teleprinter motor now permits the exchange of answer-back sequences previously described.

Disconnecting

Either the calling or called subscriber may terminate a Telex connection by depressing the stop key on the remote control unit for about one second. This transmits a steady spacing polarity to the distant end, longer in length than normal teleprinter signal combinations. Regardless of which terminal such a disconnect signal emanates from, it is recognized by the calling subscriber's preselector—in this case New York—which in turn transmits a steady spacing signal through the GS/TZM, outgoing or two-way repeater at New York, through the Montreal, Winnipeg and Vancouver exchanges. This signal effects a release of the trunk circuits and switching equipment in the various Telex exchanges in the same sequence in which the connection was originally established. As the disconnect takes place, the subscriber sets at both ends of the circuit are restored to the idle condition by having the teleprinter motor and operate lamp turned off and the dial unit at the calling station relocked.

Dialing Western Union

As shown in Figure 7, the Western Union local position preselectors are connected through matching relays C directly to specified levels on the GS/TZM switches, effecting a savings in final selector equipment. As a New York subscriber dials 1, 3, and so forth, the GS/TZM switch is stepped vertically to the proper level where it then free-hunts and connects to the first idle position.

OTHER EXCHANGE EQUIPMENT

The following paragraphs briefly describe the operation and arrangement of other equipment in the exchange not explained in the foregoing description of a typical connection.

Pulse Generator

The various pulse rates (P.P.M.), one of which is picked up by the time zone meter for each chargeable call to step the subscriber's pulse rate counter, are supplied from the pulse generator rack shown in Figure 10. This rack contains two pulse generators, one working and one fallback, a changeover frame and 18 output relays, producing various outputs from one up to 36 P.P.M. In case of equipment failure, the companion pulse generator is automatically placed into operation.

The individual pulse generator consists of two polar telegraph relays having an RC (resistor-capacitor) oscillatory circuit adjusted for a basic output frequency of 360 OPM (operations per minute). This output is used to drive several groups of switching relays, in a frequency-reducing network, which in turn drive 18 output relays corresponding to the required pulse rates. For the pulse and no-pulse intervals, a combination of negative battery and ground potential, respectively, is applied from the contacts of each output relay to the various pulse rate leads which connect to the time zone meters. The absence of this combination for any length of time enables an automatic pulse control monitor to detect an open, short or ground on any of the pulse leads.

In addition to the tariff function, a selected number of these pulse leads are used, instead of electronic timers, to actuate alarm and control circuits for abnormal exchange functions. For example, when a subscriber depresses the start button and does not dial a number, the exchange equipment is restored to normal after about three minutes by a control circuit which absorbs three of the 1-P.P.M. pulses.

Central Test Transmitter

The New York exchange is equipped with a central test transmitter, also shown in Figure 10, which *automatically* transmits a choice of three types of tests for the use of maintenance personnel in checking local subscriber equipment or transmission over Telex trunk circuits. The characters for the test transmission are programmed by relays from a drum-type distributor and each test can be transmitted simultaneously to five different lines.

When the digits 5, 6 or 7, respectively, are dialed from a local subscriber set, the following tests are continuously provided by this transmitter:

1. A printing test utilizing all the lower- and upper-case teleprinter characters.
2. An unbiased "Quick brown fox" sentence.
3. Five lines of "Quick brown fox" in which one-half of each test sentence is spacing bias and the other half is marking bias. Each line is prefixed with 0, 20, 30, 35 or 40 percent to indicate the *amount* of bias being transmitted.

Canadian exchanges may also obtain these three tests automatically from New York by dialing 015-5, 015-6 and 015-7, respectively, in order to check northbound trunk circuit transmission.

Exchange Multipling and Grouping

The rack multipling between the stator points of all group and final selector switches is made with 15-conductor ribbon wire which can be seen in Figure 11. The ten points on the preselector switches are multipled in groups of 20 switches each which are wired to ten GS/TZM's and some of the latter are shared by several preselector groups. Ten group selectors are multipled in one group. Where the number of outlets exceeds the ten points on the vertical level of these switches, such as levels 1 or 3 for the Western Union receiving positions or level 2 for the input to the final selectors, a mixing plan arrangement is used and in some cases several groups of group selectors share the same outlet.

★ ★ ★ ★ ★

Experience with Telex in New York in providing a fast teleprinter service with direct distance dialing by customers through automatic exchanges has been highly satisfactory. Experience in the technical aspects of exchange operation also has been most satisfactory. Under the circumstances, rapid expansion of Telex service throughout the United States is indicated.

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Philip R. Easterlin began with Postal Telegraph in 1920, progressing from Morse and automatic operator to multiplex, repeater and wire chief regulating work. He entered the Engineering Department in 1939 and helped design and test Postal's semiautomatic reperforator system, later supervising its application in many Army Signal Centers during the war. After the merger, he served in the Development and Research and Applied Engineering Departments where he designed a number of widely used rack mounted repeaters, including a Switching System for Dispatcher Test Wires, described in the January 1953 issue of TECHNICAL REVIEW. He was active in the development of Plan 21 reperforator switching equipment, conducted several schools for technicians, and was responsible for the testing at the Minneapolis and Detroit offices. Mr. Easterlin also directed the development of the Control System for Integrated Data Processing described in TECHNICAL REVIEW for July 1956. In his present capacity as Assistant Planning Engineer, Mr. Easterlin was responsible for the over-all technical planning of Western Union's Telex network and has served as coordinator of the New York and Chicago installations. He is a member of AIEE.

C. S. LAWTON, General Plant Engineer, International Communications

More About Nonarmored Submarine Cable

After almost seven years on the ocean floor at depths of a mile or more, an experimental nonarmored cable recently was recovered by the Western Union Cable Ship *Lord Kelvin* for examination. Design, manufacture and laying of the nonarmored ocean cable was discussed in TECHNICAL REVIEW for October 1953; now an evaluation of the successful experiment is given.

AT THE AIEE Winter General Meeting in January 1953, a report[1] was made of the design, manufacture (1950) and laying (October 3, 1951) of an experimental length of novel nonarmored deep-sea submarine telegraph cable[2,3] in 1250 fathoms of water. In the course of the discussion of the paper it was stated that after a test of about three years it was hoped to recover the cable and present a further report on its condition.

Cable Recovery

Actually no suitable opportunity was found to pick up the experimental cable before the old coastwise section in which it had been installed was taken out of service in January 1955 with the closing of Western Union's Canso, N. S., station. In July 1955, while C.S. *Cyrus Field* was in the vicinity, an attempt to recover it was made, but the ship's dynamometer was insensitive at the low tensions required and the speed of picking up was excessive. The cable parted near the splice to the transitional type on one end and the bight splice to the armored cable on the other end. No further ship time could be spared until the summer of 1958 when C.S. *Lord Kelvin* recovered the entire length laid in 1951 with the exception of 150 fathoms pulled off the ends and recovered in the previous attempt along with the transitional types.

The recovery of this experimental cable on July 26-27, 1958, is of particular significance in the light of recent developments. In 1956 the British Post Office announced "A New Deep-Sea Coaxial Cable," the culmination of five years of development work,[4,5,6] thus confirming a forecast made in the 1953 discussion that "No obstacle is seen to the design of nonarmored coaxial cable." Not long after came news of the

Photo H-2350

Figure 1. Half-scale Gifford grapnel

proposal for a single all-British transatlantic telephone cable (to handle 60 simultaneous two-way telephone conversations) which would be nonarmored throughout the deep-water portion of the route.[7] In July 1958 it was announced that this cable definitely would be a reality by 1961. As a matter of fact, signalling frequencies in carrier-operated transocean telephone cables rapidly are approaching the realm where steel armor wires must be eliminated if attenuation is to be kept within bounds. Whereas laying and recovery tests have been made with nonarmored coaxial cable of British design,

A paper presented before the Winter General Meeting of the American Institute of Electrical Engineers in New York, N .Y., February 1959.

there have been no actual service tests to our knowledge.

Both ends having become detached, recovery of the experimental cable with which this report deals had to be effected by grappling for the small cable itself. It was hooked on the second tow 2.04 nautical miles from the east end using 1750 fathoms of 3 by 3 rope, six fathoms of 9/16-inch ground chain and (Figure 1) four 4-hook sets of half-scale Giffords (with a boat grapnel at the tail end for good measure). The average towing speed was 0.85 knot, producing an average dynamometer tension reading of 27 cwt, and the cable was hooked about midway along the Giffords, the indication being a rise of dynamometer tension to 32 cwt. The average speed of raising the grapnel to the surface was 0.31 knot. The tension while doing so dropped from 30 to about 11 cwt. The standing "strain" with both parts of the cable at the bow was 8 cwt.

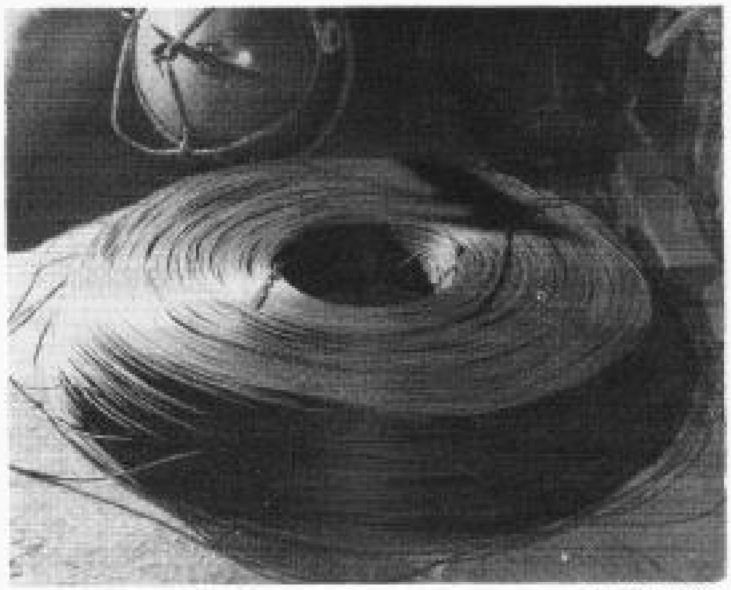

Photo H-2353

Figure 2. Condition of recovered cable (loose coils contain joints)

The short end was found wrapped around the cable for perhaps 50 fathoms when brought to the bow. To be sure of clearing all turns a total of 80 fathoms was picked up on the bight before applying stoppers, cutting off the short end at that point and both parts at the grapnel, thus making it possible to clear the turns and recover the short end separately. This condition was the natural result of the final bight splice dropped at the conclusion of the 1951 laying operation where the nonarmored cable had been spliced directly to the conventional armored cable at the eastern end of the pay-out. (The transitional types had been at the west end.) Upon release of tension, the torsional equilibrium of the armored cable would have been restored by normal twisting, thereby transmitting turns to the adjacent nonarmored cable.

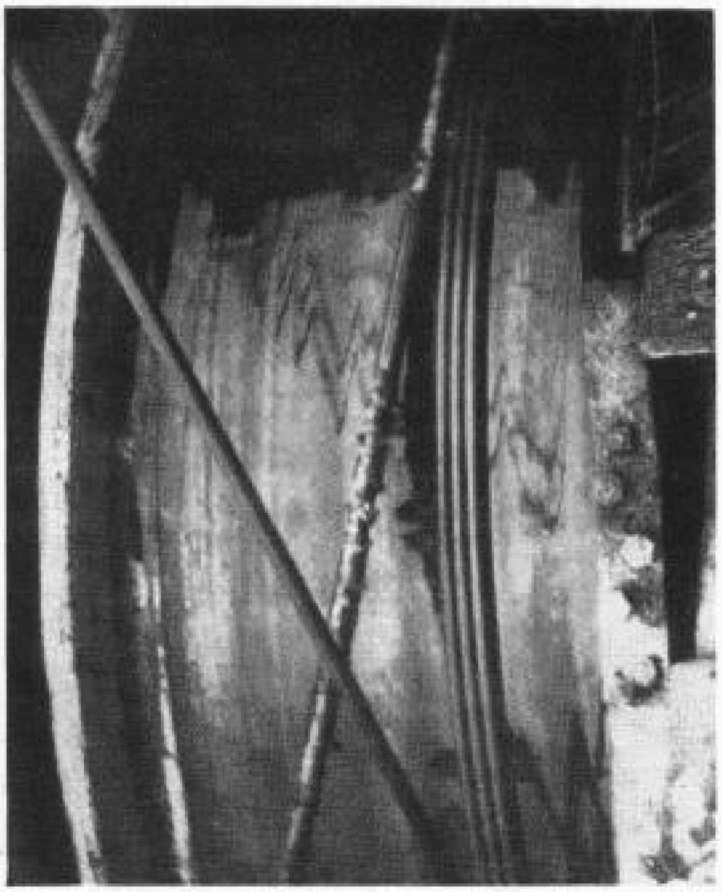

Photo H-2351

Figure 3. Parcelling and service adjacent to joint

Tension during the actual pick-up which ensued ran between 7 and 9 cwt generally but with occasional surges to a maximum of about 12 cwt. (All measurements are in British hundredweights of 112 lbs.) The picking-up speed averaged about 0.6 knot and while picking up, the downward trend of the cable was aft by 10 degrees to 30 degrees from the vertical. The best condition was found to be about 15 degrees aft, and to our knowledge this is the first time there has been definite substantiation of the theory[8,9] that under certain conditions less tension will be developed if the ship over-runs the cable, thereby causing it to be inclined forward as it leaves the water. This practice can be followed only with cable not susceptible to kinking on the bottom when relieved of tension, of course.

Condition of Cable

The main body of the cable came up without any evidence of twisting and coiled down perfectly (Figure 2). The polyethylene insulation, which deliberately had been left exposed to worms, if any, showed no evidence of attack except closely adjacent to some of the molded joints, where the ship had applied canvas parcelling and untarred hemp spunyarn to elongate the taper in diameter over several feet before laying. These materials as recovered were in poor condition, some frayed or missing entirely, but mostly having to be stripped off for examination of the insulation underneath (Figure 3). The evidence was in the form of light scorings, none more than about a thirty-second of an inch in depth but typically at random such as would be caused by teredo attack (Figure 4). No worms were found and whether the attack still was in process at the time of recovery is doubtful.

Photo H-2409

Figure 4. Nonarmored cable joint — teredo marks accentuated by chalk

It has been suggested that a worm needs support from behind to start the boring action. This would seem to be confirmed. It further has been suggested in view of the depth of water and proximity of the cable to the Gulf Stream, that these may have been sporadic attacks by stray worms transported by the current and not indigenous to the region at all. Apart from this, the outside of the cable after nearly seven years' submersion could not be distinguished from its condition when manufactured.

One interesting feature of the recovery operation was the bringing of the cable to the surface and inboard over the ship's bow from a depth of over 1200 fathoms on a Gifford hook, the palm of which was only 2½ inches wide, without putting a fault in the cable (Figure 5). As a matter of fact, the whole length showed no electrical weakness.

Conclusions

It is evident that a modulus higher than five will be necessary for successful recovery in greater depths and that to attain this some use of steel in the strength member is indicated. (When the experimental cable was being designed there was some apprehension about the use of two dissimilar metals since diffusion of water through the dielectric was known to take place and it was thought possible that galvanic action might develop, but this now is recognized as being unlikely because salts do not come through.)

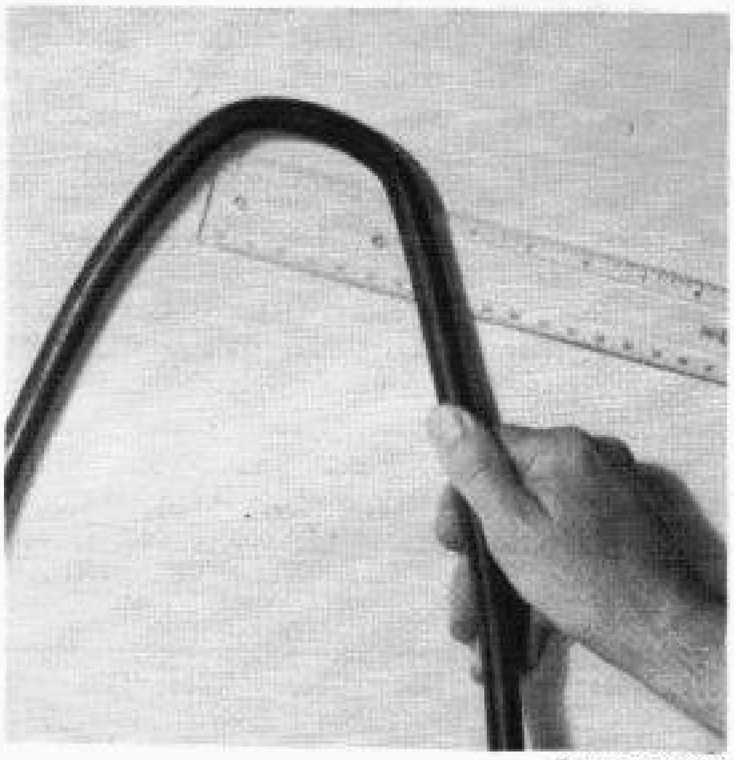

Photo R-11,356

Figure 5. Cable where hooked and raised by grapnel

With the successful conclusion of this experiment, much of the uncertainty surrounding the ability of nonarmored cable to perform satisfactorily in deep-sea environment has been removed. Naturally, if time were of no importance it would be desirable to make tests in more than one locality and at various depths. Certainly where bad bottom is known to exist with current sufficient to remove the normal deposit of silt, prudence still dictates caution, but it is felt that there now is substantial evidence to support the underlying premise that expensive armor wire on the outside of cable for use in deep water, generally speaking, is unnecessary.

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C. S. Lawton graduated from the University of Michigan with a B.S.E. degree in 1919 shortly after receiving his commission as an Ensign in the Naval Reserve. He was with the Federal Shipbuilding Company until March 1922 when he joined our ocean cable plant staff. From 1933 to 1939 he was in charge of the development of the equipment and methods used to plow submarine cable into the bed of the ocean to protect it from fishing trawlers. In 1936 he was appointed Assistant Ocean Cable Engineer and in 1943, as Ocean Cable Engineer, was placed in charge of Western Union's cable ships and depots. On January 1, 1946, coincidently with the establishment of the International Communications Department, he was made General Plant Engineer and as such is responsible for all matters pertaining to the Company's ocean cable plant and overseas telegraph plant construction and maintenance. Mr Lawton is a member of AIEE and the Society of Naval Architects and Marine Engineers, and an Associate of the Woods Hole Oceanographic Institution.

JAMES J. LENEHAN, Radio Engineer

The Western Union MLD-4 Microwave Relay System

Development by Western Union engineers of MLD-4 *(medium bandwidth long distance 4000-mc)* microwave equipment has provided the company with radio facilities eminently and uniquely well suited to telegraph system requirements. Electronic diversity switching, duplex antennas and terminal combiners are valuable features.

WESTERN UNION'S MLD-4 microwave relay equipment was designed to meet the extremely rigid standards of modern day telegraphy. Before going into the system in detail it might be well to review the continuity of service demanded by some of the latest methods of communication. The use of data processing in nationwide networks has been one of the principal reasons for developing transmission systems with extremely small outage times. Because these systems are essentially telegraph, that is, binary forms of coding, a break of small duration can produce an error. While breaks of a few milliseconds can be tolerated for certain forms of communication, the transmission of high-speed data will not permit such breaks. The Telegraph Company, in addition to providing public message service, is supplying a continually growing number of private wire systems that must handle integrated data processing. The MLD-4 development was carried on with this requirement in mind.

Photo H-2175

Passive reflector antenna system used with the MLD-4 equipment

Tower Locations

Western Union began the installation in 1945 of the first commercial microwave telegraph system in this country. This included circuits between New York and Pittsburgh, Pittsburgh and Washington, and New York and Washington, so that the three circuits form a triangle which provides fallback in the event of failure on any leg. In addition to these facilities two parallel beams were installed between New York and Philadelphia.

The layout of towers for this system appears in Figure 1. Spacing between towers varies between 2 miles and 54 miles with 30 miles the average. The equipment employed in this early system relied upon space diversity to minimize the outages due to fading. With the first transmitters limited to a power output of 100 mw, however, it was found that the propagation outages were greater than telegraph service could tolerate. A microwave amplifier was added and the in-

A paper presented before the Winter General Meeting of the American Institute of Electrical Engineers in New York, N. Y., February 1959.

crease in transmitter power to ten watts resulted in greatly improved reliability.

Experience with this system was an important factor in determining the program for locating MLD-4 repeater sites between Pittsburgh-Cincinnati and Cincinnati-Chicago. The map in Figure 2 shows the route of the latter radio relay system. Between each of these cities there are two parallel, but separate and distinct, radio systems which are independent of each other in every respect with the exception of the supporting structures. This separation is carried out even to employing separate antennas and power sources. This MLD-4 system is different from the earlier New York-Pittsburgh system in that it uses over-all frequency diversity rather than space diversity in each section. This design decision was based on experiments that demonstrated the frequency selective fading characteristics of microwave signals. The frequency spacing used between parallel beams over the same paths is 240 mc which has worked very well during this first year. Although a closer spacing would have been adequate, this particular choice was made after reviewing the possibilities of interference to both Western Union and other systems. Further protection against fading is provided by an all-electronic diversity switching unit installed at the terminals. This device detects circuit deterioration and switches to the better of the two parallel beams in the event of fading or equipment failure. It will be described in greater detail later.

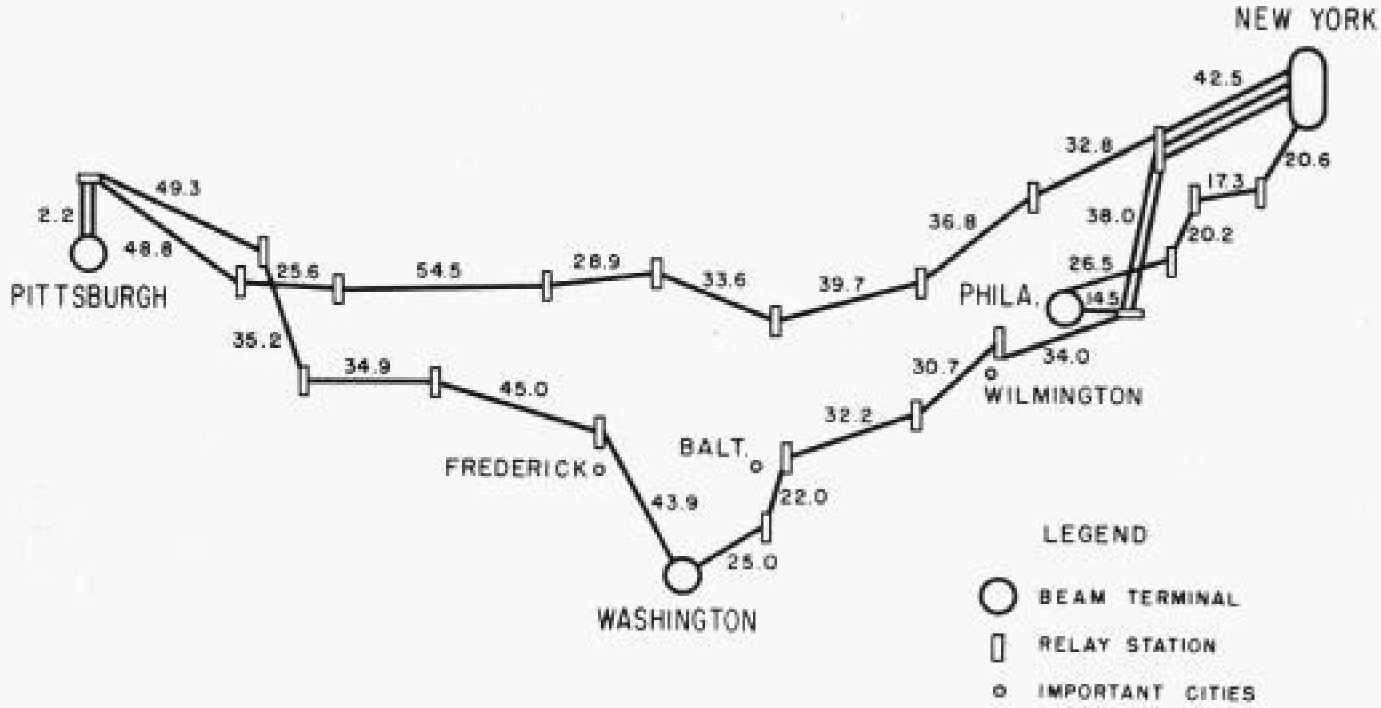


Figure 1. Location of repeaters and terminals, New York—Philadelphia—Washington—Pittsburgh

While the principles of parallel path, frequency diversity, and electronic switching are important, they do not reduce the need for the careful attention that must be given to the choice of tower locations. The Pittsburgh-Cincinnati and Cincinnati-Chicago systems employ tower spacings ranging from 2 miles to 37 miles with the average being 28 miles. In addition to having the proper clearance, each path was chosen with an eye to the possibility of mutual interference between Western Union equipment and other systems. Because the route it was necessary to follow paralleled sections of a high-capacity system operating in the same 3700-mc to 4200-mc band, the possibility of interference was a very real one. After careful analysis and some testing, a frequency coordination plan was arrived at that did meet the requirements of all the equipments involved.

The system was also planned with an eye to the needs of national defense. In this respect it was the policy to keep all tower sights a minimum of 25 miles from any prime target area. It was also decided to locate towers either side of major cities so that line of sight existed between them as well as into the city itself. When this is added to the desire to keep every tower on a well-traveled road to insure accessibility during snow storms, and the additional requirements of the CAA, it becomes evident that the choice of tower sites was a major task.

things as local zoning regulations or plot size. The plot size is of special importance in the case of guyed towers because of the need for extra land on which to locate the anchor blocks.

The crews were equipped with barometric altimeters to make a check of elevation at the proposed sights and at high points along the path. Special attention was given to any building or other form of obstruction in the path. If this initial survey met all the requirements, options were taken on the property.

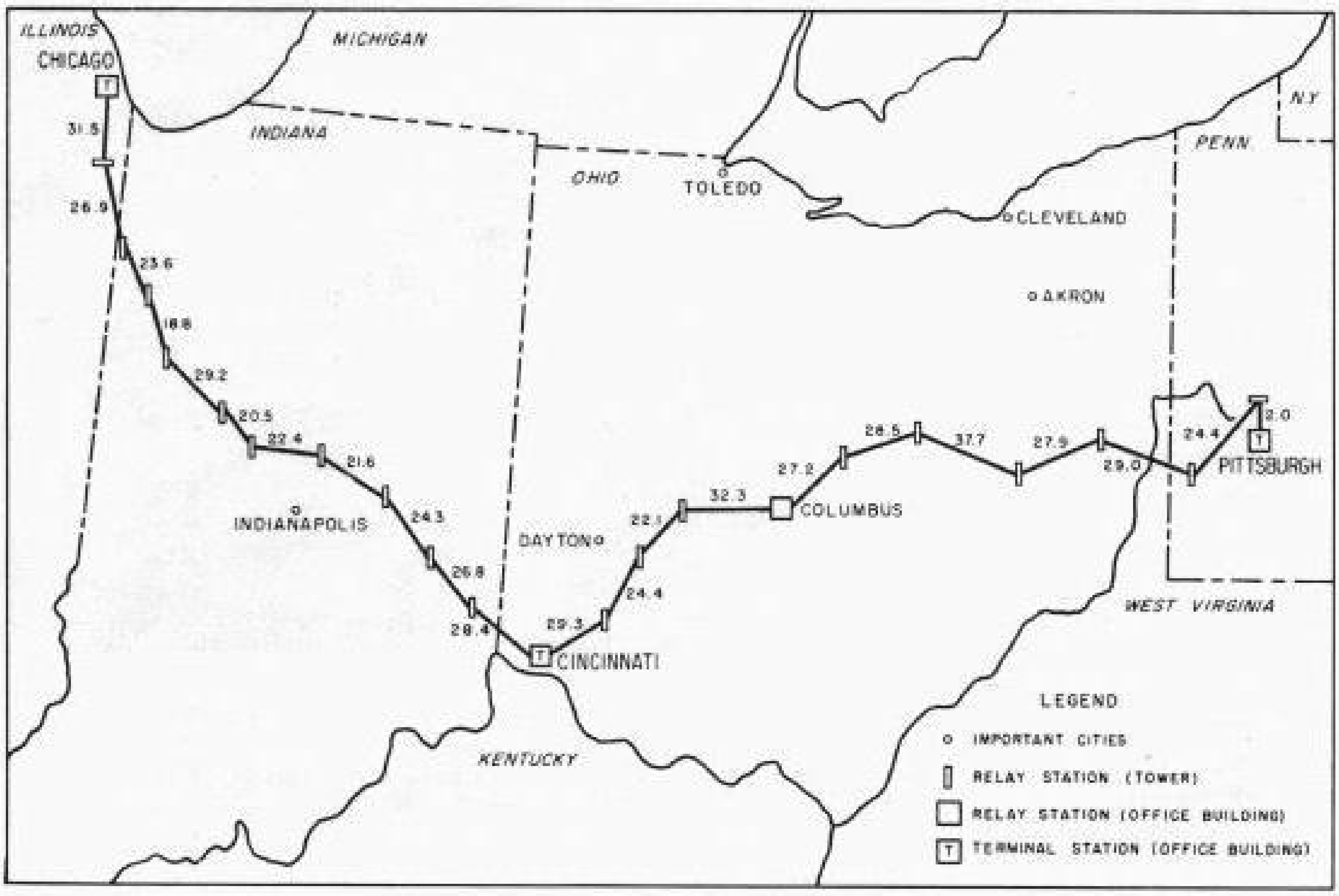


Figure 2. Location of repeaters and terminals, Pittsburgh—Cincinnati—Chicago

The limited number of satisfactory sites in large cities made the choice of terminal space the first step in this program. After these terminal sites had been optioned, tentative paths for the MLD-4 system were laid out on topographic maps if such maps were available. These maps were available for Pennsylvania, Ohio and Illinois, but were not available for Indiana at the time of the preliminary survey. In the latter case, however, it was possible to prepare crude topo maps from the available bench mark information.

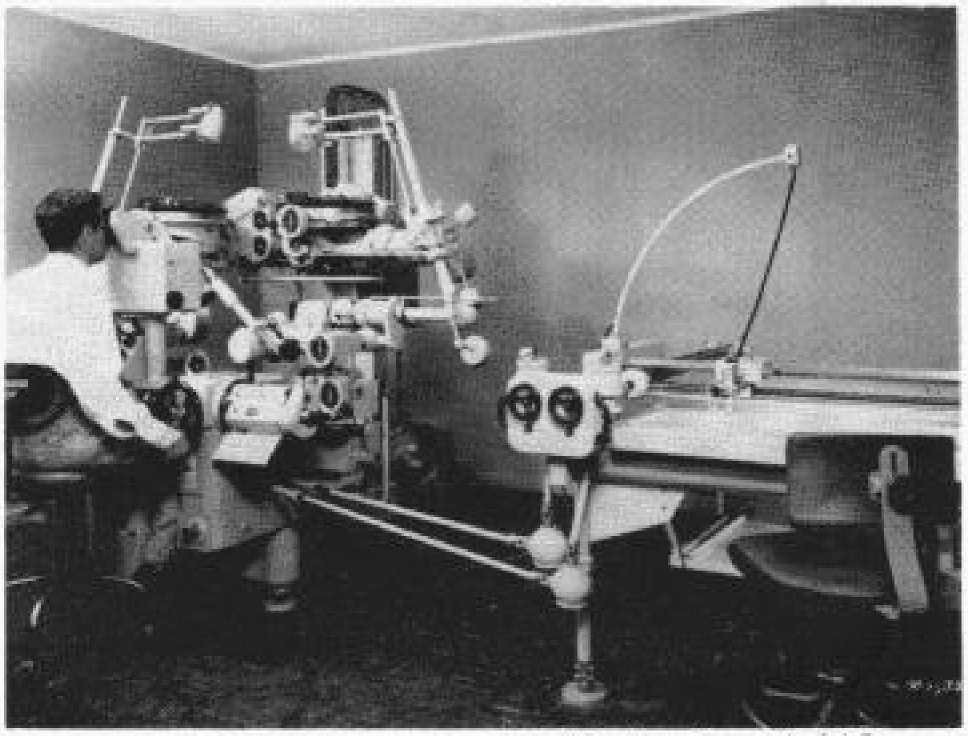
After using these maps to determine which paths would meet the requirements of Fresnel clearance, field crews were sent out to see if there were any obvious reasons for ruling out any of the choices. One thing they checked was availability of land, which can be controlled by such

Because experience has shown that a survey of this type is open to some error, an aerial survey was made before the property was actually purchased. Although the aerial survey added to the cost of the site-selection program it was felt that it was excellent insurance against there being any serious errors in tower height or site choice. The survey for the system was made using photogrammetric techniques by the Hycon Aerial Survey Company, of Pasadena, California. Each path was flown at an approximate elevation of 8000 feet, and with stereo techniques it was possible to plot profiles to an accuracy of six feet. An operator is shown plotting a path profile in Figure 3.

Measurements of path attenuation between each station have been in very close agreement with theory. It is believed the entire program of site selection has been a success in the light of the very low percentage of outage time that occurred during the first fading season.

System Design

In the design of a microwave system, one of the first concerns is the degree of nonlinearity, hence crosstalk, that is added by each repeater. In the first systems installed between New York, Philadelphia, Pittsburgh, and Washington, a subcarrier method of modulation was used to reduce intermodulation produced by each repeater. A later review of this method indicated that the extra bandwidth required (at both microwave and intermediate frequencies) by the subcarrier method, as compared to direct modulation, resulted in very little if any reduction in crosstalk for a rf circuit response having the classical phase and amplitude characteristics. On the other hand, laboratory and field trials indicated that some advantages still could be obtained with subcarrier modulation under certain conditions. For this reason it was decided to design the MLD-4 repeater to handle either direct or subcarrier modulation. This form of repeater is known as the heterodyne type, whereas the radio terminals at Pittsburgh, Cincinnati, and Chicago, were of the subcarrier type. A block diagram of a sending terminal, a one-way repeater, and a receiving terminal appears in Figure 4.



(Courtesy Hycon Aerial Surveys)

Figure 3. Photograph of operator using stereoplanigraph to plot profiles

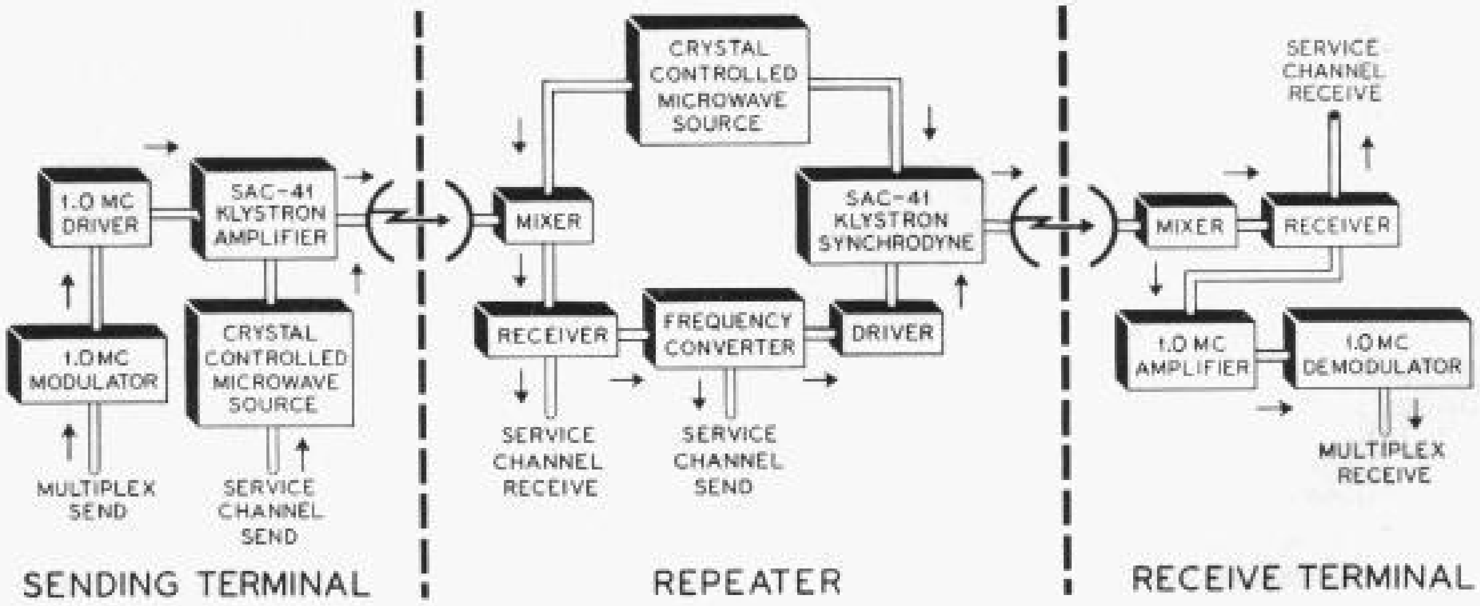


Figure 4. Block diagram of an MLD-4 send terminal, repeater, and receive terminal

A drawing representing the output waveshape of the 48-channel frequency-division multiplex equipment appears in Figure 5. The power level present at the input to the radio equipment is the summation of the powers of each of the 960 telegraph channels. The telegraph channels use frequency-shift keying and therefore the power level per channel is the same whether it is operating mark or space. The modulating waveform shown in Figure 5 is unlike a sine wave in that the peak-to-rms factor does not remain the same with time. This is true because the instantaneous voltage produced at the output of the multiplex send terminal is the sum of the 960 individual tones that comprise it. In addition to these there are pilot tones and translating tones on the equipment used on the Pittsburgh-Cincinnati-Chicago system which increases the load to the equivalent of approximately 1300 telegraph channels.

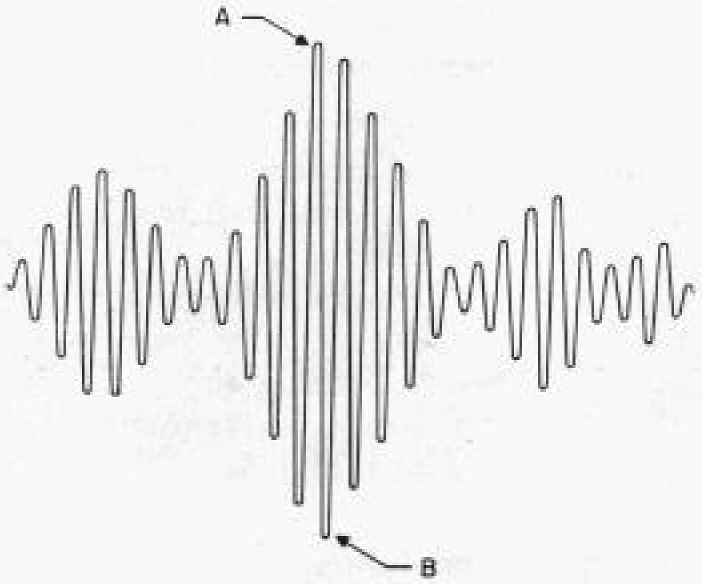


Figure 5. Multiplex baseband signal

This composite signal frequency modulates the 1-mc subcarrier. As in any FM system, the greater the deviation the greater the improvement over white noise. Because the nonlinearities, hence the intermodulation, increase with deviation, there must be a compromise between greater noise suppression and crosstalk. The MLD-4 was designed so that the optimum combination of noise suppression and intermodulation would occur at a subcarrier deviation of plus or minus 400 kc. By deviation is meant the extent of the frequency excursion at the times of peak voltage (A and B) shown in Figure 5. The ratio of the peaks to rms of this waveshape is 10 db. Actually peaks greater than those shown in A and B do occur, but probability dictates that their rate of occurrence will be so infrequent and their length so brief that they can be neglected.

One-Megacycle Modulator

The 1-megacycle FM subcarrier is generated by beating a 42-mc crystal oscillator against a 41-mc oscillator that has been frequency-modulated by the baseband signal. The subcarrier in turn is amplified and modulates a SAC-41 3-cavity klystron. A schematic representation of the klystron modulation circuit appears in Figure 6. The cavities are tuned to the desired frequency and the input to the klystron is driven from a crystal controlled source. The modulation of the microwave carrier takes place because the 1-mc voltage developed across L_1L_2 varies the tube anode potential at a 1-mc rate. This results in velocity modulation of the electron stream and produces a phase-modulated rf carrier. The nominal deviation of this transmitted microwave carrier is plus or minus two mc.

Crystal Control

A crystal controlled source is used to give the MLD-4 its high degree of frequency stability. At terminals this unit

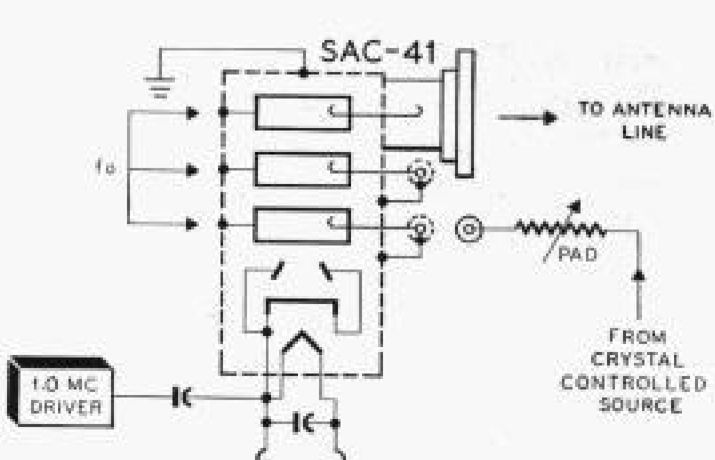


Figure 6. Schematic of MLD-4 terminal klystron modulation circuitry

also provides the means for introducing the service channel modulation. The crystal multiplier chain begins with a crystal operated at approximately 20 mc. A photograph of this unit appears in Figure 7. The early stages employ simple lump constant circuitry while the latter stages use lighthouse tubes operated in cavities. Very special attention had to be given in the design of this unit to insure that the leakage of energy was kept to a minimum. This leakage, if not controlled, will produce interfering signals when the radiated harmonics fall in the receiver passband. Interference of this type manifests itself as high-level noise in the telegraph channels.

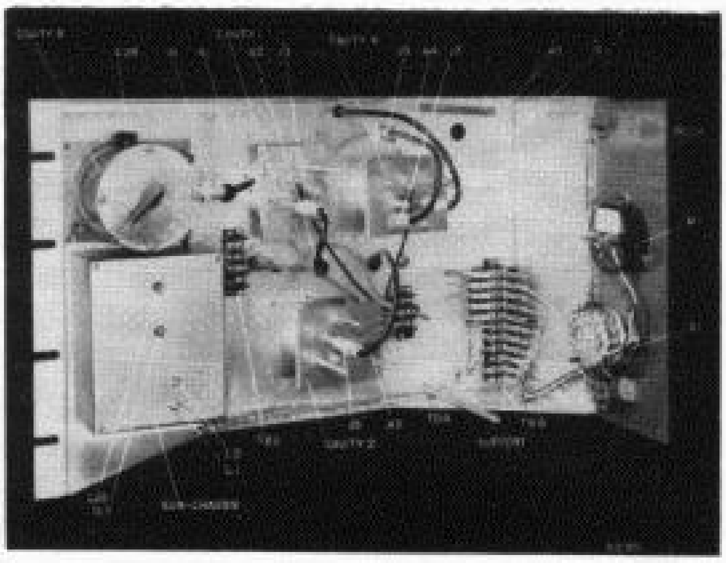


Photo R-10,301

Figure 7. Photograph of MLD-4 crystal multiplier

Heterodyne Repeater

A block diagram of the MLD-4 heterodyne repeater is shown in Figure 8. The term heterodyne applies because of the way the signal is operated on as it passes through the repeater. In this system the incoming microwave signal is mixed with the crystal controlled local oscillator frequency to produce the first intermediate frequency. After amplification at the 70-mc intermediate frequency it is translated to a second intermediate frequency of 110 mc. It is then amplified at this frequency and recombined with the crystal controlled microwave frequency for retransmission. There are two reasons for this double translation. The first is the inability of a microwave repeater to employ the same frequency for transmission that it does for reception. This is due to the fact that the back-to-back rejection of the antennas and/or the reflections from the surrounding terrain are usually not as great as the path loss between repeaters. If this difference between incoming and outgoing frequency were not maintained, the spillover from the transmitting to receiving antenna would drive the station into oscillation.

The second translation in the MLD-4, that is, from 70 mc to 110 mc, was necessary to reduce the amount of gain at any one frequency to a level that would eliminate the possibility of undesirable feedback at the intermediate frequency. This consideration was especially important in the MLD-4 design because the final translation to the microwave frequency at a repeater occurs at a high level.

Terminal Demodulation

Referring again to Figure 4 it is seen that the incoming signal at the terminal is heterodyned down to the first intermedi-

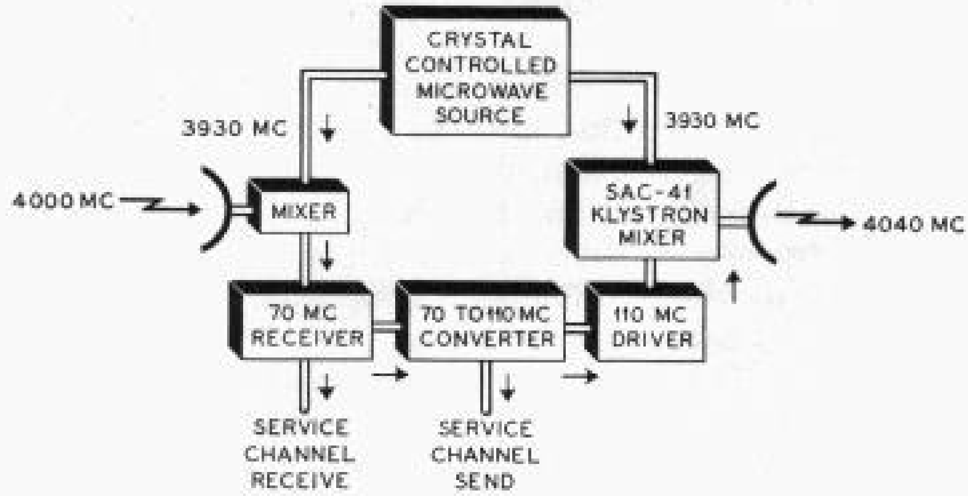


Figure 8. Block diagram of MLD-4 repeater

ate frequency in the same manner as at a repeater. This terminal receiver differs from the repeater receiver in that it includes a special discriminator for removing the subcarrier modulation and the service channel. The detected subcarrier is fed to a 1-mc amplifier, and then to a counter-type demodulator which recovers the complex baseband signal. The demodulator also includes an extremely low-distortion baseband amplifier capable of delivering an output of +27 dbm. The output of the baseband amplifiers, one for each of the parallel beams, is then connected to the electronic switching system.

Fault-Locating System

A fault-locating system built as an integral part of the MLD-4 was designed to report seven troubles. The faults that can be reported from each repeater are: (1) a drop in transmitter power; (2) a receive signal drop; (3) failure of upper tower light; (4) failure of lower tower lights; (5) commercial power failure; (6) failure of 3-unit power converter; and (7) illegal entry. The system provides an audio oscillator at each repeater which comes on in the event of any of the above faults. A different audio frequency is assigned to each repeater, and complementary audio filters bridge the service channel at the receiving terminals. Recognition circuits beyond these filters make it possible for the terminal maintainer to recognize which tower is in trouble. A keying unit at each station codes the audio tone to indicate which fault has occurred.

At repeaters these audio tones and the voice modulation of the service channel are placed on the carrier by FM modulation of the 40-mc oscillator used to translate the 70-mc intermediate frequency to 110 mc. The service channel modulation originating at the terminals or at other repeaters is demodulated at each repeater by a 70-mc discriminator which bridges the receiver output. This discriminator does not interfere with the heterodyne feature of the repeater described earlier.

A photograph of an MLD-4 repeater appears in Figure 9.

Installation Problems

In spite of every possible precaution in the laboratory, the field installation showed up some problems that did not arise during the design stage. One of these was the effect of unwanted emission from the crystal multiplier. As mentioned earlier, a unit of this type is rich in harmonics

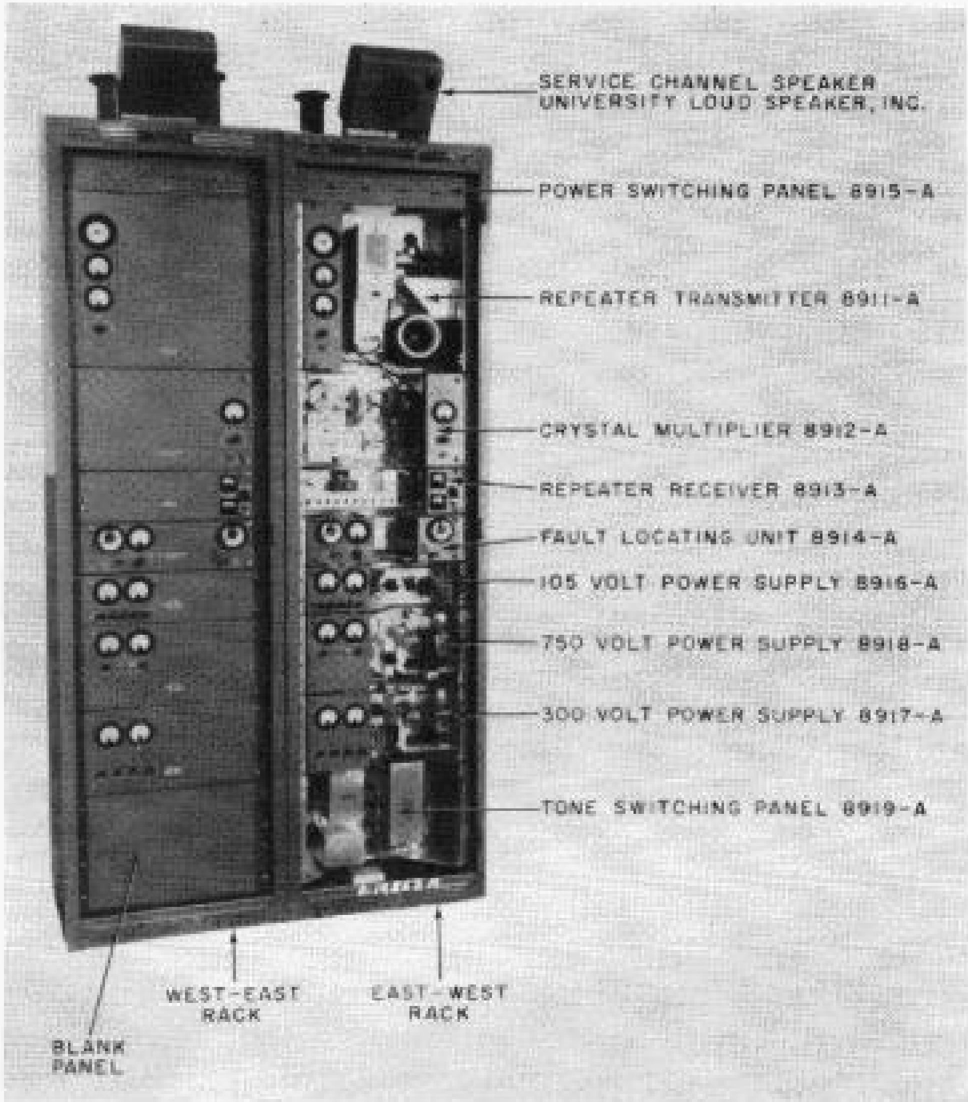


Photo R-10,863-A

Figure 9. Photograph of MLD-4 two-way repeater

of the basic crystal frequency, and it will be a source of interfering signals if they fall within the if amplifier passband. Because the receiver is a high-gain wideband device (16 mc to the 3 db point) a voltmeter will read a rather high noise level when connected across its 72-ohm output, in spite of a noise figure as low as 12 db. For this reason, the change in this noise reading due to these low-level interference spikes was attributed to the expected noise figure spread between receivers. Traffic tests, however, quickly showed that such spikes could not be weighted in the same manner as an equal noise power spread throughout the receiver passband. Because these interfering frequencies were appreciable when compared to a sideband produced by a single telegraph channel, the result of this form of interference was poor performance in that direction. In order to eliminate this possibility it was decided to duplex antennas, that is, place the receiver and transmitter of the same system on a common antenna. This method places very severe demands on the microwave filters since it means separating signals that differ in power level by 70 db under normal conditions and 100 db or more under fading conditions.

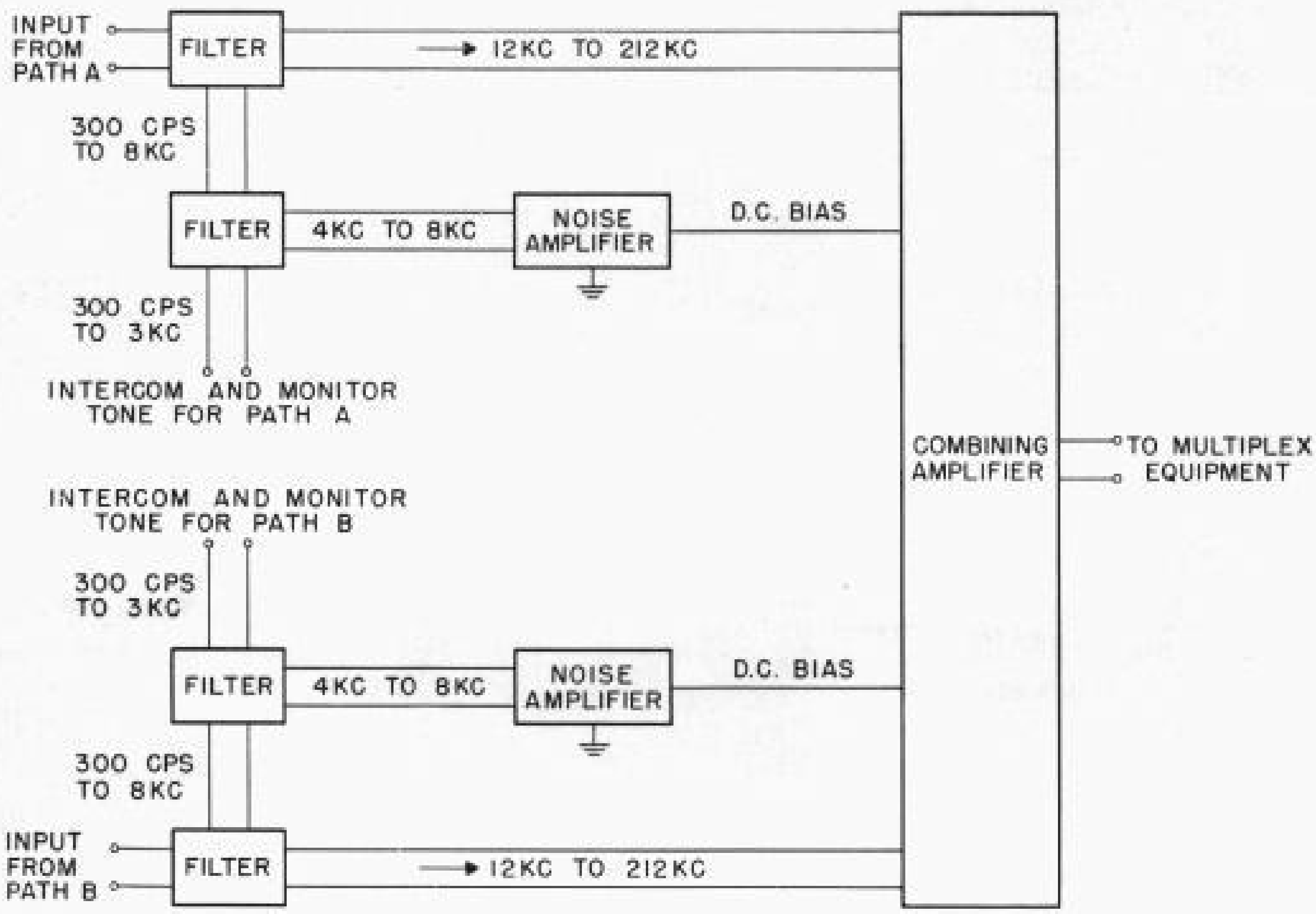


Figure 10. Block diagram of terminal combiner

certain bands. In order to correct this trouble it was necessary to improve the shielding of the receiver and crystal multiplier.

Another problem which arose was the result of the extra precautions taken to insure the complete independence of operation between parallel systems. Since the Pittsburgh-Chicago circuit uses the passive-reflector type tower shown on the first page, the possibility of falling ice damaging a parabolic reflector was a very real one. If the diplexing method of antenna multiplexing were used, that is, placing transmitters facing one direction on a single antenna and receivers on another, the loss of a single parabola due to falling ice would mean total outage in

Still another problem that arose was the second harmonic generated in the transmitter output tube. In some cases this would beat with the second harmonic of the receiver local oscillator or with other sums or differences produced in the mixer crystal to produce a signal that fell in the if band. While the second harmonic output of the transmitter is extremely low, it must be remembered that the normal received signal is approximately 70 db lower than the output of the transmitter fundamental frequency. For this reason, any second harmonic output of a transmitter, even if it is 120 db below the transmitter fundamental, will reduce the C/N at the receiver mixer to 50 db if the filter presents no loss to the second harmonic frequency. Because the attenuation of the microwave filters at the second harmonic was not adequate, it was found necessary to add low-pass microwave filters in the receiver waveguide circuitry at certain repeaters. The locations of these filters in the microwave lines were carefully chosen since they affected the receivers' match and mixer image response.

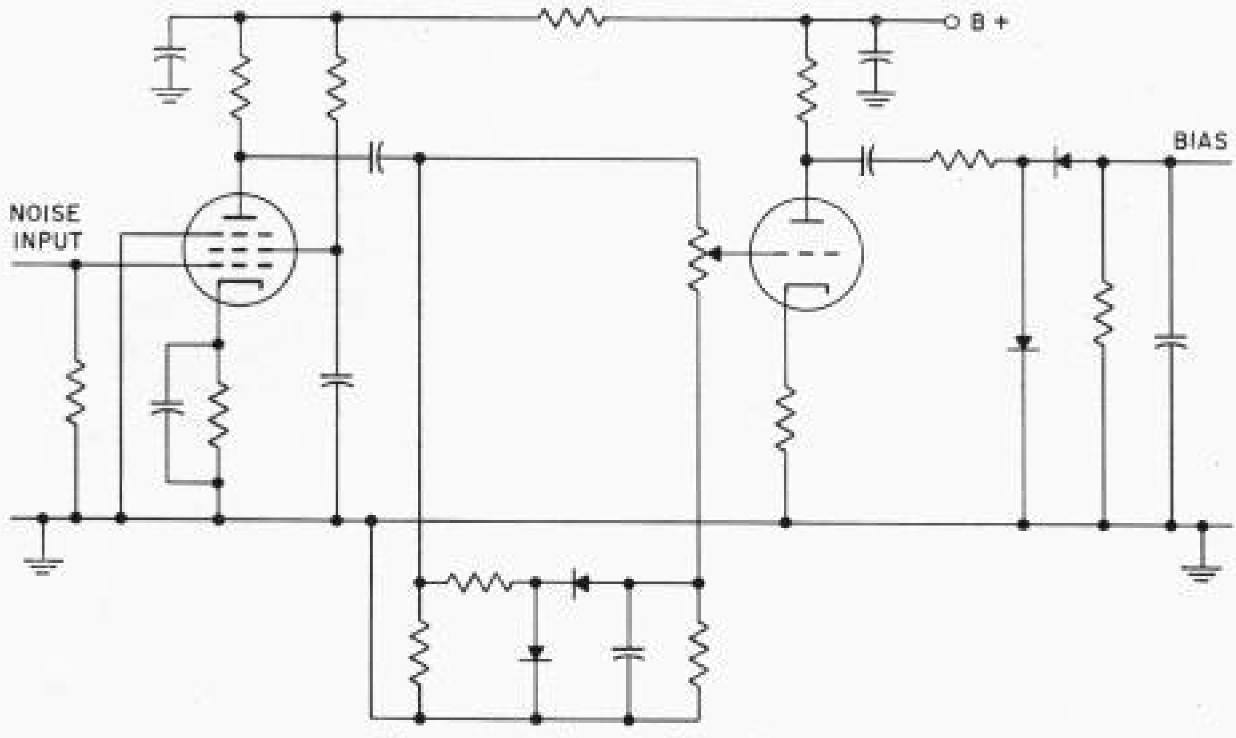


Figure 11. Noise amplifier schematic

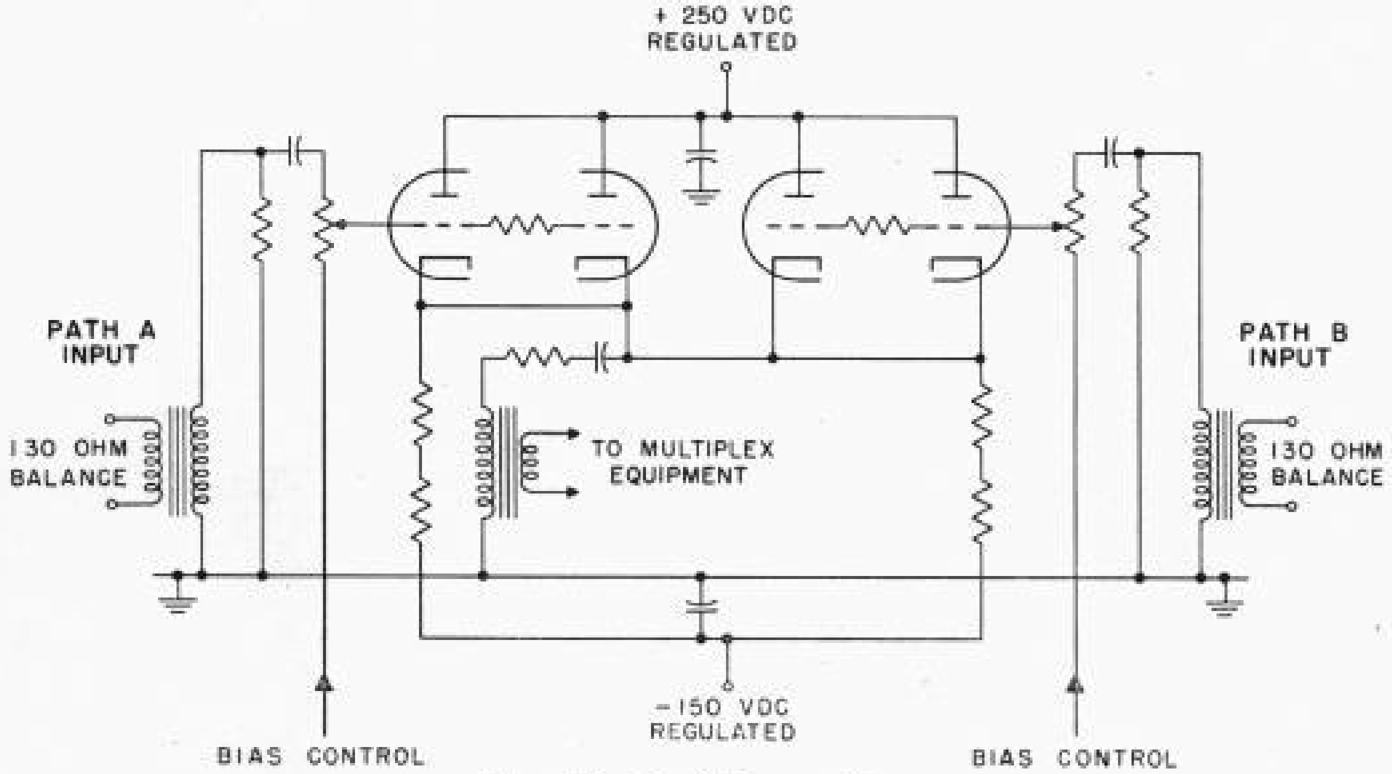


Figure 12. Combining amplifier

Terminal Combining

A good deal of the successful operation of the system to date is due to the performance of the combiner. It has performed satisfactorily not only in the case of fading but also at times of equipment failure. A block diagram of this equipment appears in Figure 10.

At the sending terminal the baseband output of the multiplex equipment is fed to the 1-mc modulator of each of the parallel radio systems. At the receiving terminal the output of each demodulator is fed through a separate baseband filter to separate tubes in the combining amplifier. The system discussed here has a baseband located between 12 kc and 212 kc. A set of bridging filters is used to pick off a section of the baseband spectrum below the traffic channels. In this equipment the "out-of-baseband" noise filter is located between 4 kc and 8 kc. This part of the spectrum is then fed through an audio amplifier and detected in the noise amplifier shown in Figure 11.

The combiner amplifier showing the two separate inputs appears in Figure 12. In the event of a fade or other failure in path A the noise in the 4-kc to 8-kc slot will increase and the noise amplifier will produce a higher value of bias voltage. This reduces the gain of V_1 and its contribution to the output signal, and would also reduce the desired level into the multiplex equipment if the gain of V_2 did not increase by an amount almost equal to the loss of gain in V_1. The reason the gain of V_2 increases with a drop in current of V_1 is the very tight coupling through a common cathode load. This method requires that cathodes be operated from a well-regulated negative source rather than ground.

A photograph of this combiner appears in Figure 13.

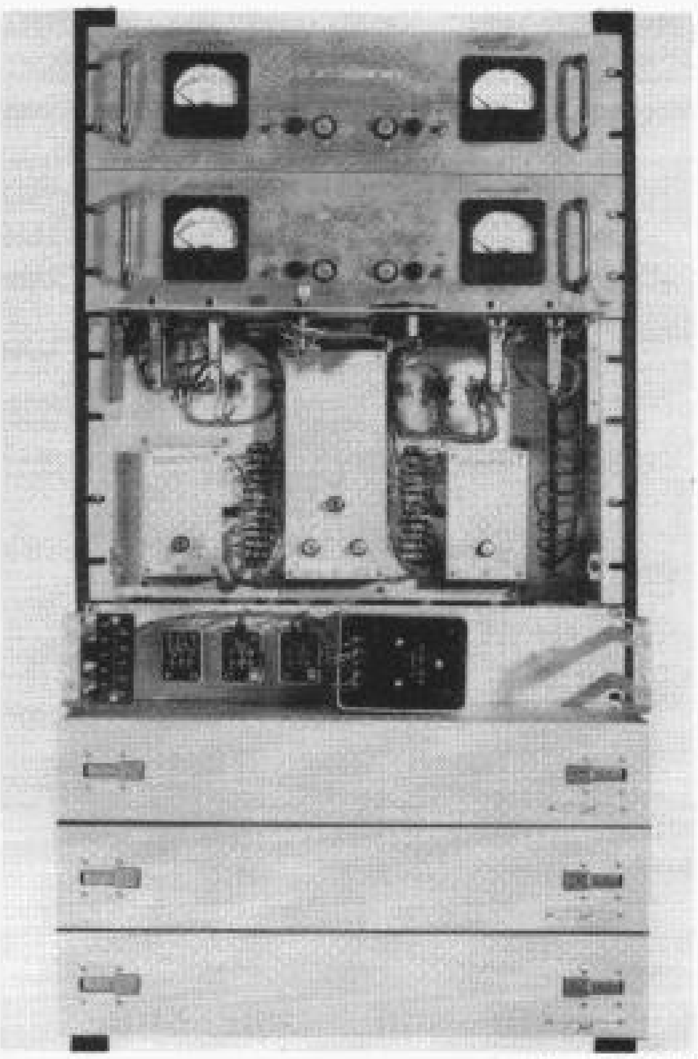


Photo R-10,812

Figure 13. Photograph of combiner with dust cover removed

★ ★ ★ ★ ★

The system described in this paper was designed to provide a trunk line transmission medium that would meet the very severe reliability requirements of present day communications practices. The combination of good design, careful tower location selection, and the automatic switching device or combiner, has helped in attainment of the goals sought. The MLD-4 installed between Pittsburgh, Cincinnati, and Chicago, has an initial load capacity of approxmiately 1000 telegraph channels.

James J. Lenehan received his Bachelor's Degree in Electrical Engineering from New York University in 1947. He has been a member of the Development and Research Department since his separation from the Navy in December of 1945. He took an active part in the early phases of the New York-Washington-Pittsburgh radio relay system, including the preparation of a training program for engineers and maintenance personnel. As group head he was responsible for the system design of the MLD-4 equipment. In January of this year Mr. Lenehan was appointed Radio Engineer. He is a member of the Electronic Industries Association Committee for "Microwave Relay Systems for Communications," and is Chairman of the Committees for "Multiplexing and Terminating Equipment," and "Microwave Transmission Systems." He is a member of IRE.

T. M. GRYBOWSKI, Senior Project Engineer, Radio

W. G. VIETH, Senior Project Engineer, Transmission

A Transistorized 20-Channel Carrier Terminal

Designed with plug-in assemblies, numerous accessible test points, many trouble indicating devices, and with high-quality components, a new channel terminal bay featuring transistorized FM carrier terminals requires 60 percent less space and 65 percent less power per channel than previous designs with which it is fully compatible.

SINCE its introduction in 1938 FM carrier has found ever-increasing use in the Telegraph Company's service. Gradual evolution from the Type 15 to the current Type 40 carrier telegraph terminal has seen an increase from two telegraph channels per bay to ten channels in the same space. The equipment herein described mounts two 10-channel groups per bay along with associated power supplies, bias and leg controls and metering and monitoring facilities. This design has been designated as the Type 60 channel terminal.

PHYSICAL DESCRIPTION

The design of the Type 60 channel terminal decided upon in the planning phase of the project included consideration of the degree of size reduction made possible in a completely transistorized equipment, the practicability of manufacture, and the ease of installation and maintenance. These considerations resulted in the complete equipment being mounted on what is now known as Channel Terminal Bay 601-A.

The 601-A bay consists of a standard 19-inch Repeater Rack 11-C upon which the equipment is mounted and occupies 9 feet 4 inches of vertical rack space. The components of the equipment are mounted in order from top to bottom as shown in Figure 1. At the top are the terminal blocks where the external carrier and d-c signal circuits are terminated and where the various components on the bay are interconnected. Next is the carrier coupler panel (not visible in Figure 1) that contains four line-isolating transformers, one

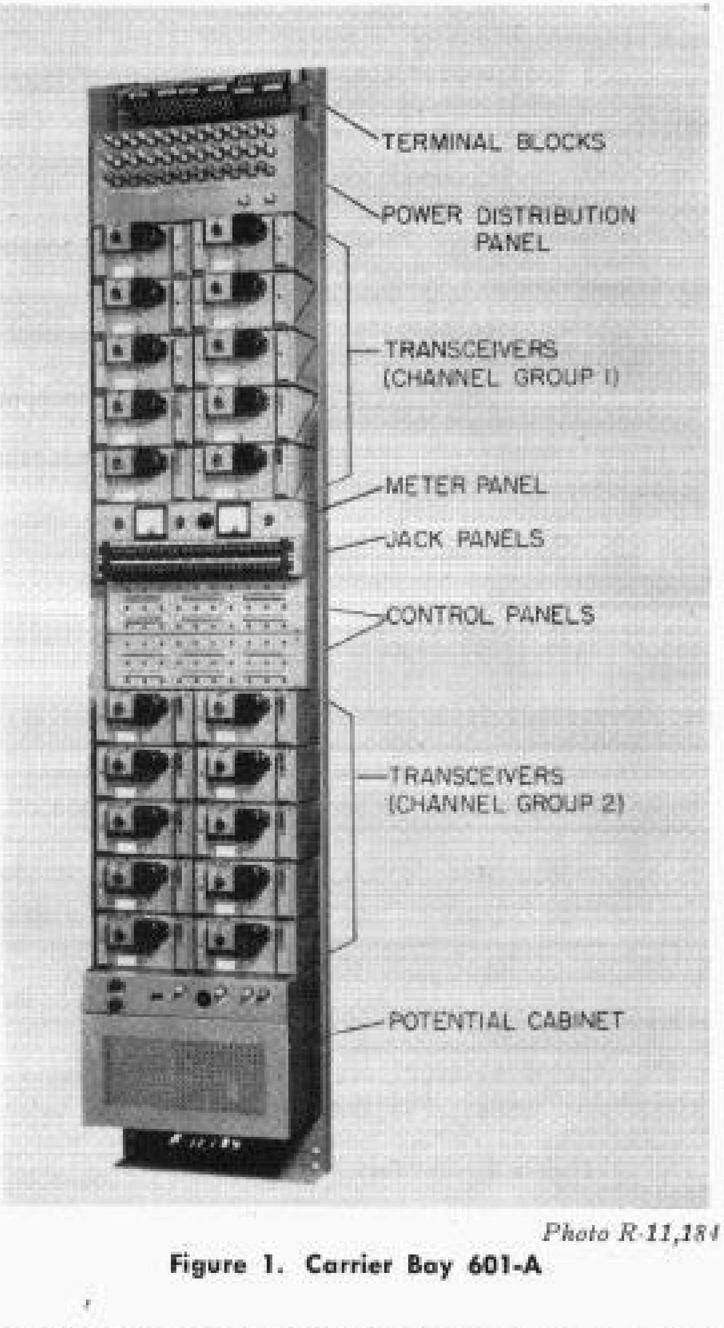


Photo R-11,184

Figure 1. Carrier Bay 601-A

A paper presented before the Winter General Meeting of the American Institute of Electrical Engineers in New York, N. Y., February 1959.

for each direction of transmission for two channel groups.

The power distribution panel contains d-c power indicator type fuses that distribute leg and transistor battery to the individual channels. This location, near the top of the bay, provides good visibility of the blown fuse indicator lamps without the use of more useful operating space. The power is brought to this panel from the potential cabinet at the bottom of the bay by a flexible conduit in the space between the rack channels. Distribution of positive and negative 125-v leg battery and negative 25-v transistor battery to each channel takes place through the wiring duct shown at the left side of the rack. Below this panel are five rack shelves each mounting two of the ten channels of channel group 1. Beneath channel group 1 and located at a convenient height are grouped the metering, monitoring and control facilities for all channels on the bay. The ten channels of group 2 and a potential cabinet and power entrance box complete the bay. The potential cabinet contains the leg battery and transistor battery rectifiers, the main fuses, power switch and a utility outlet. The power entrance box provides termination for external 115-v a-c power and circuit and frame grounds.

A single Type 60 channel terminal consists of a plug-in Transceiver 650-A and associated tuned networks (see Figures 2 and 3) and remotely located leg current and receiving bias controls. The transceiver plugs into its supporting shelf, Figure 4, and is secured by means of a cam lock fitted with a shaft which terminates on the front panel in a two-position (OPEN and LOCK) knob. The networks plug into the transceiver chassis and are fastened in place by screws. Each transceiver contains electronic sending and receiving circuits which are identical for all channels. The operating frequency of the transceiver is determined by the particular tuned networks associated with it. Circuit considerations led to the use of a receiving polar relay Type 202-A which mounts in a socket on the transceiver face.

To meet the wide variety of d-c circuit conditions encountered in the telegraph plant, a "stunt box" socket is also provided. The stunt box or leg adaptor plug illustrated in Figures 2 and 3 permits make-break leg operation on a full-duplex, half-duplex or duplex repeater basis. Other plugs are available for polar, Telex, and a wide variety of special applications. Each leg adaptor plug is secured by a locking latch that can be released by raising and sliding its handle to the right. Other controls on the transceiver face include a transmitter ON-OFF switch, a transmitter LEVEL control and a number of test pin jacks. Only sufficient test points are provided to determine if the unit is defective so it may be replaced immediately with a spare unit to maintain service. Figure 5 shows a rear view of the transceiver with the networks removed, and the hinged side panels open to expose the transistorized subpanels.

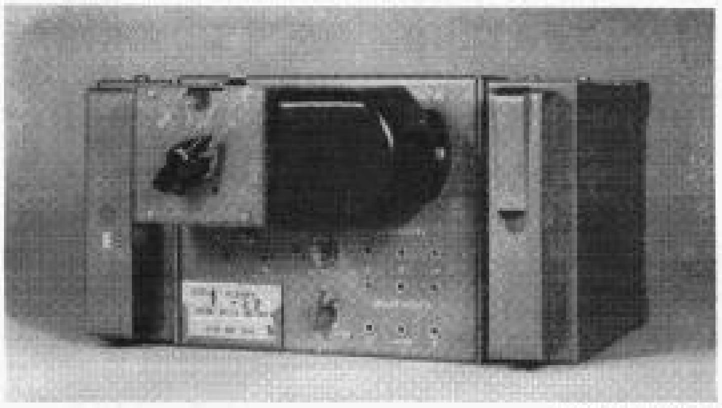


Photo R-11,010

Figure 2. Channel Terminal Type 60

Photo R-11,009

Figure 3. Channel Terminal Type 60 partially disassembled

The control facilities for the bay, Figure 1, consist of a jack panel and control panel for each channel group and a common meter panel. The jack panel permits the meter panel to be corded into the sending and receiving leg circuits of any particular channel so that testing and regulating functions may be performed.

The control panels contain a sending and receiving leg rheostat and a receiving bias control for each channel. Practically all of the heat dissipation in the bay is concentrated in the leg rheostats. This was a major consideration in the rack layout to avoid exposure of transistor circuitry to excessive temperatures, and resulted in an open framework mounting for the rheostats and a louvered front cover to provide maximum ventilation. The back of the rack shelves visible in Figure 4 are also perforated for ventilation of the battery tap resistors mounted on the rear of the transceiver chassis. The perforated and louvered covers on the potential cabinet and control panels, in conjunction with the space between the rack channels, create a chimney effect causing air flow through the bay to prevent excessive temperature rise. Measurements indicate a maximum rise within any transceiver of only 12 degrees centigrade above ambient room temperature.

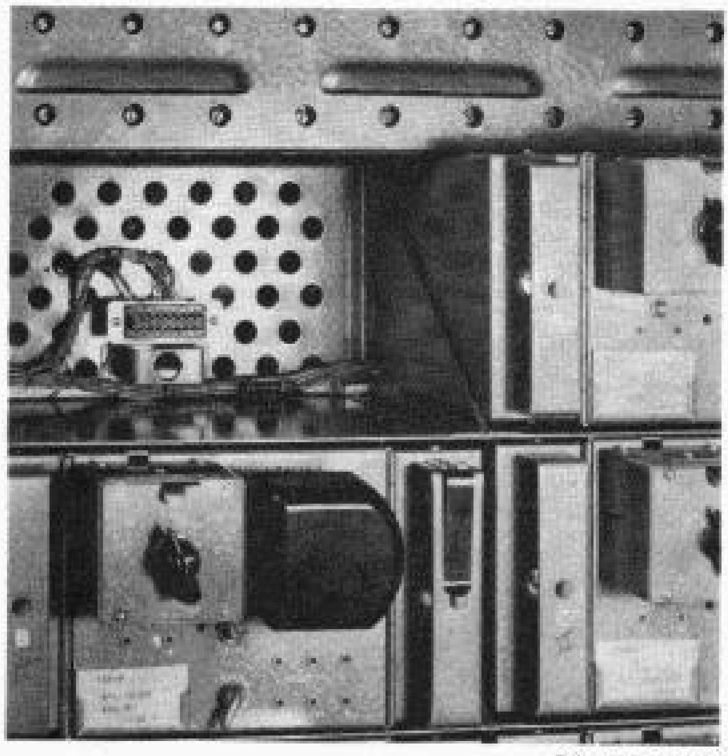


Photo R-11,296

Figure 4. Close-up of bay with one channel terminal removed from a shelf to show shelf detail

The 601-A bay represents a marked change in design of carrier equipment and methods of mounting. Panels and mounting shelves are now essentially a part of the rack, and the plug-in shelf mounting concept for the transceivers and plug-in power supplies make for ease of shipment, installation, inspection, maintenance or replacement. The bay design permits assembly of the permanently mounted components and complete wiring of the bay to be performed at the factory. At installation it is required only to set the bay in place, wire the external transmission facilities to the terminal blocks at the top of the bay and a-c power and grounds to the power distribution box. The transceivers and power supplies are then plugged in place to complete the installation. The plug-in components comprise 340 pounds of the 650-pound total installed weight. The 601-A bay requires 60 percent less office space and 65 percent less power per channel than currently used equipment.

CIRCUIT DESCRIPTION

The Type 60 channel terminal is fully compatible with the Types 20, 30 and 40 currently in use throughout the telegraph plant. In each Type 60 channel terminal

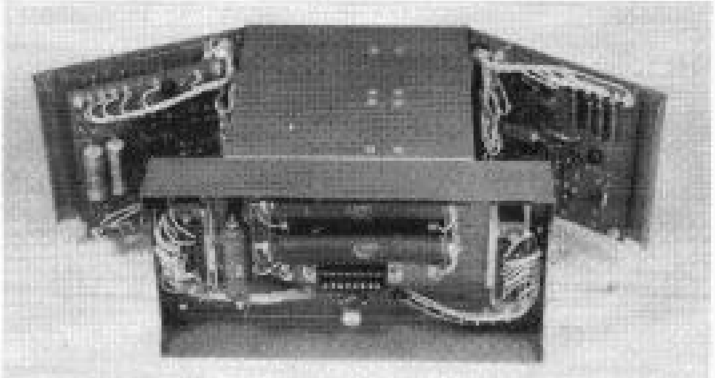


Photo R-11,011

Figure 5. Transceiver 650-A, rear view with hinged side panels open

the marking and spacing signals frequency-modulate an audio-frequency carrier which is then combined with other channel frequencies for transmission over a carrier subband facility. The operating speed of these circuits is 75 bauds to provide suitable margin for teleprinters operating at 100 words per minute. Frequency modulation of the transmitted carrier is accomplished by lowering the carrier frequency 35 cycles below channel mid-frequency for a marking pulse, and by raising the frequency 35 cycles above mid-frequency for a spacing pulse. Ten individual channels are provided, spaced at 150-cycle intervals from 375 to 1725 cps. Both channel groups (channel group 1 and channel group 2) of Bay 601-A utilize the same frequency allocations.

The basic block diagram of a carrier channel as arranged for make-break leg operation is shown in Figure 6. The closing

Transmitter Circuit

Since the general theory of FM telegraphy has been adequately covered[1,2] this paper will describe how the new terminal differs from existing vacuum tube types, particularly with respect to design features necessitated by the use of transistors.

The basic circuit of the transmitter arranged for neutral leg operation is shown in Figure 7. Functionally, the trans-

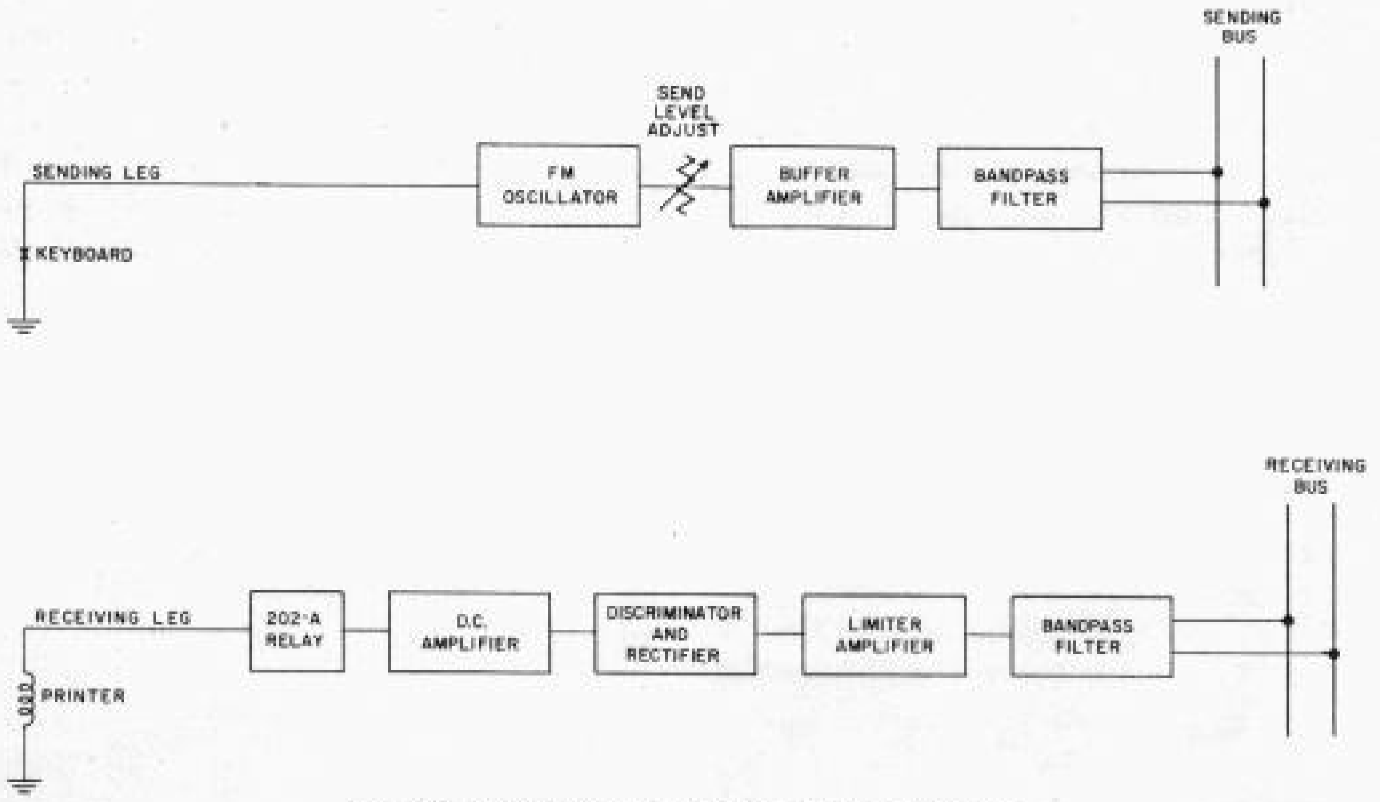


Figure 6. Channel terminal—Type 60, block diagram

and opening of the sending leg by a printer keyboard (or other keying source) causes the frequency of an oscillator to be shifted to the marking or spacing frequency by a capacitive reactance switched into or out of circuit by means of a diode bridge switch. The carrier signal is amplified by a buffer stage and applied through a band-pass filter to the sending bus. Continuous adjustment of the sending level is accomplished with a gain control potentiometer coupling the oscillator and buffer amplifier. At the receiver, a suitable band-pass filter selects the desired carrier signals from the receiving bus. These signals are amplified and limited and applied to a series-tuned discriminator. The resulting d-c polar telegraph signals pass through a d-c amplifier and operate a Type 202-A polar relay.

mitter consists of an oscillator, keyer and buffer amplifier. When the sending leg is closed and the leg rheostat adjusted for a current of 70 milliamperes, a potential of approximately minus 83 volts exists at point A. Since point B is held at minus 104 volts by a voltage divider, the anodes of diodes CR1 through CR4 are more negative than the cathodes (by 21 volts), causing them to be nonconducting. The oscillator frequency is determined by L1, L2, C1, C2, C3, and in small part by the emitter-base or diffusion capacitance of transistors Q1 and Q2. When the sending leg is open, point B becomes positive with respect to A, and the diodes conduct. As a result, capacitor C2 is short-circuited and the resonant frequency is determined by L1, L2, C1 and C3. By design, the two resonant frequencies differ by 70 cycles.

The use of the diode bridge configuration minimizes the induction of a keying transient into the oscillator tuned circuit.

The oscillator circuit is of the push-pull, common (grounded) emitter type similar in operation to the vacuum tube equivalent. The similarity is obvious if the correspondence between collector, base and emitter of the transistor and the plate, grid and cathode, respectively, of the vacuum tube is considered. NPN transistors are used because they provide greater frequency stability with temperature change than PNP types. This is true since the emitter-base capacitance of the typical NPN is less than one-tenth that of the typical PNP. The corresponding change of capacitance due to temperature change is reduced proportionately. An output is taken from a tap on the primary of L1 and applied through the send level control R3 to the base of buffer amplifier Q3. Potentiometer R3 permits a continuous adjustment of the transmitter carrier level. A carrier level of plus 7.5 dbm is available at the output of the sending filter. The input impedance of the send filter is 7500 ohms and the output impedance 600 ohms. The sending filter and the oscillator circuit components C1, C2, C3, L1, L2 and R2 are mounted in the sending network located on the left side of the transceiver and visible in Figures 1 through 4.

The network connectors are polarized to prevent the insertion of a sending network into a receiving network position or vice versa. A sending network is identified by the letter designation of the channel on the handle as well as by a type number and channel frequency stenciled on the top of the network container, visible in Figure 3. The hole in the handle allows access to trimmer C3, which provides frequency adjustment.

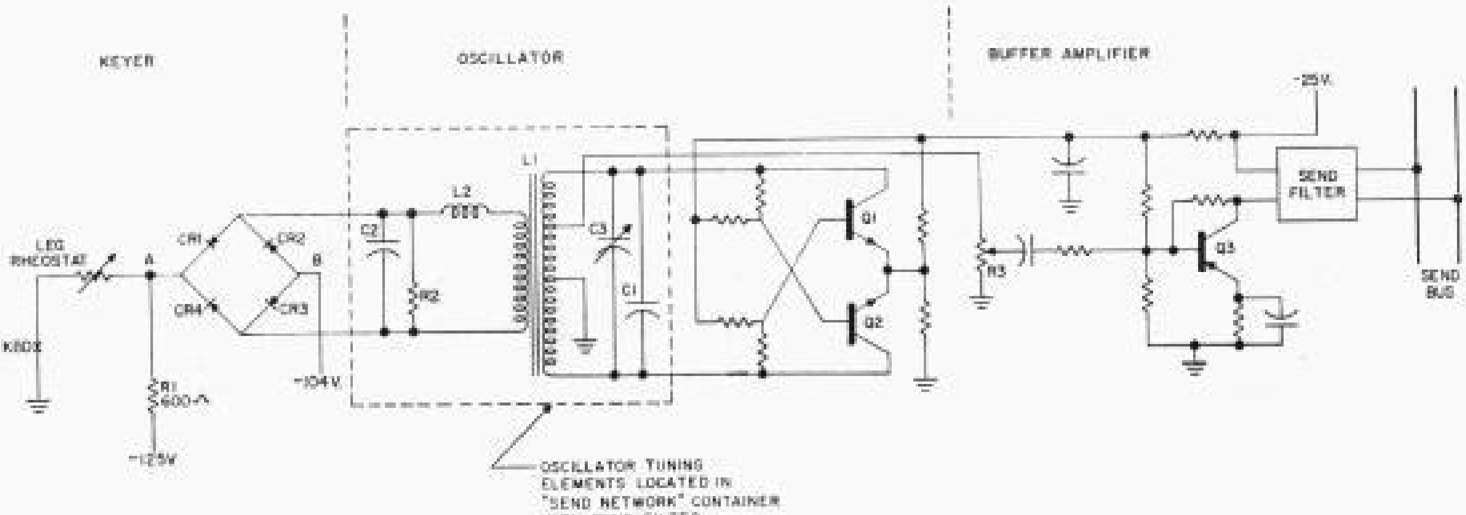


Figure 7. Transmitter circuit

Receiver Circuit

The receiver circuit is diagrammed in Figures 8 and 9. The received carrier signal passed by the receiving filter enters the limiter-amplifier (Figure 8), consisting of transistors Q4 through Q7. Here amplitude variations in the incoming signal are removed and the signal is raised to the constant level required to drive the discriminator. The discriminator driver transistors, Q6 and Q7, are connected in a complementary symmetry arrangement to provide uniform loading of the discriminator transformer T1 and also to simplify the circuit. For signal levels of less than minus 45 dbm, Q4 acts essentially as a Class A amplifier. For larger signals limiting begins. Q5, directly coupled to Q4, further amplifies and limits the signals. For inputs in excess of minus 55 dbm the gain of Q4 and Q5 is sufficient to saturate the output transistors, resulting in an 18-volt peak-to-peak square wave at primary of T1.

The discriminator converts the incoming frequency-modulated carrier to d-c polar signals. These signals are in turn amplified by transistors Q8 through Q11 to operate a polar relay. Four transistors are used as a protective measure since under the three-fold circumstance of loss of incoming carrier, an ambient temperature of 55 degrees centigrade, and proper (or improper) setting of the receiver bias control, the dissipation ratings of the transistors can be exceeded.

The discriminator consists of driver transformer T1 and two series-tuned circuits and their associated diode bridges. A series-tuned discriminator is used since a d-c load current of three to four milliamperes must be supplied to the output transistors. About one milliampere of base current will cause collector current saturation, and the added current gives a measure of post-detection limiting and also allows for transistor variation and aging. Parallel resonant discriminators are essentially high-impedance, high-voltage circuits and are not as suitable for transistor applications as the series resonant type. For this reason series resonant circuits are used which maintain adequate Q while delivering the required current.

In operation, Zs (Figure 9) responds to spacing frequency from transformer T1 to produce a positive output from diode bridge CR5 through CR8. Similarly, Zm responds to marking frequency from T1 to produce a negative output from diode bridge CR9 through CR12. The two bridge signals are differentially combined through resistors R4 and R5 and applied to the input of the d-c amplifier transistors. A typical discriminator characteristic is shown in Figure 10. The peaks in the discriminator responses are 100 to 120 cycles apart to insure a linear response over the channel band. Capacitor C5 (accessible through the hole in the receiving network handle) adjusts the discriminator tuning so that zero response is produced at the channel center frequency.

For an incoming marking signal applied to T1 from the limiter, equal voltages are applied to Zm and Zs, the marking and spacing tank circuits, respectively. Zm, tuned close to the marking frequency, provides a low impedance to the induced voltage; Zs, tuned away from the marking frequency, presents a high impedance. As a result, more current flows through the marking bridge (CR9 through CR12) than through the spacing bridge (CR5 through CR8). Capacitors C7 and C8 act to filter the rectified output of the diode bridges and remove the harmonics of the detected carrier frequency. Due to the larger voltage developed across C8, point A becomes negative with respect to point B. Current flows from point B through diode CR14 and the emitter-base circuits of transistors Q8 and Q9 to cause these transistors to conduct. The voltage drop across diode CR14 biases the bases of transistors Q10 and Q11 to cutoff. (A negative voltage on the base of a PNP transistor results in con-

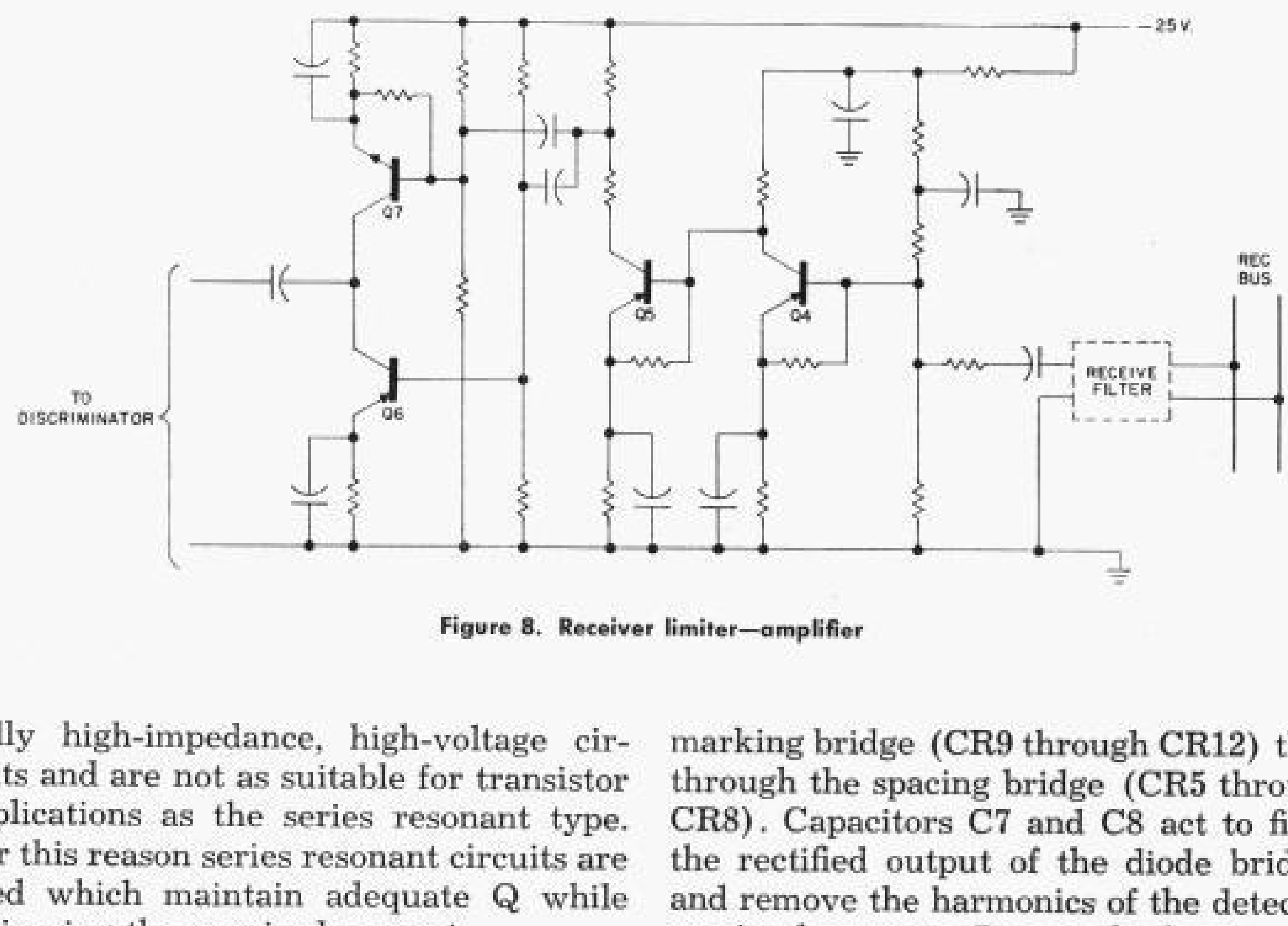


Figure 8. Receiver limiter—amplifier

duction; conversely, a positive potential at the base will result in collector current cutoff.)[3]

Current flows from ground through transistors Q8 and Q9 in parallel, R6, relay windings (U)-(D) and A′-A in series, and resistors R7 and R8 to negative battery causing the relay to close on its marking contacts. When a spacing signal is received a similar train of events occurs except that point A is now positive with respect to point B, transistors Q8 and Q9 are cut off, Q10 and Q11 conduct, and current flows through the other pair of relay windings in series causing the relay to close on the spacing contact. Capacitor C9, in conjunction with the relay coil inductance and series resistances R6 and R10, forms a low-pass filter to discriminate against carrier frequency or other interference lying above the signalling range which may have passed through the receiver filter. The discriminator tuning elements C4, C5, C6, L2 and L3, the discriminator driver transformer T1, and the receiving filter are mounted in the plug-in receiving network located on the right side of the transceiver (Figures 1, 2, 3 and 4). The receiving network is distinguishable in that it mounts a designation clip and omits the channel letter designation on the handle. As with the sending network, the network type number and channel frequency are also stenciled on the top of the container.

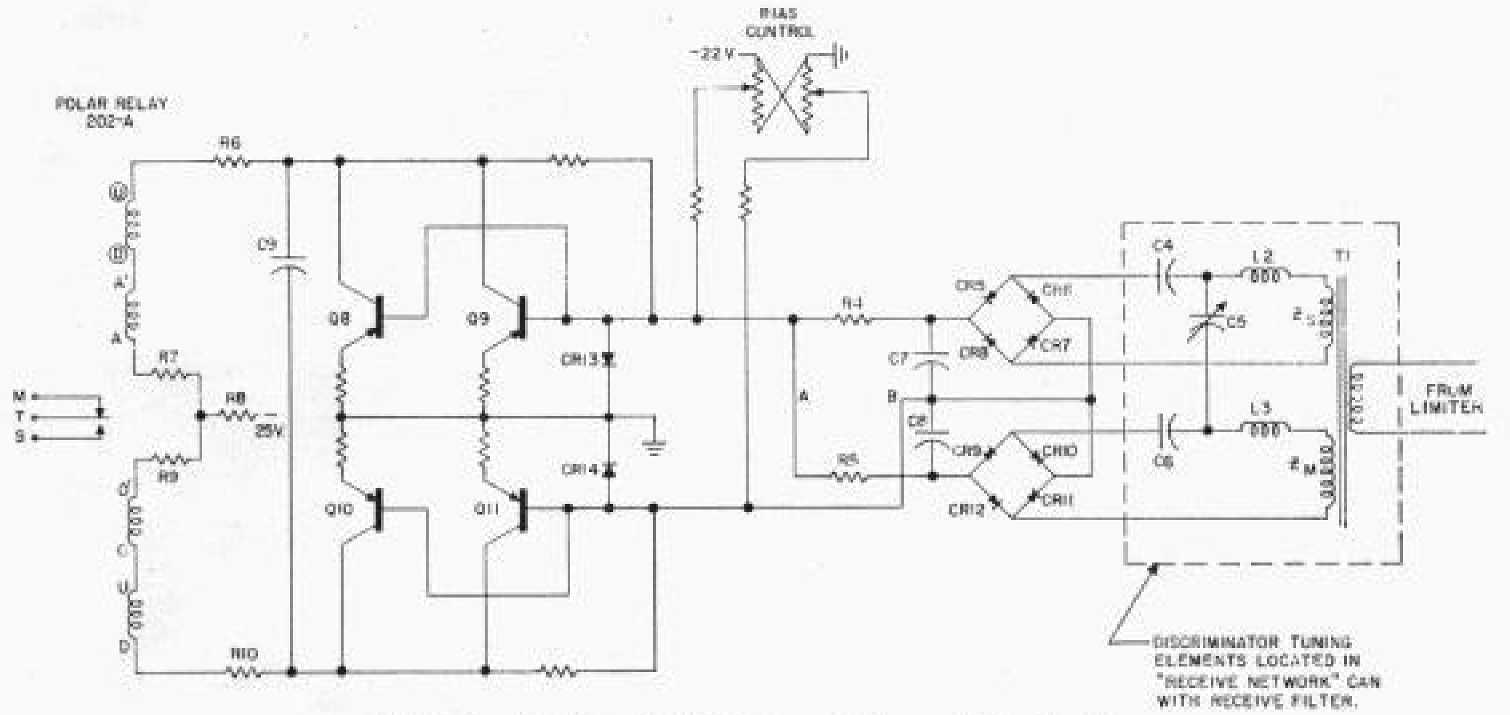


Figure 9. Receiver-discriminator and d-c amplifier circuits

POWER CONSUMPTION

The extent of miniaturization and reduction in power consumption achieved with this equipment was possible only through the use of transistors. Their low voltage, low current requirements, without the need for filament supply voltage, caused a significant reduction in power consumption. Each transceiver, containing 11 transistors, requires only 1.25 watts of power for its operation (25 volts at 50 milliamperes) exclusive of telegraph leg power. This is less than the heater power for a single vacuum tube in the older channel terminal. Also noteworthy is that about 30 milliamperes of the 50 are required by the four transistors operating

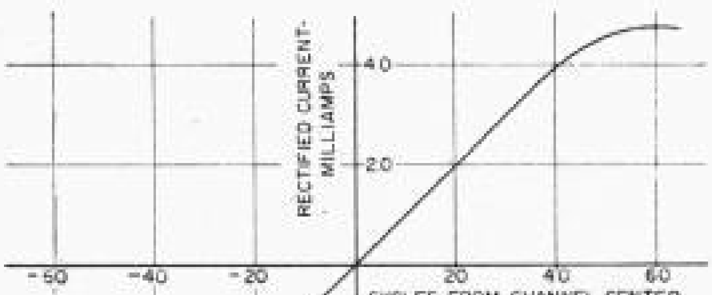


Figure 10. Typical discriminator characteristic

the output relay. The polarity of the transistor battery supply is negative with respect to ground since most of the transistors employed are of the PNP type. A comparison of the power requirements of the Type 60 and the Type 30 is shown in Table I. Of interest is the fact that a bay of 20 Type 60 channels requires less total power than a bay of eight Type 30 channels and occupies no greater floor space.

circuits. Industrial or computer quality transistors are used to insure long life. Silicon junction rectifiers are employed in the power supplies.

Test points on the front of the channel transceiver, visible in Figures 2 and 3, facilitate testing and aid in localizing faults. The indicator fuses located on the power distribution panel and the potential cabinet signal the failure of a particular channel or power supply. Primary power and leg circuit fuse indicators are of the neon glow lamp type. Transistor and bias circuit fuse indicators are of the incandescent lamp variety.

Table I

Comparison of Power Requirements
Type 60 vs Type 30

TYPE 60			TYPE 30		
REQUIREMENT	PURPOSE	POWER	REQUIREMENT	PURPOSE	POWER
—25v, 50 ma	Transistors	1.25w	+120v, 18 ma	Tube Circuits	2.16w
—22v, 5 ma	Bias Control	0.11w	—120v, 73 ma	Tube Circuits	8.76w
—125v, 140 ma	D.C. Legs	17.5w	50v, 20 ma	Bias Control	1.0w
—125v, 7 ma	Voltage Divider	0.875w	—120v, 140 ma	D.C. Legs	16.8w
			—120v, 20 ma	Voltage Divider	2.4w
			25v a-c 1.05 amp.	Filament	26.2w
	Leg Power	17.5w		Leg Power	16.8w
	All Other	3.8w		All Other	40.5w
	Total per Channel	21.3w		Total per Channel	57.3w

Maintenance

In order to reduce the need for and to facilitate maintenance where required, a certain design philosophy has been followed. These ideas may be grouped generally under three headings: quality components, use of test points and other failure-indicating devices, and plug-in construction. The quality components employed include hermetically sealed paper and solid electrolyte tantalum electrolytic capacitors for coupling and bypass purposes in the transistor circuits. Silvered mica and mylar film capacitors are used in the tuned circuits of the sending and receiving filters, oscillator and discriminator tanks. Ferrite cup-core inductors are used in the oscillator and discriminator tuned

Life Test and Field Trial

On January 31, 1958, the prototype bay herein described was placed on 24-hour-a-day life test in the 9th floor laboratory. On July 18, 1958, the equipment was transferred to the 11th floor T&R room where it has been in continuous traffic-carrying service. The caliber of some of the circuits is such that any trouble would be noted immediately and reported by the patron. During the entire test period there have been no failures or trouble of any kind.

The design objectives of this development have been substantially achieved. The advantages of space-saving, flexibility and self-containment as to power supply and test facilities, and reduced heat dissipation enhance the value of this equipment. Both small offices, where load requirements make but a single voice-frequency band necessary, and large installations where space problems, floor loading and air-conditioning load are becoming serious problems, are likely locations for this equipment. The use of reliable and long-lived components should considerably reduce the cost of maintenance. The trouble-free performance of the bay during life tests and field trial is an effective demonstration of the dependable operation to be expected from this equipment.

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2. An FM Telegraph Terminal Without Relays, F. H. CUSACK and A. E. MICHON, *Western Union Technical Review*, Vol. 1, No. 2, October 1947.
3. Transistor Characteristics and Circuits, HARRY C. LIKEL, *Western Union Technical Review*, Vol. 11, No. 4, October 1957.

T. M. Grybowski joined the Radio Research Division in 1951 after a period as an instructor in the Electrical Engineering Department of New York University. His early work for the Telegraph Company was on the fault location and IF amplifier sections of the MLD-4A microwave radio relay system. He developed the wider bandwidth IF amplifiers used in the modification of the New York-Washington-Pittsburgh radio beam triangle in 1955, and the shielded IF preamplifier for use in high-interference level areas on the same system. The narrow-band microwave receiver used for forward scatter propagation tests was also one of his developments. During his association with the Transmission Research Division in 1957 and 1958 the carrier telegraph terminal described in this paper was developed. He is presently engaged in the development of an IF preamplifier and mixer for 4000- and 6000-mc microwave receivers. Mr. Grybowski received his B.E.E. from Manhattan College in 1949 and his Master's Degree in E.E. from New York University in 1951. He is a member of IRE.

W. G. Vieth joined the Transmission Research Department in 1927. From early in his association with Western Union he has been engaged in the design, testing and standardization of carrier current telegraph components and terminal equipment for AM, FM, and pulse-amplitude modulation systems. At present he is coordinating the mechanical design of carrier and data handling equipment in the Transmission Division. Mr. Vieth received the degree of B.S. in E.E. from New York University. He is an active member of AIEE, serving as Secretary of the Telegraph Systems Committee, Vice Chairman of the New York Section, and as a trustee of the Engineering Societies Library and of Engineering Index. He is also a member of IRE.

Telefax Developments

Among advances in the facsimile art during 1958 as reported at the recent AIEE Winter Meeting were these interesting developments.

MOLDED STYLUS BELTS FOR TELEFAX RECORDERS

Western Union's continuous facsimile recorders, like most multistylus recorders, have employed an endless steel belt on which the individual stylus holders are mounted. Due to the stringent accuracy requirements, quality control in the fabrication of these belts has been a problem and production costs high. Belt life has been limited by a number of physical considerations and an improved design has been sought.

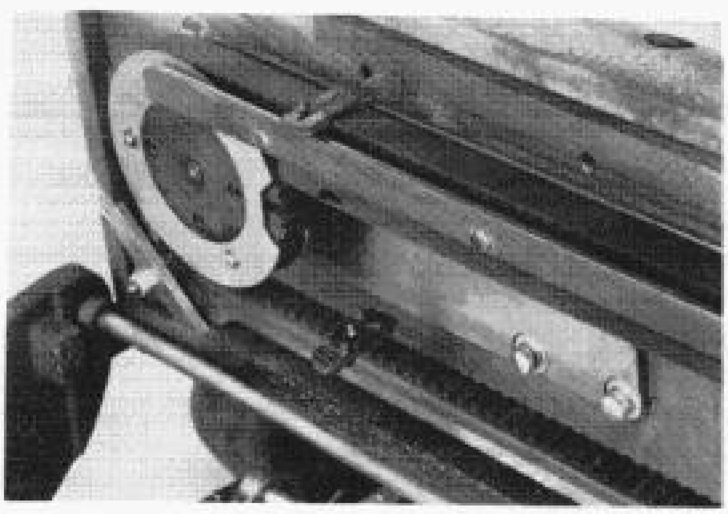

Photo M-4035

Figure 1. Molded stylus belt geared to drive pinion

A solution to this problem appears to be a toothed neoprene belt with imbedded steel wires commonly called the "Gilmer" belt. Since this is a molded belt, once a sufficiently accurate mold is obtained accurate reproduction of the belt itself is assured and quality control problems are largely limited to mounting and positioning of the stylus holders. A preferred method for accomplishing this has been devised and patented by D. M. Zabriskie.

Molds have been developed for belts for both Recorder 7219 used in Letterfax (documentary) facsimile services and for Recorder 5616 (standard telegram size) used primarily to record messages from Desk-Fax* transceivers in public message service. Extensive laboratory tests of the molded Letterfax belt indicate that it meets the requirements with respect to accuracy of stylus position and dimensional stability and its life is many times greater than that of the steel belt. In fact, it was found necessary to redesign the stylus holders to take advantage of the greatly increased belt life. Field testing of the new Letterfax belt is in progress and Recorders 5616 also are being equipped with the new type of belt for field trial.

WRAPPER DRUM FOR VERTICAL FACSIMILE TRANSMITTER

One of the problems in the development of facsimile systems and apparatus is to provide for the efficient handling of various sizes of subject copy. Most business organizations have several sizes of forms in regular use and it is not always a simple matter to change to a standardized form. For this reason several different types of facsimile equipment are in use, some of which are especially tailored to fit specific applications; for example, weather map service (12 by 18 inches), documentary service (8½ by 11 to 13 inches), and space reservation service (1½ by 4½ inches). It is for this reason, also, that equipment designed for documentary service generally is provided with the facility to handle sheet sizes smaller than the maximum as, for example, in the Western Union Letterfax where there is a scanner drum transparent plastic wrapper under which any size sheet smaller than the maximum may be inserted for scanning.

Recently a wrapper drum has been designed for the Western Union vertical drum transmitter somewhat similar to that for the Letterfax transmitter which enables the mounting of any size subject copy up to the maximum limits. In one installation, signature verification is pro-

*Registered Trademark, W.U.Tel.Co.

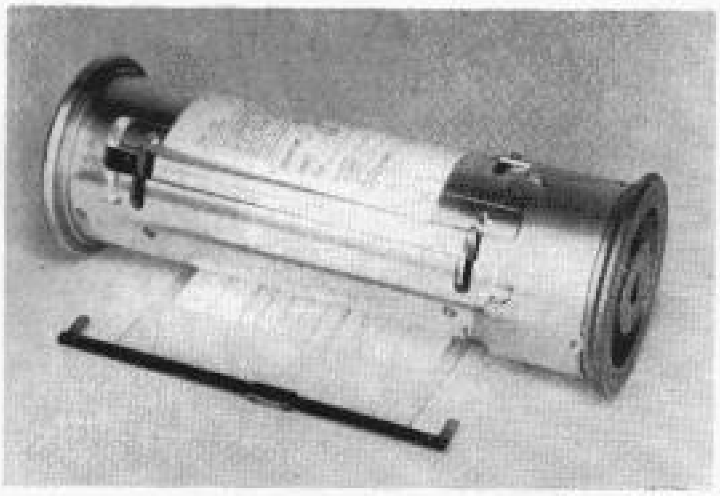

Photo R-10,872

Figure 2. New drum for vertical facsimile transmitter has plastic wrap-around message cover

vided by transmitting signature cards from the main office of a bank to any branch upon request. Stop payment notices are also transmitted to all branches using these equipments. Several such notices may be mounted under the wrapper at one time since they are small and

Photo H-1590

Figure 3. Drum is positioned in vertical transmitter

only one line of text on each notice need be transmitted. This drum and the simpler standard (telegram) drum using toroidal springs for sheet mounting are interchangeable and are inserted into the transmitter in much the same manner as the container is inserted into a soda-fountain mixer.

TICKETFAX IN NEW YORK

Equipments and the system for handling Pullman space reservations by facsimile in the Philadelphia area have been described.[1,2,3] This service was extended to the New York City area coincident with the modernization of ticket-handling facilities there at Pennsylvania Station. All purchasers of Pullman space on trains leaving Penn Station receive a facsimile of the ticket representing that space, the tickets themselves remaining on file at Penn Station.

Two concentrators equipped with a total of eight transmitters and eight recorders of the type used in Desk-Fax service serve 25 industrial customers and agencies throughout the metropolitan area. These customers utilize Desk-Fax transceivers to transmit requests for space and to record their facsimile tickets. Eight Ticketfax recorders serve the front counter at Penn Station. These record facsimile tickets transmitted by any of 18 Ticketfax transmitters located throughout the ticket file area. Requests for Pullman space are by voice communication from the front counter. These 18 transmitters operate through a push-button switching concentrator so that any one may transmit to any of the front counter positions or to any of seven other recorders located at six branch or satellite offices. Requests for Pullman space from the satellites are received on a bank of ten recorders operating through an automatic line-finder concentrator.

Another push-button concentrator employing five Ticketfax transmitters is used to transmit space reservations to recorders at "will call" positions in Penn Station and to three of the satellite offices for pickup by patrons making reservations by phone to Penn Station. Four of the transmitters and associated push-button turrets of this concentrator may be seen in the photograph. At the right are the ten recorders associated with the automatic concentrator serving the satellites.

It is interesting to note that although one of the New York satellites is at Trenton, N. J., the 6-second scanning time for the 1½-by-4⅛-inch scanned area is maintained throughout the system. This is due in part to the availability of large-gage conductors along the railroad right-of-way, only one repeater being required. A problem was presented in connection with the Newark and Trenton satellite circuits due to their operation on a different power system from the rest of the network and the unusual method of phasing employed in the high-speed Ticketfax recorder. This was solved by transmitting a sample of the 60-cycle commercial power driving the recorder to the transmitter, which is provided with a motor-drive amplifier. At Penn Station no special transmitters are assigned to the New Jersey satellites; selection of either satellite at the push-button turret disconnects New York power from the drive motor of the transmitter being used and connects a motor-drive amplifier whose input is connected to New Jersey power.

Photo H-2115-C

Figure 4. Ticketfax equipment at Penn Station, New York

Ticketfax equipments also are being used by a brokerage firm in the handling of reports of executions of odd-lot transactions on the New York Stock Exchange. In this application odd-lot orders from the firm's offices are received at the Exchange on tape printers and gummed to a 3-by-4½-inch form. After the transaction has been completed, this form with the price written thereon is folded lengthwise and inserted into one of a bank of Ticketfax transmitters which transmits the pertinent information to the firm's main office. Here appropriate records of the transaction are made and a confirmation sent back by printer to the originating office. Information now handled over the facsimile link previously was handled by telephone. Fewer errors are incurred in the facsimile operation. The original system has been in operation since January 1957 and handles about 2400 transactions on the average day on the Exchange. An additional circuit for this firm handles sales and reports between one of the New York branch offices and the main office experimentally. Some changes have been made in the Ticketfax equipments for this installation to accommodate a different blank size.—J. H. HACKENBERG, Assistant to Telefax Engineer.

References

1. THE TICKETFAX SYSTEM, ARCHIE S. HILL, *Western Union Technical Review*, Vol. 9, No. 3, July 1955.
2. TICKETFAX TRANSMITTERS AND RECORDERS, DOUGLAS M. ZABRISKIE, *Western Union Technical Review*, Vol. 9, No. 3, July 1955.
3. TICKETFAX ELECTRONICS, CHARLES JELINEK, JR., *Western Union Technical Review*, Vol. 9, No. 3, July 1955.

F. BEAUMONT BRAMHALL

As Chairman of Western Union's Committee on Technical Publication, which is responsible for production of the REVIEW, F. Beaumont Bramhall has expertly guided that undertaking over a period of some ten years. Now, after 38 years of company service, his retirement as of February 28 has been announced.

His personal contributions to the technical literature of telegraphy have been primarily concerned with transmission techniques and carrier circuit developments. His authoritative articles in these and other areas have appeared in the REVIEW and other technical publications. In 1957 he received the F. E. d'Humy Award in recognition of his "contributions to the art of frequency-modulated carrier telecommunication and for technical direction leading to its wide adoption." His duties with Western Union have included those of Transmission Research Engineer, Transmission Planning Engineer and Automation Engineer. He is a Fellow of AIEE, Senior Member of IRE, and has been active in the Association of American Railways and in the Electronics Industries Association. He has been regarded quite generally by his professional associates as Western Union's ambassador and plenipotentiary.

Between 1949 when Mr. Bramhall assumed the chairmanship of the Committee on Technical Publication and 1959 the REVIEW has been favored with ever-increasing prestige as well as continuous expansion in circulation among both professional and nonprofessional workers in the communications industries. The Committee herewith records its acknowledgement of Mr. Bramhall's inspiring leadership and expresses its deep appreciation.

Patents Recently Issued to Western Union

Telegraph System

T. S. PESSAGNO, W. B. BLANTON, B. V. MAGEE
2,860,177—November 11, 1958

Way-wire signal system wherein pressure of a push-button corresponding to the station for which a message is waiting causes a single numbering machine common to all of the stations to send first an activating signal followed by a sequence of characters, one or a group, for each way station, in order. For the wanted station or stations, the characters perform a selection but for all other stations are nonselecting. The sequence number is then sent, followed by a release signal for the nonselected stations, and then the message, so that all stations print the initial characters and the sequence number but only the selected station or stations print the message.

Message Accumulator and Stacker

E. W. HEWITT, J. J. KRAKUSKY
2,868,874—January 13, 1959

In a page teleprinter which is equipped with means for automatically severing the message sheets in random lengths, a stacking mechanism which, as each message is ejected, lifts the near edge of the stack so that the new message is added at the bottom. The message stack rests upon the hinged printer cover as does the stacking mechanism which is belt driven from the printer platen.

Two-Way Facsimile Repeater

F. G. HALLDEN, M. J. MCCANN
2,870,246—January 20, 1959

A repeater system for facsimile signals which employs separate amplifiers for each direction activated alternatively for transmission in either direction by the facsimile d-c control signals as applied either by the central office or by a branch office. Normally the control signals by-pass the facsimile repeater, but in one version a supplemental relay system regenerates the control signals as well. Repeaters of the second type may be inserted as needed in long circuits.

Microwave Energy Attenuating Wall

H. E. STINEHELFER
2,870,439—January 20, 1959

A wall or barrier for absorbing microwave energy as for the testing of antennas and for shielding, comprising a surface of insulating material bearing parallel V-shaped serrations of 20-30-degree angle and coated with an electrically resistive film. The microwave energy, as it enters the V, is attenuated by the multiple reflections. The wall may be divided into sections with the serrations of each oriented at right angles to each other.

Facsimile Apparatus for Use in Producing Tickets, Messages and the Like

R. J. WISE, D. M. ZABRISKIE
2,872,275—February 3, 1959

A facsimile machine in which the leading edge of a message blank is inserted into the crevice formed by the junction of a wrapper web with a cylindrical former and the former then rotates to draw the blank into cylindrical form for inside scanning. Further mechanism aligns the blank with the scanner and, after scanning, rotates the former in reverse to eject the blank. Although a recorder is illustrated, transmitter scanning is also contemplated.