F. B. BRAMHALL, Transmission Planning Engineer

Transmission of Business Machine Data Over Standard Telegraph Channels

Business machine data may be transmitted readily over telegraph communication circuit facilities. Although minor modifications in terminal equipment may be desirable, the telegraph company's standard FM channels are not susceptible to conditions that disturb AM operation. Wave distortion and timing of signal impulses delivered to data processing apparatus, and propagation delays are discussed.

Computer Requirements

The transmission of digital information over long distances for the operation of business machines is a problem that will engage increasing attention of communication engineers. High-speed electronic computer-type business machines are being called upon more and more to operate on information fed from distant points. This new form of transmission results in encoded information which is not at all intelligible in the accustomed sense. Such communication is nevertheless telegraphy in every true sense of the word. The "record" of this new form of record communication may not be a printed page to be sure, but rather a record more easily reread into the computer machine when needed. The technical problems encountered in the transportation of business-machine information from one point to another are those long familiar to the telegraph engineer.

While it may be expedient that the computer functions of the business machine be carried out at high speed, the operating speed of the communication circuits which bring information from distant associated business offices may be quite different. The reasons for this difference are varied. For instance, the computer may be serving several distant branches on a time-sharing basis. Further, a considerable part of the information fed to the computer for a given task may be unchanged from a recent previous assignment and may, therefore, have already been stored in memory devices. For instance, in payroll work, the hourly rates, the tax rates and the like are probably unaltered, only the hours information is brought in over the communication circuit each pay period. Likewise, in an inventory type of operation, prices are remembered by the machine, only type numbers, quantities, and the like come over the wire. The required telegraphic speed then, instead of being in the region of hundreds of thousands of pulses (bits) per second, may well be such that it can be accommodated by a few hundred cycles of bandwidth or indeed even by one or more conventional telegraph circuits. Fortunately, modern record communication facilities lend themselves readily to almost any signaling speed that ultimately may be proven most advantageous from the standpoint of the machine and the work it is required to perform. Only minor new developments in terminal equipment are required to accommodate these new business methods as they evolve, in any case.

Present Facilities

The 3-kc voice-width band is the "vehicle" of all present-day, long-haul telegraphy. Operated by time-division technique, with the coded data transmitted seriatim at high speed, this universal vehicle will convey many hundred information bits per second. It may well evolve that this commonly-available unit of communication spectrum will come into wide use for feeding information to and deliver-

A paper presented before the Summer and Pacific General Meeting of the American Institute of Electrical Engineers in San Francisco, Calif., June 1956.

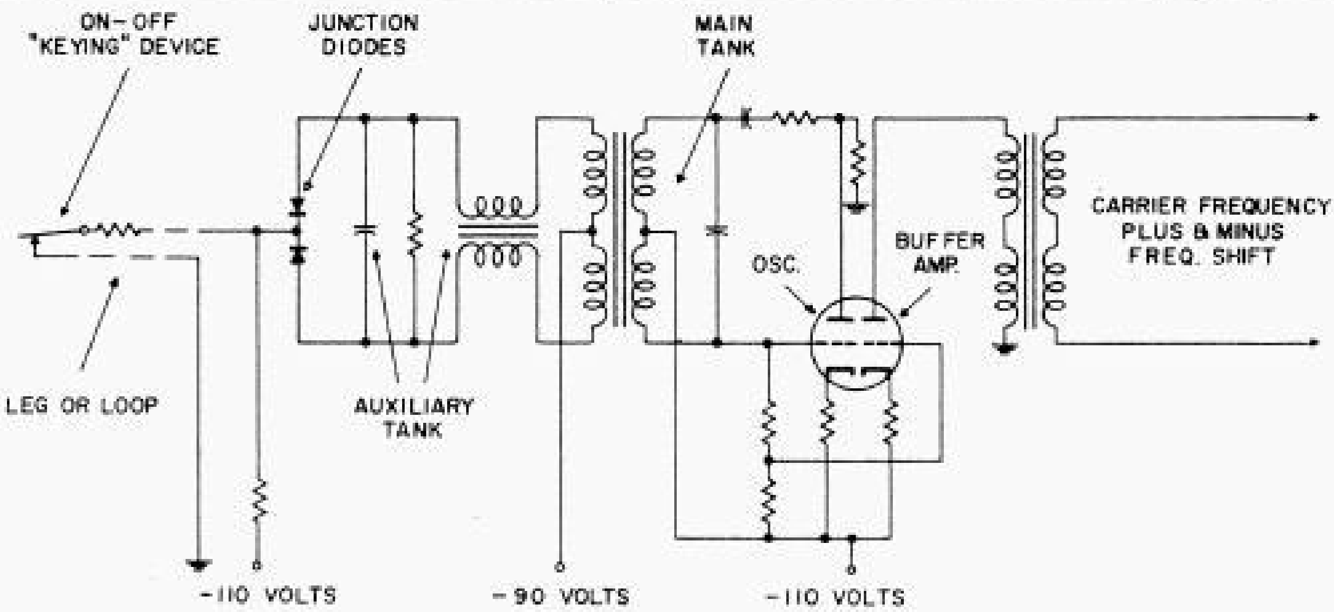


Figure 1. Electronic transmitter of frequency-modulation telegraph channel

ing results from digital computer-type business machines. Another readily available communication spectrum unit is the half-band. The 3-kc bands of the Telegraph Company's entire trunk network are divided into two half-bands or "subbands", as they are called. Each of these subbands has a useful spectrum range from approximately 350 cycles to 1,625 cycles. This subband with a probable speed capability of perhaps 750 or 1,000 bits per second may prove to be a useful and economical spectrum unit for data transmission.

As used in conventional message traffic and private lease service, each subband carries ten telegraph channels. The signaling rate on these telegraph channels is 45, 57, or 75 bauds (bits per second), depending on the nature of the service. Contemplating the widespread use of 100 speed (words per minute) particularly in private wire service of special classes, the modern telegraph plant was designed to render substantially error-free transmission at 75 bits per second. Presently a considerable demand for data transmission at rates materially lower than 750 bits per second is being met by the use of one or more of these standard trunk telegraph channels. The following sections of this paper are devoted to a recitation of the characteristics and capabilities of these channels.

Frequency Modulation

The Telegraph Company pioneered in the development and application of frequency modulation for telegraphy. Its whole plant, comprising several million channel miles, is operated by this method. As a result, it enjoys a unique freedom from errors due to changes in transmission equivalent on the "vehicle" channels, and errors due to extraneous disturbance from all sources.[1, 2]

In simplest language, these advantages accrue from the circumstance that positive control is maintained at all times. In transmission, a "yes" bit is represented by a certain frequency, and a "no" bit by another frequency. This contrasts strongly with amplitude modulation, where "yes" is represented by the presence of a carrier, and "no" is only presumed because nothing is transmitted during the intervals of all "no" bits. In the AM, on-off method, spurious impulses due to either man-made or natural interference may be easily interpreted as "yes" during a "nothing" period. A second great advantage of FM also follows from the fact that "yes" and "no" are represented by equal-valued signals of different frequencies. Changes in signal strength do not cause shortening or lengthening of the "yes" bit with respect to the "no." The length of each is determined only by the time interval between the frequency shifts from one to the other and not by the magnitude of the incoming envelope of carrier compared to a local reference level, as in AM signaling. Design objectives and automatic controls notwithstanding, attenuation changes on the "vehicle" carrier system do occur. Balancing, shielding and other precautions mitigate but never completely eliminate noise. The transmission system which side-steps these hazards has been shown to offer great advantage in error freedom.

The Telegraph Channel Transmitter

A brief exposition of the theory and circuitry of the standard telegraph channel terminal will show its extreme simplicity. From a read-out at the sending station, it is required only that "d-c" potential be applied to a "loop" circuit which shifts the frequency of the transmitting oscillator. The schematic arrangement of the control circuit of that oscillator is shown by Figure 1.

The transducer which converts the coded "d-c" signals into corresponding frequency changes of the carrier is, in fact, only a pair of contact rectifiers. When rendered conducting by the opening of the transmitter loop, the frequency of the carrier oscillator is increased. When made nonconducting by the closing of the loop, the oscillator frequency is depressed. The difference between these two frequencies is 70 cycles. The shift from one to the other takes place rather abruptly, with the trigger action specified by Figure 2, all within the limits of a 20-volt swing in control potential. The frequency shift as observed at the output of the sending-end channel filter, however, is gradual, as dictated by the bandwidth of that filter. (The concept of "amplitude time constant" in a band-pass filter is a familiar one. It is commonly remembered that the time required to establish a new carrier amplitude at the output of a filter is inversely proportional to half the bandwidth. The fact that a filter has the same reluctance to accommodate a shift in frequency is equally valid, though perhaps not so generally appreciated.)

For no other reason than to permit a complete mental picture of the signal currents resulting from frequency-modulating a carrier, Figure 3 is presented. "A" depicts the control current delivered to the telegraph channel terminal when the information is alternate "yes" and "no" bits. "B" shows the essentially instantaneous frequency shifts which result. "C" shows the frequency-shifted wave after it has passed through the band-limiting "channel" filters. Two special characteristics are of interest. The frequency

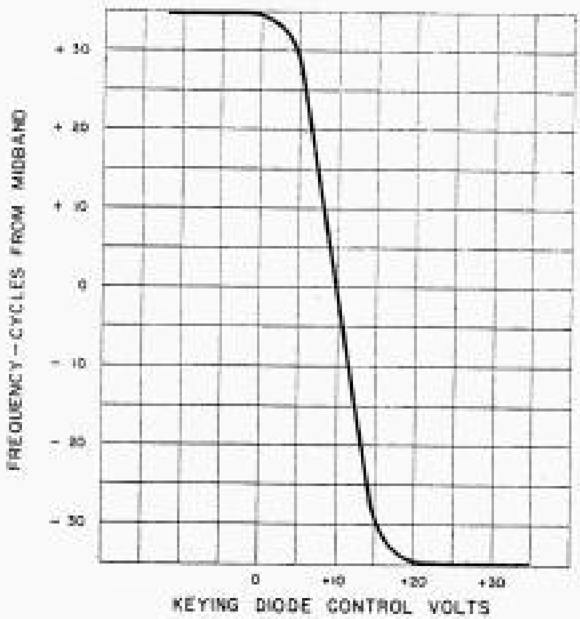


Figure 2. Response of FM oscillator to keying potential

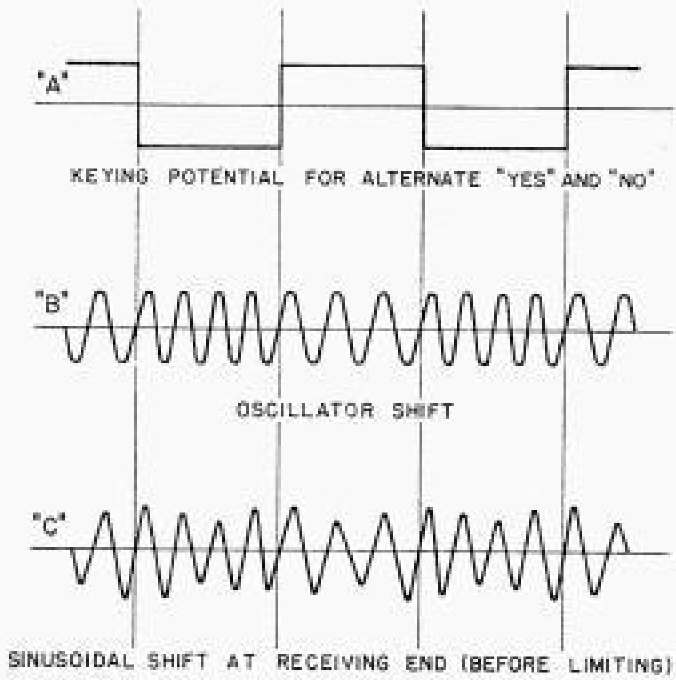


Figure 3. The carrier signals in frequency-modulation telegraphy

change is gradual, practically sinusoidal in fact, just completing one transit in time to start the next. The frequency change is accompanied by a decrease in amplitude corresponding to each upward and downward shift. This latter characteristic is the result of eliminating products of modulation higher than the first order sidebands.

Keying Methods

Actually, a carrier transmitter may be "keyed" by one of several techniques. A preferred method is by the opening and closing of a 2-wire loop as indicated by Figure 1. A simpler method, permissible when the "keying machine" is close to the carrier channel terminal, is by the opening and closing to ground of a single wire "leg." By rearrangement of the potentials applied to the channel terminal, it is permissible to "key" by the application of positive battery to a single wire leg. Polar battery, too, with negative representing "yes" and positive representing "no" may be employed.

The keying may be at any rate up to and including 75 bits per second, corresponding to a bit duration of 13.3 milliseconds. It is presumed, however, that "bit" timing intervals are uniform with a fair degree of precision. In other words, all signal intervals, whether open or closed, "yes" or "no," are presumed to be of 13.3-millisecond duration or of lengths which are integer multiples of 13.3 milliseconds.

Wave-form Distortion

The absolute propagation time is ordinarily not a significant characteristic of a telegraph circuit for simple station-to-station teleprinter working. Only when a communication system depends upon answer-back or error correction does transmission delay become an important matter. Relative shifts of pulse arrival time from the idealized are, however, extremely important in transmission of all forms of encoded information. In nearly all systems of record communication, some selection or gating device functions on a local receiving-end time base. Time displacement of the rise and decay transients of signaling pulses or bits from their idealized position is distortion. Measured in milliseconds, it has a concrete meaning to the terminal equipment designer. For these reasons, considerable attention is devoted to arrival wave forms and the possible conditions which may displace or alter them. In Figure 4, there are presented time graphs of the response of the channel as measured at the FM detector, the discriminator. The response is shown as having a negative sign for the "no" or low-frequency condition, and as positive for the "yes" or high-frequency condition. For the immediate purpose, the receiving mechanism will be presumed to be actuated when the detector voltage passes through zero. By this token it will be noted from graph "A" that the arrival of a "yes" indicating "crossover" lags its initiation at the sending station by just under 30 milliseconds. It should be noted also that arrival wave "A" overshoots 100-percent response and oscillates mildly.

For the purpose of the following dissertation on wave forms it is convenient to consider a specific pattern of "yes" and "no" bits. The presumed transmitted signal combination for curve "A" is a number of "no" bits followed by a number of "yes" bits. If the situation is reversed and the signals under study are a number of "yes" bits followed by a number of "no" bits, then the transient from one to the other has the shape of curve "B." The transition from the one to the other is presumed to have been initiated one "bit" interval later than the transition shown by "A." Ideal transmission would, of course, require that the "A" and "B" arrivals, the points of zero crossing, be precisely one bit length apart. This would be only a necessary but not a sufficient criterion of perfect receiving-end signal reproduction. In perfect transmission, the arrival of any "bit" transient, no matter what information preceded, "yes" or "no," must coincide with perfect "bit" interval timing. Any departure from ideal timing of a transient due to the combination of "yes" and "no" pulses may very appropriately be called "previous history" distortion. This term is perhaps not found in a glossary of telegraph words, but it does have the acceptance of fairly common usage and is certainly descriptive.

By graph "C" is shown the arrival wave resulting from the transmission of a single "yes" bit following a number of "no" bits. It is to be noted that the zero crossovers marking the beginning and ending of the pulse do not fall precisely where they would had the information content of the character been different. It is not at once apparent which timing is ideal. Speculation quickly reveals that neither beginning nor ending is the same as it would have been had the pulse train been alternate single "yes" and "no" bits. Still, it is not obvious which timing should be called the standard. By accepted usage, the locations of the crossovers of a steady succession of alternate positive and negative "bits" are taken as the reference standard. Pulses shortened, lengthened, or displaced from that standard are said to be distorted. If the distortion is of a repetitious form which may be attributed to an electrical characteristic of the circuit, sluggish response, or other exhibits of nonlinearity or memory, it is said to be "characteristic" distortion. Good engineering practice in the Telegraph Company holds this distortion within plus or minus 1.0 millisecond per telegraph section.

(A telegraph "section" is defined as that part of a circuit included between two carrier channel terminals. A glance at the national circuit layout and routing chart indicates that section length has little, if any, relation to circuit miles. Even many transcontinental circuits are but a single section. The audio-frequency, frequency-shifted carrier generated in New York City for instance, for a Los Angeles, San Francisco, or Portland transmission of about 2900 miles, is first detected and restored back to bit length "d-c" pulses at the city of destination. On the other hand, the 90-mile New York to Philadelphia hop is also a section. Transmission frequency on the two is essentially the same.)

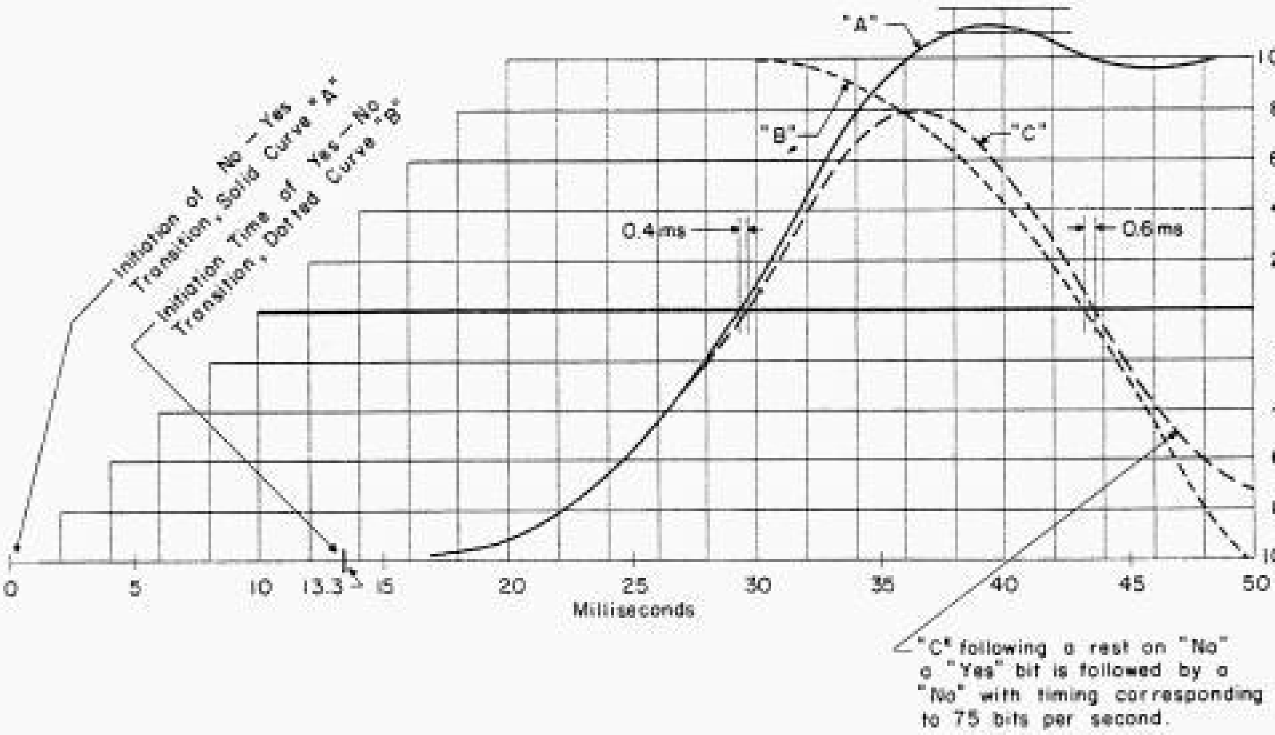


Figure 4. Time delays and wave forms in telegraph channel at 75 bits per second

Distortion which consistently lengthens either the "yes" bit or the "no" bit with respect to the other is called "bias" distortion. Marking bias lengthens the "yes" at the expense of the "no," and spacing bias lengthens the "no" at the expense of the "yes." Bias distortion is not allowed to exceed 5 percent of bit length.

A third source of bit length variation is the distortion due to noise, crosstalk, and/or whatever form of extraneous currents or spurious signals may creep into the signaling path from man-made or natural sources. Such interferences are present in all communication, but under good design and particularly with frequency modulation the susceptibility to their influence is minimized. This form of distortion is defined by the apt descriptive adjective "fortuitous," meaning quite by chance, completely and wholly irregular. Figure 5 shows the response of the pulse amplifier of the carrier channel terminal to the discriminator detector action. Into that amplifier is built such "trigger" action as to make complete rise or decay of the delivered pulse take place in about two milliseconds. The wave form delivered by that amplifier is a trapezoid, the rise of which is just slightly slower than the decay.

minal machines and trunk circuit equipment. If signals are used directly to drive an electromagnetic device, the nominal steady-state current is either 60 or 70 milliamperes. If the machine employs electronic techniques and presents essentially ohmic impedance to the communication link, 20-milliampere loop current may be used. Figure 6 summarizes the maximum permissible distortions as 13 percent of the bit length at 75 bps.

Propagation Delay

The absolute delay from sending mechanism to receiving mechanism is shown as about 30 milliseconds. This parameter of the usual telegraph transmission facility perhaps should be somewhat more carefully broken down. In the first place, there

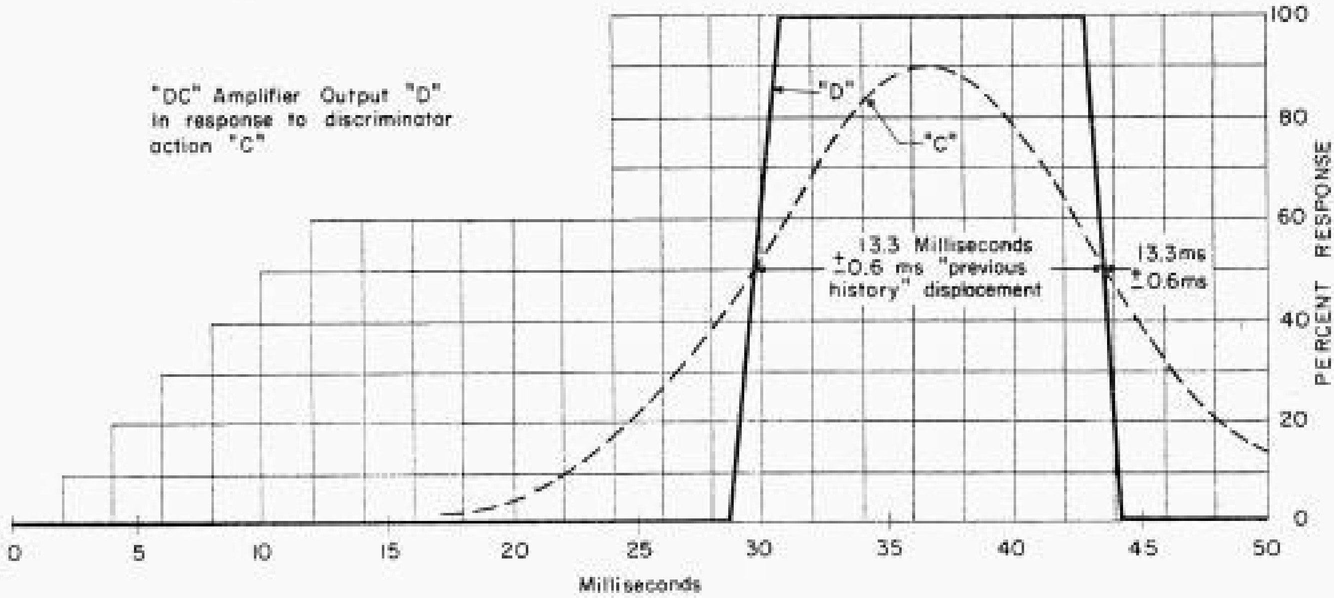


Figure 5. "Triggered" response of channel amplifier output

Figure 6 shows the shape and timing of the information bit wave delivered to the computer, business machine, or teleprinter. The corners have been perceptibly rounded to eliminate the possibility of interference to nearby radio equipment or other communication circuits. Such signals, again, may be either single current open or close, or polar. In the latter form, it is customary that negative battery represent mark or "yes," and positive battery represent space or "no." The single pole (neutral) form is more commonly used for short feeder connections between ter-

are differences in absolute delay between channels amounting to over 4 milliseconds. The measured lags vary from 25.3 to 29.6 milliseconds. Whenever the necessity appears, these discrepancies may be easily equalized. The technique, of course, is to build the faster channel out to the slower by means of a delay insertion network. Between any two trunk telegraph channel terminal points the delays may be made equal within 200 microseconds.

Whenever there are telegraph sections connected together in tandem, either because service between the two points involved cannot be provided by direct single-hop circuit or because "drop" service is a requirement, distortions and delay are greater than for the single section. Generalization in the amount of distortion on multisection circuits would be of little value here. The separate section losses are almost never directly additive. Whenever, after three or four tandem section interconnections, it exceeds about 30 percent, regenerative repeaters are employed. These restore transmission efficiency to essentially 100 percent and the signals then may again be passed through a number of sections before becoming materially degraded.

Absolute delay, of course, is directly additive section after section. In addition to that delay of about 30 milliseconds due to telegraph equipment, there are delays due to vehicle band equipment and to line propagation. The vehicle band equipment may be approximated at one millisecond per band section (two terminals). The line propagation time on wide-band systems, including repeaters, is in the neighborhood of eight microseconds per mile. Microwave facilities, exclusive of channelizing equipment but including repeaters, account for about six microseconds delay per mile.

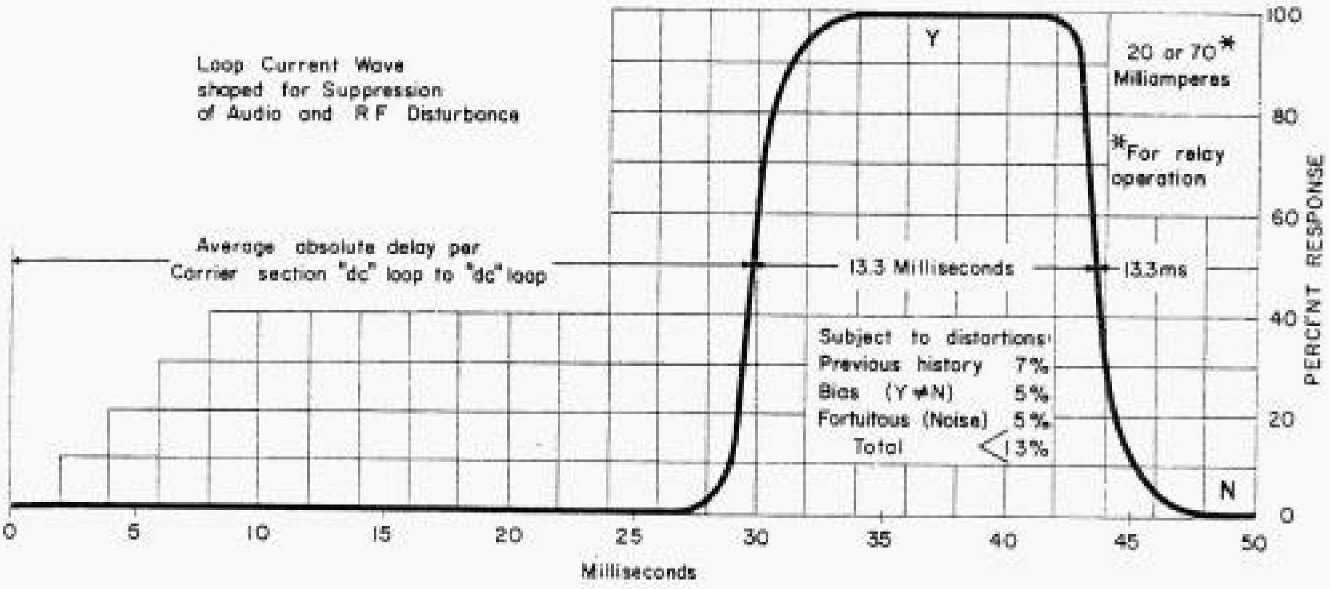
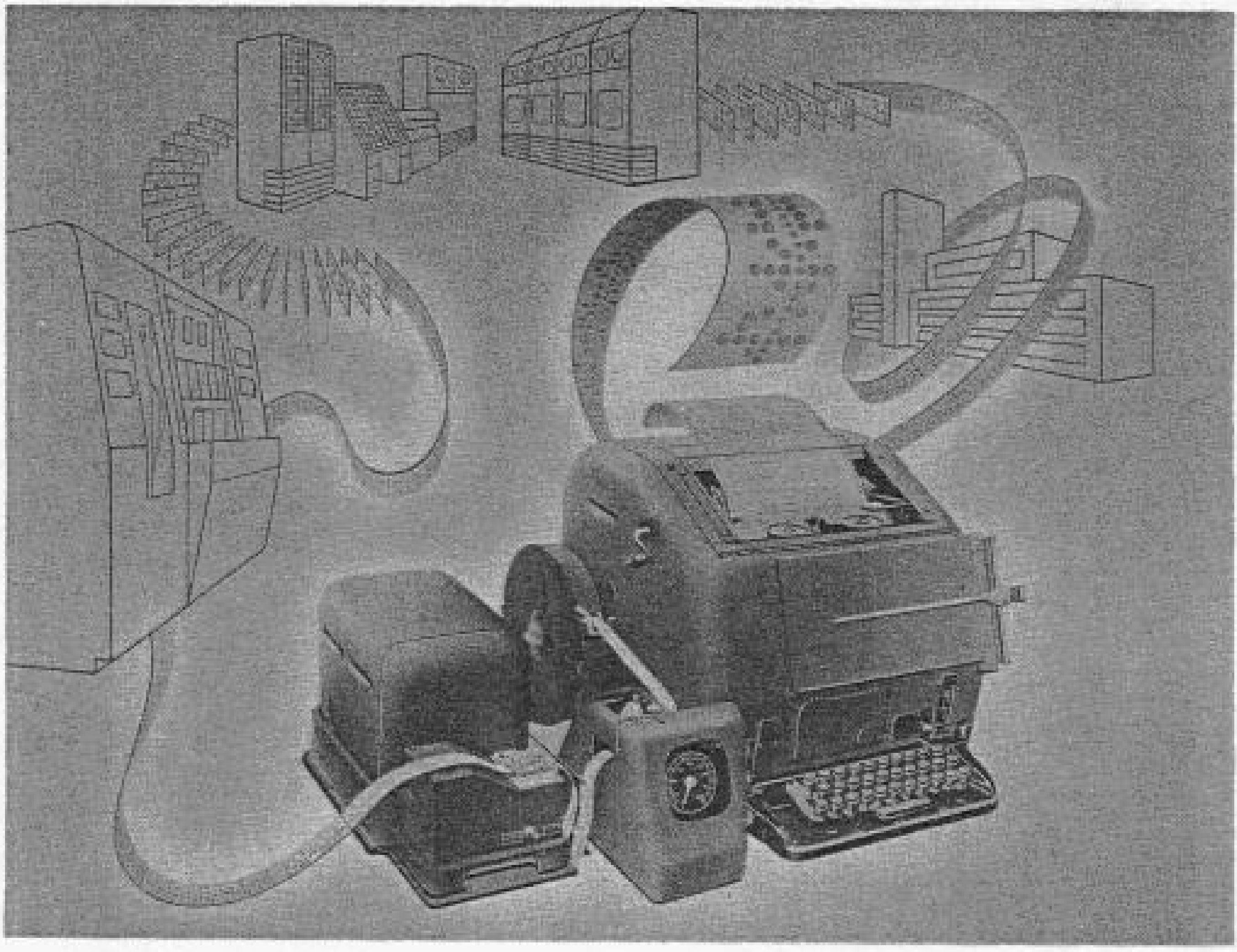


Figure 6. Shaped signal delivered to "data" machine

References

1. A Frequency Modulation Telegraph Terminal Without Relays, F. H. CUSACK and A. E. MICHON, *AIEE Transactions*, Vol. 66, 1947. *Western Union Technical Review*, Vol. 1, No. 2, October 1947.
2. A Nationwide FM Telegraph Network, F. B. BRAMHALL and L. A. SMITH, *AIEE Transactions*, Vol. 70, No. 4, 1951. *Western Union Technical Review*, Vol. 5, No. 2, April 1951.

Mr. Bramhall's biography appeared in the April 1954 issue of Technical Review



ROBERT F. DIRKES, Director—Facsimile and Private Wire Services

Telegraph Applications of Integrated Data Processing

More and more telegraph apparatus is being applied these days to meet both ordinary and unusual applications in the field of Integrated Data Processing, generally referred to as "IDP." There are other similar names in this field such as "Office Automation," "Automated Data Processing," and "Electronic Data Processing," all intended to describe modern methods of machine processing of statistical information.

It is the purpose of this article to show how various telegraph techniques and equipment are being used in practical applications of IDP to accomplish vast amounts of "paper work" and record keeping rapidly and conveniently.

Baudot Code Commonly Used

Information from source documents usually is converted to a form such as the familiar Baudot code 5-channel perforated tape, often as a by-product of the routine preparation of the order form or statistical report. The tape is coded so that it may be saved and reused for other purposes such as the preparation of other documents, management reports or shipping papers, or to activate or control other data processing equipment.

IDP has created a great interest in all telegraph communication equipment because no IDP program involving distant or wide-spread locations can be completely successful without a communication system. Since they have been developing coded tape devices for many years, Western Union's engineers are recognized, by those studying possible uses of IDP, to be well-qualified to design special arrangements of equipment to meet customers' requirements.

Basically the telegraph company's nationwide message switching system is in itself a data processing system but normally it is not "integrated;" although much statistical data goes over telegraph circuits, it is not usually delivered as perforated tape for *automatic* processing into financial reports or inventory records, for example. However, the Western Union 48-state printing telegraph network is adaptable readily for this purpose, and inquiries for such applications are increasing in number and size.

The Western Union system has a tremendous capacity for handling data other than telegrams and it is quite feasible to fit it into an IDP program for the public. By means of the thousands of teleprinter connections from customers' offices to this network, in the near future it may be feasible for data to be transmitted and delivered in tape form or as electrical signals almost anywhere in the country, and for volume handling of such material, especially at night, attractive rates might result.

Data By Telegraph

Several companies now are using Western Union message facilities for IDP purposes such as reporting sales and inventory and periodic cash balances. It is especially convenient for instances where roving salesmen are involved as they can deposit messages in prearranged form at any Western Union office. Receipt at the customer's headquarters would be in the conventional perforated tape ready for use in IDP office equipment, as well as in typed message form. Such conventional perforated tape, which will actuate a variety of data processing devices, is frequently referred to as "common language" tape.

Photograph H-1890-C

Automatic sending and receiving set, Type 19, perforates tape and types page copies simultaneously. Selector unit at right makes connection to distant stations and starts transmission automatically

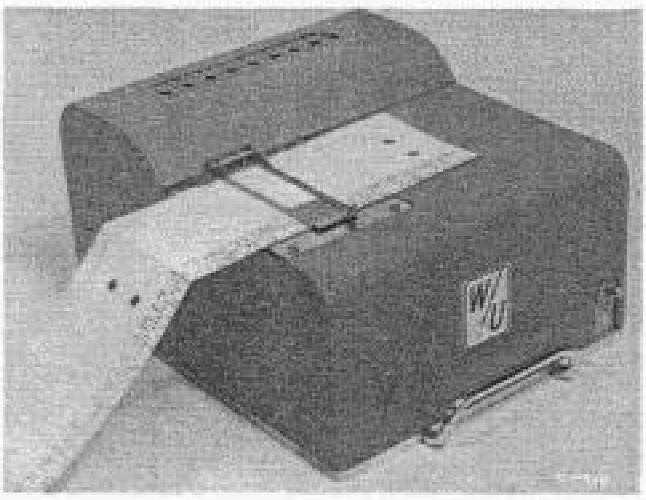
Original recording of data in a manner which produces a by-product punched card or punched tape so the data may be reused without manual retyping (sometimes called "self-perpetuating"), and the ability to add or delete data when required are fundamental to IDP. There is also the matter of delivering the data to the proper place in the proper form. These fundamentals and others have been provided for in Western Union leased wire equipment.

The conventional type 19 set keyboard teleprinter will perforate a paper tape for transmission, and will provide by-product page copies for local distribution, record purposes and verification. The teleprinter may be equipped with automatic tabulation. After the tape has been prepared, it is inserted in the transmitter and a "request button" on a Western Union designed selector is depressed. No further action is required by the operator; transmission begins automatically when working with one other station. If a "way" circuit (one with more than two stations) is involved, and the circuit is busy, transmission will begin automatically when the circuit is idle. This is an important feature as it eliminates the necessity of waiting for the circuit.

Coded Cards Often Useful

An automatic transmitter which will transmit from either edge-punched cards or 5-channel tape is in the development stage at the present time, and a model is being tested. The edge-punched cards could be useful for master records in lieu of tape master records.

When it is planned to employ punched tapes or edge-punched cards which contain constant data, "slave" equipment frequently may be used to advantage. The punched tapes or cards are inserted in an off-line transmitter arranged to send signals to a printer-perforator, which will make a complete new tape containing both constant and variable data. Codes perforated in the constant data tape will stop the transmitter for manual insertion of variable data by keyboard after which the transmitter is re-started by depressing a transmitter start button. The new tape thus created is inserted in the "on-line" transmitter, for transmission to destination.



Photograph R-10, 408

Model Western Union transmitter will accommodate either edge-punched cards or 5-channel tape

When there is more than one circuit in a system, it becomes necessary to provide a means of interconnection of the circuits for proper routing of traffic. This is accomplished by use of switching centers. Messages are received in the switching center on easily-read printed, perforated tape. This tape is then fed through a transmitter which is connected to the proper circuit.

Manual or Automatic

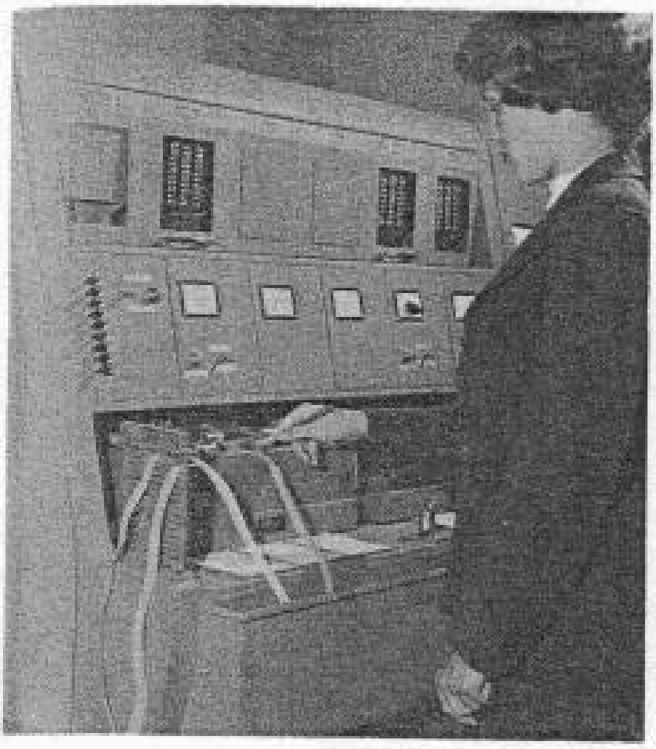
There are several types of private wire switching systems available, each designed to handle a different level of communications volume and more or fewer interconnected circuits. The Western Union Plan 111 switching center[1] is a "torn-tape" system in which the tapes are received on a typing reperforator, separated manually by tearing the tape, and inserted in the transmitter for the appropriate circuit.

The Western Union Plan 54 switching center has a continuous tape arrangement in which the transmitter associated with each receiving position is electrically connected to the outgoing circuit by merely depressing the appropriate push button. It is designed to serve up to 125 stations per switching center.

A fully automatic Western Union switching system known as Plan 55 also has been designed. This system automatically routes messages through the center by electronic reading of characters in the perforated tape and is capable of switching messages to thousands of stations. In Western Union switching systems all messages traversing the switching center are automatically and sequentially numbered in order to assure that all messages are received by the tributary stations.

Inasmuch as the task of selecting, sorting and editing data is handled most often at some central point, it is for such locations that there have been designed special equipments capable of doing the "stunts" required to meet customer objectives.

Various types of way-station selectors are used on private wire networks to assure automatically that only the proper station will receive a message. In one type, the selection of a station is made on the basis of a call letter or letters assigned to each office, and a common disconnect character. The designated receiving printer will recognize its own selection letter, ignore the disconnect character, and thus copy the message. A nonselected station will not receive its call letter, will obey the disconnect character, and thus not copy



Photograph H-1841-A

Manual switching center, Plan 111, offers simple method of receiving and resending message tapes

the message. End-of-message characters will return the line to an idle condition from which any station may again be selected. The selection characters may be initiated by keyboard at the originating station, may be in the original tape, or may be initiated automatically from a switching center automatic numbering machine, depending upon the type of system involved.

Sales Order Processing

A skeleton description of a steel company's order processing system will serve to illustrate the editing potential of Western Union equipment. Assume there are three offices involved: New York sales, Trenton mill, and the controlling mill at New Haven.

Sales orders are received in the New York office. Here prepunched tapes containing product descriptions are kept on file, and for certain customers the customer name, shipping instructions, and most frequently ordered items are kept in the prepunched tapes. These tapes also contain the controlling codes for the various editing operations.

Upon receipt of an order the proper prepunched tape is removed from the file and inserted in an off-line transmitter for preparation of a complete order tape. A "figure K" code in the prepunched tape will stop the transmitter for insertion of variable data by keyboard. The complete order tape is then transmitted to New Haven which is the control mill where the decision is made as to whether the order will be processed at New Haven or Trenton.

For this illustration, assume that the order is to be shipped from Trenton. The order tape is then retransmitted from New Haven to Trenton, and the order is filed at New Haven pending receipt of notification of shipment. At Trenton the order is received simultaneously on perforated tape and on a teleprinter which makes a multilith "master" capable of reproducing all the mill copies necessary; and, upon receipt of the proper code signals, a printer-perforator in the shipping department will perforate only the information necessary to prepare shipping labels or tags. This first editing function is actuated by receipt of "figures, L" and terminated by receipt of "figures, L,L."

The complete order tape and one hard copy are sent to the invoicing department where they are filed until the order is shipped. After shipment, the order tape is inserted in an off-line transmitter, and variable data are entered by keyboard from extension work sheets. A complete invoice tape is thus produced.

The completed invoice tape is fed through a transmitter which will produce a multilith master on a teleprinter for making all necessary invoice copies, and three partial tapes. These partial tapes are for sales statistics, accounts receivable, and production control, and will be used in a tape-to-card machine to produce punched cards necessary for each of these operations.

The printer-perforators which make the partial tapes will perforate information which is preceded by certain characters, and will stop perforating upon receipt of certain other characters. Data for sales statistics are preceded by "figures, F" and terminated by "figures, F,F." Accounts receivable data are preceded by "figures, G" and terminated by "figures, G,G," and data for production control are preceded by "figures, H" and terminated by "figures, H,H." In the tape, these characters precede and follow the information to be extracted, but are *not* printed on any of the order forms.

It can be seen that there is no repetitive typing involved, and that all keystrokes are to add information as it develops in the process of filling the order.

Railway Data System

Another Western Union IDP system has been arranged for railroads. The railroad waybill is, of course, complete information relative to one car in a train. A train "consist" report is a summary statement of the waybills for all the cars in a train, but for train make-up purposes only a small portion of the entire waybill for each car is necessary. In order to save "in yard" time, train consists are telegraphed ahead to the next yard as a train departs. The next yard will then be prepared in advance to remove cars and add new ones, thus having the train's outbound consist ready before the train arrives.

A train consist is received from a preceding yard in both perforated tape and page form. Some of the items contain only the information necessary for train make-up, but other items with complete waybill data represent cars that have been added at the preceding yard; much of the latter will be automatically deleted before transmitting the new consist to the next yard. The purpose of complete waybill data being included in the first transmission for each car is so that the accounting center will receive complete data only once for each car as it passes from yard to yard.

The received consist tape is inserted in an off-line transmitter associated with a printer-perforator and a page printer. This transmitter is conditioned to delete, by idling through, portions of the tape following designated symbols, and to begin sending again upon the receipt of other symbols. This transmitter also automatically causes 18 "letters" characters to be inserted between the data pertaining to each car so that the new tape may be torn and rearranged if desired.

Photograph H-1958

Push-button switching center, Plan 54, provides efficient interchange of messages for larger private networks

The new tape contains only the necessary data for the next yard. This tape is then torn between the data for each car, and the sections of tape for cars to be dropped off at this yard are removed. Meanwhile, new complete waybill tapes have been manually perforated for all cars to be added to the train at this yard. These tapes are collated with the remainder of the received tapes to form a new train consist for transmission to the next yard.

Business Control, Research

Another Western Union IDP system illustrates different arrangements. It includes invoicing, payroll, order and production scheduling, as well as scientific computation for Sylvania Electric Products Corporation. A computing center is at Camillus, N. Y., where a Univac computer has been installed by Sylvania. Data originating at approximately 53 locations across the United States are transmitted over a network of 34 circuits and three switching centers to the Camillus center for sorting and processing. In addition to the data communications function there is the function of administrative communication superimposed on the system. At outside stations the same teleprinter machine is used both for administrative telegrams and for data.

At the Camillus center each circuit used for data processing terminates in a printer-perforator. Messages are received here on perforated tape feeding continuously through a transmitter which is automatically connected to the correct final position for a particular type of data. That is to say, this transmitter will recognize invoice data, be connected to a printer-perforator and transmit the signals to this perforator where the received tape will be wound on a reel for computer processing. The same occurs for payroll data, or any other kind of data, each type being received and wound on a different reel. Thus each kind of data is accumulated on a separate reel or reels regardless of the order in which it is transmitted to the computer center. However, when the sorting unit recognizes a message, as opposed to data, it will not transmit it to a storage reel, but will transmit it to a position where it will be received in form suitable for delivery. The Sylvania system has many interesting features which are described in some detail in another article in this issue of the REVIEW.

The foregoing discussion outlines only in a general way some of the many possibilities for applying telegraph techniques of long standing to the machine processing of business data.

Reference

1. A SIMPLIFIED TELEGRAPH SWITCHING SYSTEM PLAN 111-A, T. S. PESSAGNO, *Western Union Technical Review*, Vol. 9, No. 2, April 1955.

Robert F. Dirkes, Director of Facsimile and Private Wire Services, graduated from the Stevens Institute of Technology in 1920, and joined the staff of the Automatics Engineer shortly thereafter; in 1941 he became Assistant Automatics Engineer. He developed, or directed the development of such now standard pieces of apparatus as the storing transmitter, high-speed ticker, printer-perforator, automatic numbering machine, aircraft printer and silent transmitter, and assisted in the installation of switching systems in both Western Union and patrons' offices. During the war he worked on the speeding up of Army Communication circuits, the application of multiplex to Navy radio circuits, the U. S. Navy Mark II Computer and on the design of an automatic film selector for the Signal Corps. Mr. Dirkes was Patron Systems Engineer from 1945 to May 1948, and it was under his direct supervision that the modern patrons' push-button switching system attained its present efficiency; later, as Director of Operations, he was responsible for technical operating control of all Western Union circuits and associated equipment. As Director of Facsimile and Private Wire Services, Mr. Dirkes directs the sales of leased wires, custom-built telegraph systems, and private leased facsimile telegraph systems known as Intrafax. He is a Member of AIEE.

PHILIP R. EASTERLIN, Project Engineer, Electronics Applications

Control System for Integrated Data Processing

Fast transmission of business data is accomplished readily with devices and techniques perfected for message telegraph services. Punched tapes, automatic routing characters, automatic sequence number check and fast cross-office switching present a familiar pattern. A new system of flexible controls for an efficient integrated data processing installation is described.

To MEET the increasing demands from its patrons for automation equipment, The Western Union Telegraph Company has developed an extremely versatile data control system for use with high-speed electronic computers at centralized Integrated Data Processing centers. This system serves as the main artery for data information which can be transmitted simultaneously from cities throughout the country over a Western Union telegraph network. As each unit of classified information is received, it is automatically processed into the proper data category for efficient and high-speed programming by modern computers.

This development opens the automation field to many new applications by providing the vital input and output communication needs for economical use of expensive computing equipment at one centralized point in the patron's scope of operations. This article describes the new system, designated as Switching System 203-A, which has been engineered for initial use in Sylvania Electric Products' new data processing center at Camillus, New York.

APPLICATION FOR SYLVANIA

The data control system, as used by Sylvania Electric, is connected by a Western Union private wire telegraph network to their larger plants located throughout the United States. Over this network, which is also used for administrative messages between any two or more offices, data messages are originated at any of the outlying plants and contain three data routing characters, corresponding to a particular data category. Such messages are transmitted over the wire network into one of a number of input or reperforator receiving positions of the data control equipment located at the data processing center. At the reperforator receiving positions, data messages are received on chadless reperforator tape containing the printed characters as well as the punched code holes.

As each complete data message is received at a reperforator receiving position, the tape is fed to an intra-office transmitter which reads the data routing characters and automatically switches each message over the proper 5-wire, 150 words-per-minute cross-office circuit to a reperforator at the selected data storage position. As each message is switched cross-office, a sequence number check is made to assure that the characters are being punched correctly in the tape by the reperforator at the data storage position. The cross-office circuit principle employed is very similar to that used in Western Union's Plan 21-A Reperforator Switching Offices. The reperforator tape at the various data storage positions is wound on a reel, each reel containing data messages under one or a combined group of categories such as payroll, invoices, inventory, and so forth.

The classified data on individual tape reels of various data storage positions are periodically removed, and the reperforator tape is then fed into a converter associated with the electronic computer, in this case Remington Rand's "Univac." The converter translates the data information from the reperforator tape into punched

A paper presented before the Summer and Pacific General Meeting of the American Institute of Electrical Engineers in San Francisco, Calif., June 1956.

card form and the cards are then used in the conventional manner to transmit onto the magnetic tape of the uniservo units associated with the computer. A reperforator tape-to-magnetic tape converter is now under development and may be used to bypass the punched card operation.

In subsequent computer operations, the telegraph network is also used for transmitting information back from the data processing center to the originating plant.

A block diagram of the Western Union telegraph network for Sylvania Electric is shown in Figure 1. Administrative messages can be exchanged directly between

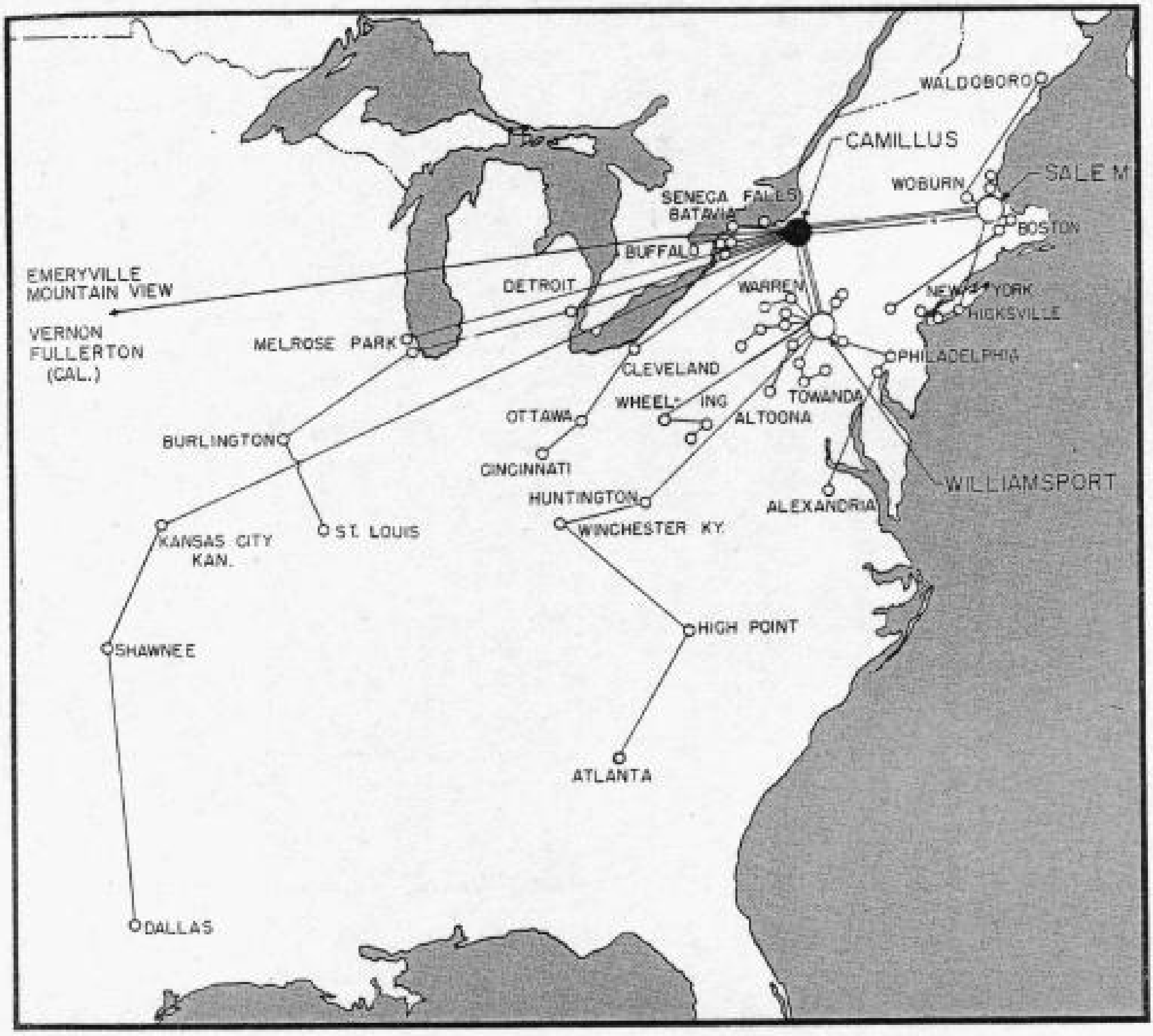


Figure 1. Sylvania Electric Products, Inc.—Private wire system

- ● Type 111-A Switching Center with Data Control System 203
- ○ Type 111-A Switching Center
- ° Terminals—Send and receive
- ═══ Duplex circuit
- ─── Single circuit

Univac is programmed to process individual data subjects such as hourly, daily, or monthly payroll, invoices, or production forecasts, which have been gathered and combined from a number of plants throughout the country. When required, any of the offices on the same telegraph circuit. In addition, messages between Sylvania plants on different circuits are relayed by Western Union torn-tape reperforator switching centers located at Camillus, N. Y., Williamsport, Penn., and

Salem, Mass. Data messages from any Sylvania plant associated with this network are transmitted into the Camillus IDP center, processed by the data control equipment, programmed to Univac, and the returnable computer information, when required, is transmitted back to the specified plant through the torn-tape switching centers.[1]

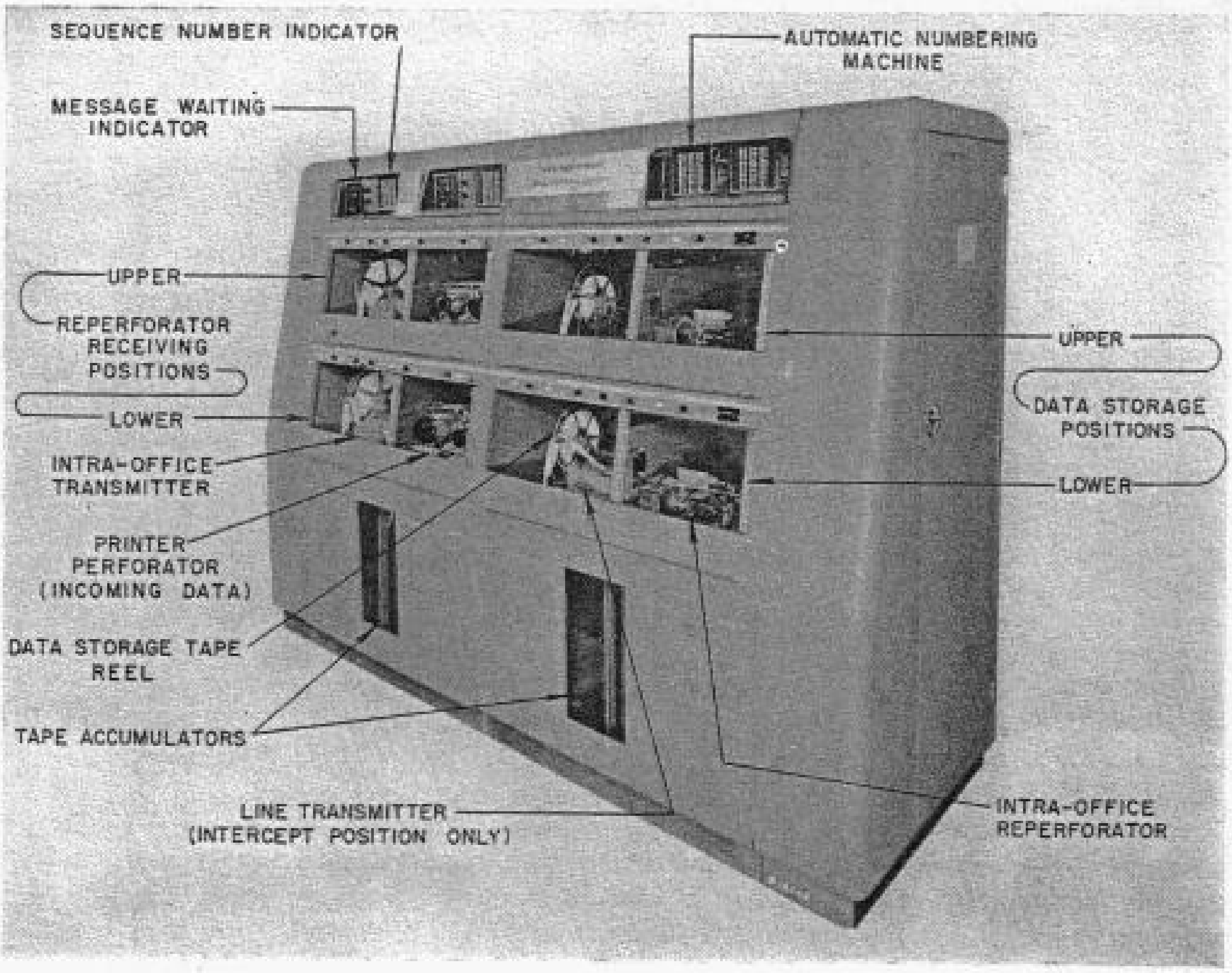
DATA CONTROL EQUIPMENT

The data control system is housed in five basic types of equipment cabinets. The input or receiving portion of the system is provided by one or more reperforator receiving cabinets having an upper and lower position. The output of this system —where reperforator tapes have been separated into specific categories—is provided by one or more data storage cabinets, also having an upper and lower position. Three types of auxiliary control cabinets are used to house the automatic switching controls. These are the automatic switching, transmitter finder, and auto control cabinets. Figure 2 is a photograph of the input and output cabinets, which are similar in appearance, and Figure 3 shows the group of three auxiliary control cabinets.

For the Sylvania application of the data control system, the auxiliary control cabinets are packaged to provide a maximum of 50 input or reperforator receiving positions and 50 output or data storage positions. However, additional input and output positions can be provided as required, by expanding the switching control equipment.

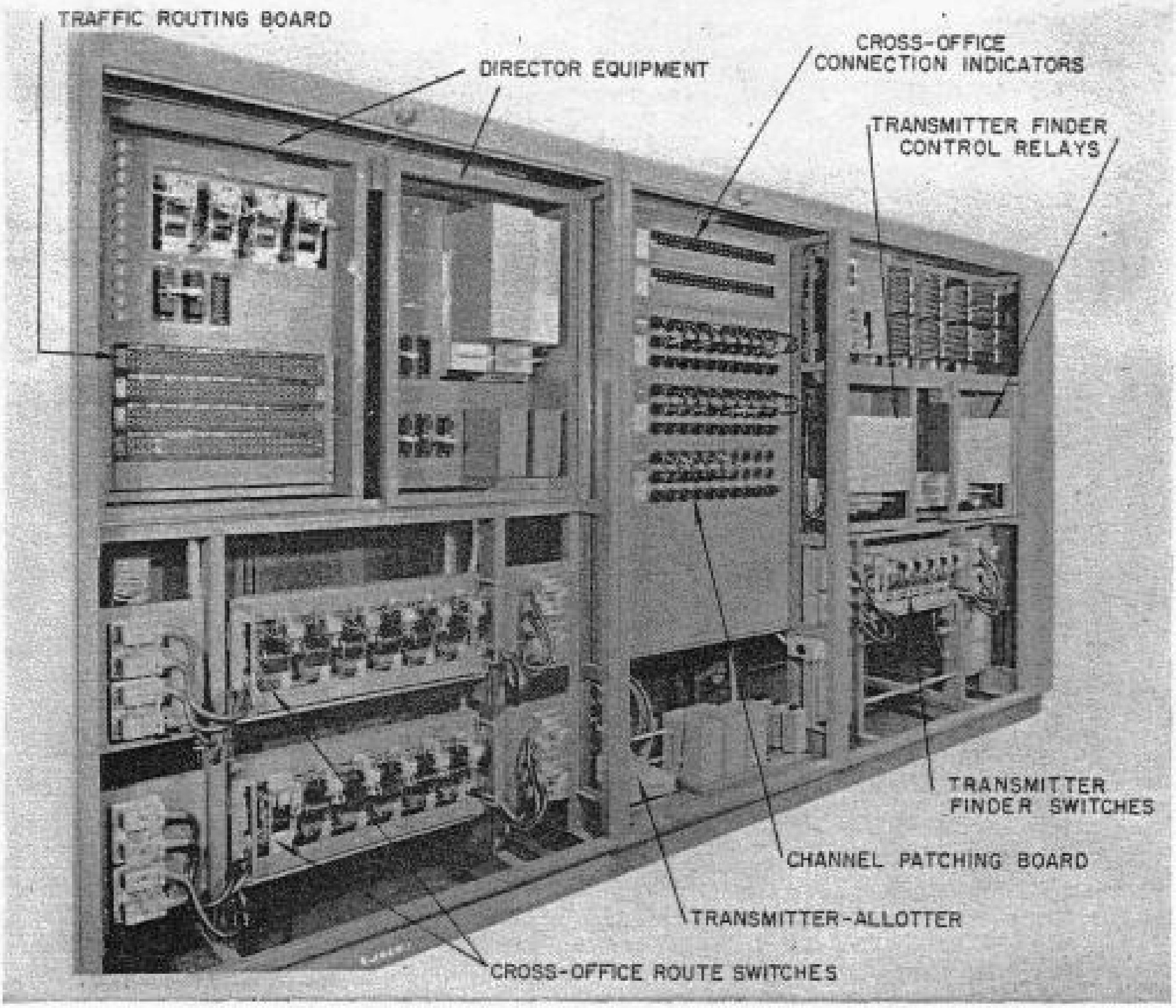
PREPARATION OF DATA MESSAGES AT OUTLYING OFFICES

Data or administrative messages at various Sylvania plants are originated on Western Union's standard Type 19 sets



Photograph R-10,640

Figure 2. Reperforator Receiving Cabinet 8302-A (left) and Data Storage Cabinet 8306-A (right)



Photograph R-10,641

Figure 3. Automatic Switching Cabinet 8304-A (left), Auto Control Cabinet 8310-A (center), and Transmitter-Finder Cabinet 8308-A (right)—front doors removed

in the form of a manually-prepared perforated tape. This tape passes through a tape transmitter that sends the message characters over carrier or physical line circuits to the distant point and provides a printed monitor copy. On circuits having more than one office, a local selector controls transmission and reception. The selector prevents the transmitter from starting until the circuit is idle and allows only the selected stations to copy the transmission.

All data messages destined for the IDP center at Camillus have a message-beginning "Z" character, followed by the routing-prefix characters "Figures, F," the three data routing characters—the first of which is always the identifying letter "D"—and the message-ending characters "Carriage Return, Carriage Return, Carriage Return." Data messages are either transmitted directly to the data control system or relayed to this equipment by means of the torn-tape switching centers. Messages of an administrative nature are preceded by appropriate routing characters and are manually routed to their proper destinations when relayed by the torn-tape switching centers.

RECEPTION OF DATA MESSAGES

Figure 4 shows in block form the principles employed in simultaneously receiving data messages from many outlying offices over a telegraph network, and automatically routing each unit of data information into a selected category as deter-

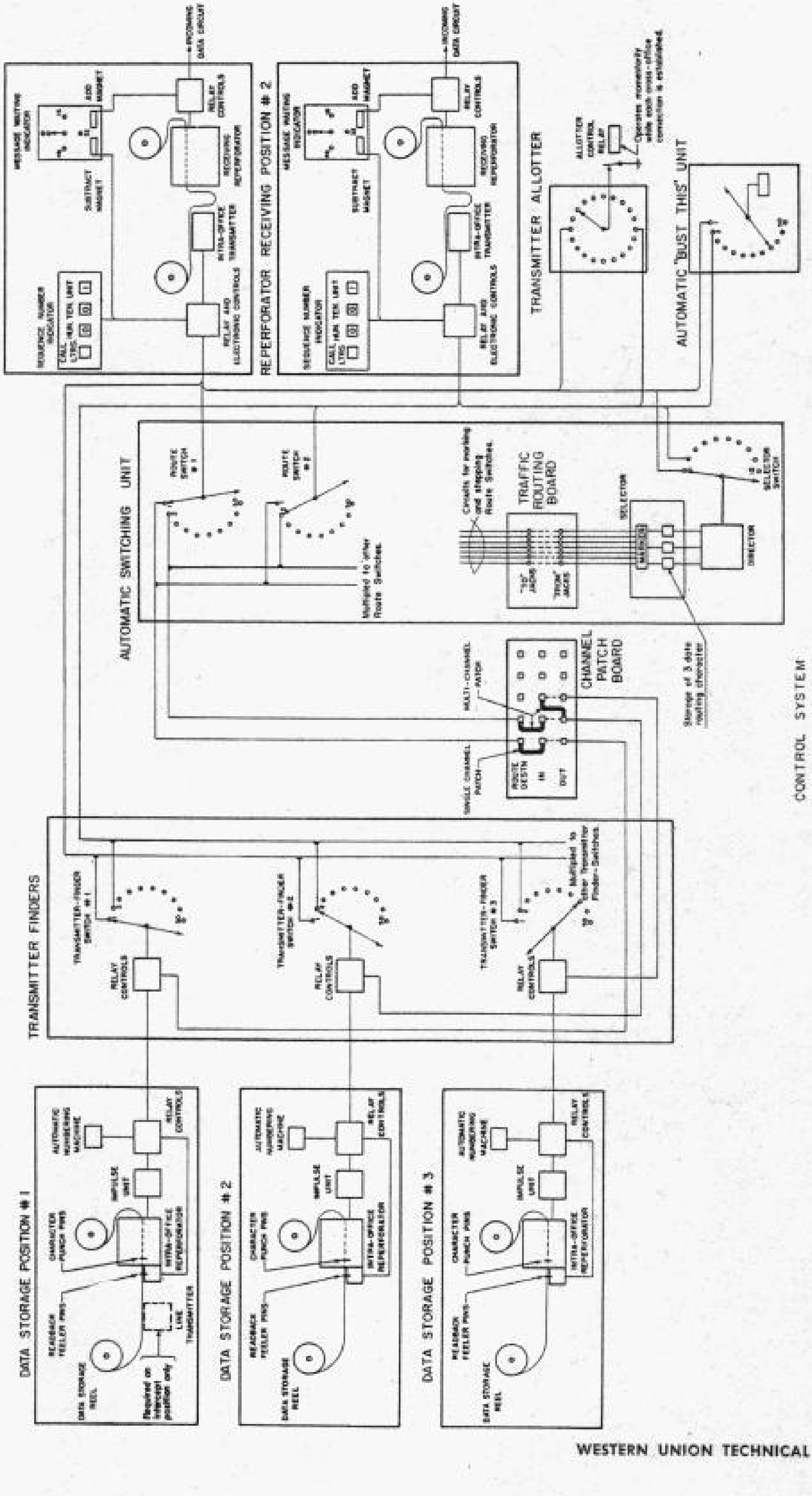


Figure 4. Switching theory of data control system

mined by the data routing characters inserted by the distant or originating office. Messages arrive at the reperforator receiving positions on a printer-perforator at 75 words per minute. As the tape is printed and reperforated, it is fed through a newly designed loop gate intra-office transmitter.

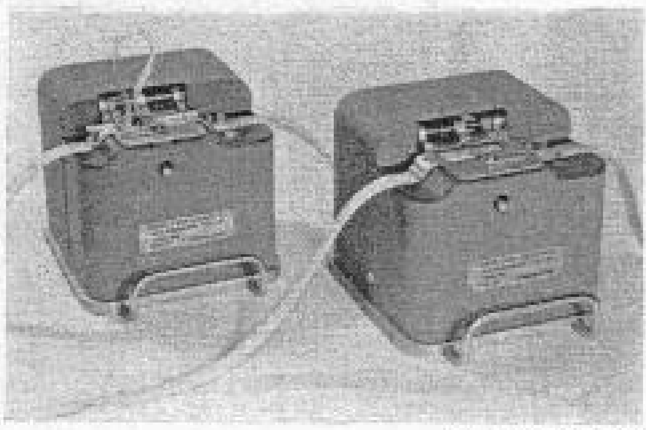
Upon reading the designated message-beginning character, this transmitter automatically shifts its tape gate to the left and develops a loop of tape while idling and searching for the routing-prefix characters embodied some distance from the beginning of the message tape. Upon locating the routing-prefix characters, the transmitter stops momentarily until signaled to transmit the three data routing characters which are used for automatic switching purposes. After transmitting this control information, the tape gate is restored to the normal or right-hand position and, while restoring, the loop of tape is smoothed out to the original starting position whereupon the complete message tape is then transmitted. Figure 5 shows two of these transmitters with the tape gate in both positions of operation.

Connection to Switching Unit

When the message-ending control of three "carriage returns" has been read on the incoming printer-perforator, a message-waiting indicator is advanced one step. This indicator is an add and subtract unit which indicates the number of unswitched messages by advancing one point on each message-ending signal and subtracting one point for each message switched cross-office. As the message-waiting indicator is stepped off the zero position—indicating one complete message to be switched. and the intra-office transmitter has read the routing-prefix characters "Figures, F," a request is made to an automatic switching unit having director equipment capable of serving a group of 12 intra-office transmitters.

As the automatic switching unit is connected to a particular intra-office transmitter, the three data routing characters are received from the transmitter and stored on selector relays located in the automatic switching unit. Contacts on these relays form character reading circuits which interpret the three data routing characters. As these characters—representing any one of a number of data categories—are stored, they cause a rotary-type route switch associated with this intra-office transmitter to step to the proper stator point corresponding to the selected data category or data storage position. As this action—requiring 3 or 4 seconds—is completed, the automatic switching unit disconnects and performs a similar cycle of operation for other intra-office transmitters having messages to be switched over the cross-office circuits.

The automatic switching unit, in addition to performing its normal switching functions, also detects administrative messages which have been misrouted into the data control equipment or data messages which contain improper or unregistered data routing characters. For example, in the case of misrouted administrative messages, the director equipment recognizes the absence of "D" as the first of the three data routing characters and such messages are switched automatically to an intercept data storage position where they are retransmitted to a receiving-only position for manual handling. However, if "D" is the first of the three data routing characters, but the following two characters do not represent a valid data category, the tape is held in the intra-office transmitter and the supervisor is automatically signaled.



Photograph R-10,564

Figure 5. Tape Transmitters 7595-A

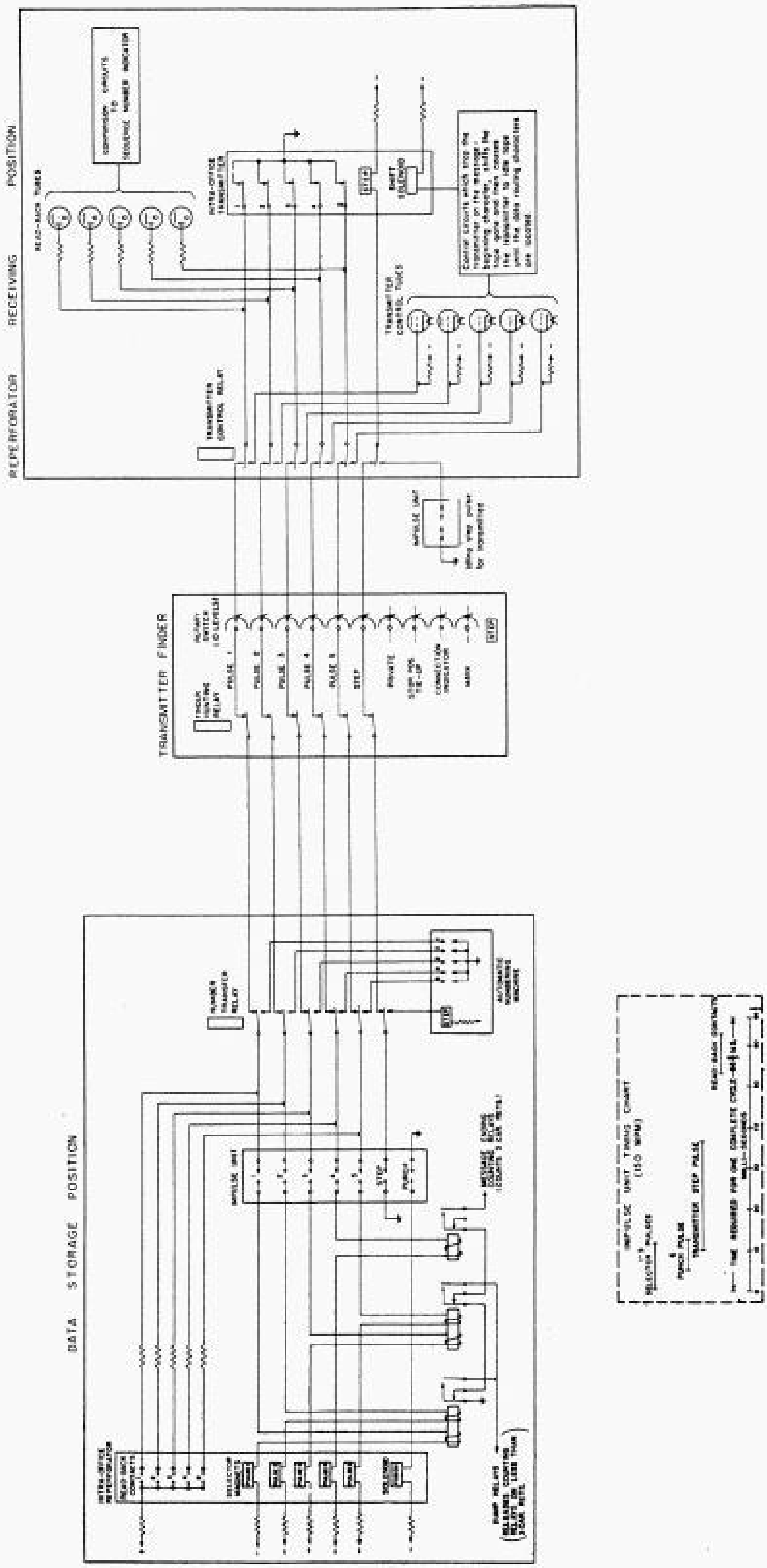


Figure 6. Theory of 5-wire cross-office circuit

Actuating Transmitter-Finder

After the automatic switching unit has directed the route switch to the proper stator point, corresponding to the three data routing characters, the intra-office transmitter waits for a ground at its individually assigned point on a ring-type transmitter-allotter. The transmitter-allotter has a rotating wiper which sequentially sweeps all points on the ring every 3.3 seconds and is grounded through the contacts of an allotter control relay.

As an individual transmitter receives an allotment, this relay removes ground from the allotter wiper until this particular cross-office connection has been completed, thereby preventing two simultaneous connections to the same data storage position. When an intra-office transmitter is actuated in this manner, the transmitter-finder switch representing the selected data storage position is initiated and this switch steps to a marked point corresponding to the intra-office transmitter seeking connection.

Connection to Selected Position

As the transmitter-finder switch is properly positioned, relay control circuits are actuated to complete the cross-office connection between the intra-office transmitter at the reperforator receiving position and a 5-wire reperforator located at the selected data storage position. The 5-wire circuit between these two apparatus units is made through five heavy-duty contacts on a free-running impulse unit operating at 150 words per minute. A simplified sketch of the five cross-office intelligence pulse circuits, including a sixth conductor for the step circuit of the intra-office transmitter, is shown in Figure 6.

Cross-Office Transmission

Before cross-office transmission begins, an automatic numbering machine at the data storage position—consisting of four rotary switches which are arranged to transmit on a 5-wire basis through the impulse unit, transmits the next consecutive message number characters into the reperforator. Following this number, relay control circuits connect the impulse unit and the associated intra-office reperforator to the five cross-office conductors of the intra-office transmitter position. Similar control circuits at this position now function to establish proper synchronism with the free-running impulse unit by absorbing the first transmitter step pulse before completing the circuit to the intra-office transmitter.[2]

The 5-wire reperforator used at the data storage position, in addition to punching the code holes, is equipped with five read-back transmitter contacts located five characters to the left of the tape punch block that perforates the chad-type holes. Five character operations after a particular character is transmitted into this reperforator, the code holes for this character appear over the read-back contacts. These contacts are connected to the five cross-office pulse conductors, and as the reperforator punches the code holes of each new character, the read-back contacts close and transmit the fifth previously received character back to the intra-office transmitter position.

Sequence Number Check

Each data message switched cross-office by the intra-office transmitter is preceded by a sequence number of about ten characters which is inserted by an automatic numbering machine located at the distant sending end of the circuit transmitting to the data control system. As these characters are transmitted cross-office, the read-back contacts on the reperforator at the data storage position function to transmit back the punched intelligence over the same 5-wire cross-office conductors and during this sequence number check transmission is at half speed, or 75 words per minute. For example, a character is sent from the intra-office transmitter to the reperforator and while the code holes are being perforated in the tape, the read-back contacts function to transmit the fifth character previously received back to the intra-office transmitter position.

These read-back signals are received electronically at the intra-office transmitter position and are compared on a sequence number indicator having several rotary switches which maintain the sequential numbering pattern. If each of the sequence number characters compares correctly, the intra-office transmitter is allowed to transmit the next character. This cycle of operation continues until the three identifying characters and a 3-digit number are compared correctly, after which time the comparison circuit is disabled and the remainder of the message is transmitted cross-office at the normal speed of 150 words per minute. Failure to compare the sequence number actuates automatic test equipment which performs an immediate check on the equipment involved in the cross-office connection. This action is described later.

When the end-of-message signal, consisting of three carriage returns, is transmitted into the data storage reperforator, the intra-office transmitter is stopped and the cross-office circuit is disconnected. This particular data storage position is now in readiness to receive a cross-office connection from other intra-office transmitters having messages prefixed with the same three data routing characters.

FAILURE TO COMPARE SEQUENCE NUMBER CORRECTLY

If a wrong comparison occurs on the sequence number check—which can be caused by improperly prepared tape or equipment trouble—the intra-office transmitter is immediately stopped and the supervisor is signaled.

In the meantime, an automatic equipment test is made on this particular cross-office circuit by an automatic "Bust This" unit. This unit functions to cut into any cross-office circuit where a wrong comparison has occurred and transmits the words "BUST THIS," followed by the end-of-message signal, into the reperforator at the data storage position. As these test characters are punched in the reperforator tape, they are transmitted back and compared by the automatic "Bust This" unit in a manner similar to the normal sequence number check. If a correct comparison of the test characters is made—indicating that the reperforator is functioning properly at the data storage position—the end-of-message signal following the words "BUST THIS" releases the cross-office connection and automatically restores the data storage position to service. Under this condition, the tape is retained in the intra-office transmitter for the attention of the supervisor.

Failure of the test characters to compare properly with the automatic "Bust This" unit indicates cross-office equipment trouble to the data storage position and the connection between the intra-office transmitter and reperforator is retained for the attention of the supervisor and, in addition, the testing and regulating attendant is alerted.

MULTICHANNEL DATA STORAGE POSITIONS

Provision is made for patching any two or more data storage positions together to form a multichannel data category to meet conditions where the hourly or daily traffic load exceeds the capacity of one data storage position. This is performed by a channel patch board located in the auto control cabinet. Also, if the capacity of a single data storage position is unexpectedly exceeded, supervisory attention is automatically directed to this condition when the cross-office holding time—inability to obtain the desired data storage connection—exceeds two minutes from any one of the intra-office transmitter positions.

TRAFFIC ROUTING

The automatic switching unit, which interprets the data routing characters and automatically positions the route switch associated with each intra-office transmitter, contains a traffic routing board which provides complete flexibility in the choice of routing and grouping data messages into any of the data categories. By means of a 2-conductor patch cord, the data routing characters can be reinterpreted to combine several categories into one data storage position. For example, it may be desired to group lightly-loaded categories on a particular day so that invoice data (DID), production schedules (DPS), inventory reports (DIR), or other specific categories will be received at one data storage position. Reassignment or grouping such as this makes it possible to associate the data storage positions normally assigned to these categories to multichannel purposes on other heavily-loaded categories.

Local Redistribution of Data Messages

Where several different data categories have been grouped into one data storage position, it is possible to rerun the reperforator tape from this particular tape reel through the system for redistribution on a local basis. For example, it may be desired to accumulate the following data subject matter into one data storage position for redistribution later: DPH—payroll hourly; DPD—payroll daily; DPW—payroll weekly; and DPM—payroll monthly.

By changing the data routing or grouping pattern at the traffic routing board and rerunning the tape through one or more intra-office transmitters located at available reperforator receiving positions, the four data categories mentioned above may be redistributed to four separate data storage positions. When data information is reprocessed locally, the normal operating features of the system are retained, including the sequence number check of each data message.

AUTOMATIC SWITCHING TO DISTANT OFFICES

While the data control system has been designed for meeting the IDP requirements of Western Union's patrons, it also may be used for automatically switching administrative messages to distant offices. This additional operating feature was considered in the design of the data storage positions, which are arranged to accommodate a line transmitter between the reperforator and the tape reel for retransmission of the perforated tape to distant offices. When used in this manner, the system will function in some respects like Western Union's high-speed reperforator switching centers, now operating in 15 of the larger cities throughout the country.

References

1. A Simplified Telegraph Switching System Plan 111-A, T. S. Pessagno, *Western Union Technical Review*, Vol. 9, No. 2, April 1955.
2. A New Automatic Message Numbering Machine, J. E. Stebner, *Western Union Technical Review*, Vol. 8, No. 4, October 1954.

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 the testing of this system in many Army Signal Centers during the war. After the merger and a period of ocean cable engineering, he designed various types of rack mounted repeaters now widely used. He was also active in the development of Plan 21 reperforator switching equipment, conducted several schools for technicians and supervised the testing at the Minneapolis and Detroit offices. Mr. Easterlin developed the patented system-wide dispatcher test wire switching system described in the January 1953 Technical Review. The development of the system described in this article was directed by him. He is a member of AIEE.

EDWARD T. FINNEGAN, Engineer, Electronics Applications

Magnetic Tape Signal Transmitter for Ocean Cables

Distortion correcting networks for submarine cable amplifiers have been adjusted customarily from observation of oscillograph patterns produced by repetitive "shaping signals." For generating shaping signals, there has been devised, recently, a magnetic tape recording procedure which is simpler and more reliable than employment of multiplex distributor equipment.

THE DEGREE of distortion sustained by telegraph signals transmitted through a submarine cable can be determined by comparing the length and relative arrangement of signal elements as sent, to the length and relative arrangement of such elements as finally delivered to the receiving device. An ideal or perfect submarine cable, characterized by only series resistance and distributed leakage, would reproduce telegraph signals at the receiving end exactly as they are impressed at the sending end with respect to length and signal element arrangement, but with reduced amplitude. These signal impulses would require only distortionless amplification to make them capable of operating telegraph printing apparatus. In reality, however, the signals are subjected to two principal types of distortion, namely, characteristic and fortuitous, both resulting from a number of different causes.

Distortion on Submarine Cables

Characteristic distortion results from the fact that no ideal submarine cable exists, for a submarine cable possesses, in addition to series resistance, a considerable capacitance to ground and very little inductance to lessen the detrimental effect of the capacity. It has no appreciable amount of conductance at all. The two predominating parameters, series resistance and shunt capacitance, cause the amplitude of the received signal to decline very rapidly as the keying frequency is increased. In addition, the time of propagation decreases as the frequency is increased. As a result, the wave front of the signal reversal is rounded off due to the diminished high-frequency content and a phase shift appears due to the varying time of arrival of the transmitted signal combinations. This characteristic distortion, so called since it is a characteristic of the propagating medium, if uncorrected, prevents accurate operation of the telegraph apparatus even when the signals are sufficiently amplified.

Compounding these adverse effects is the presence of fortuitous distortion caused by such extraneous factors as cross fire, power induction, and line hits, or by systemic sources such as residual duplex unbalance, momentary battery fluctuations, and similar effects. Naturally occurring effects, such as earth-current potentials whose slow and random variations contain very low-frequency components lying within the signal spectrum, combine with the other distorting frequencies to alter the received signals by varying degrees in an irregular manner.

Signal Shaping Networks

To remedy the effects of the cable characteristic distortion upon the transmitted signal, electrical networks, introduced between the cable head and the signal amplifier, equalize or restore the received frequency components of the signals to approximately the original amplitude and phase relationships. These networks have a corrective effect; that is, they emphasize the high-frequency components and advance the phase of the low frequencies. In addition, these same networks are arranged to pass only the narrowest band of frequencies consistent with good signal definition while avoiding undue distortion and limiting the effects of extraneous interference and duplex unbalance voltages. Direct currents and

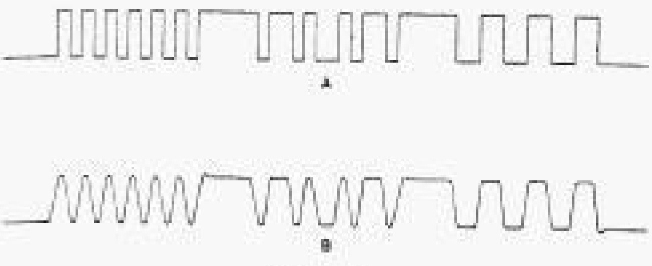


Figure 1.

alternating currents near zero frequency must be rejected to avoid earth-current effects which would otherwise cause signal wander about the zero or normal axis.

These electrical circuits, called signal-shaping networks, are resonant in behavior and when properly adjusted pass a band of frequencies which are proportioned and phased to yield a well-defined signal shape. The upper limit of the pass band of these networks must be set at a frequency specifically related to the fastest reversal frequency which will be transmitted through the cable. If the submarine cable is comparatively short (up to 200 miles) or the speed of signaling very low on a long cable, the relative attenuation between the fastest reversal frequency and the much slower reversals is very low. In this instance, after signal shaping, the fastest reversals will be leveled off to the peak amplitude of the sine wave as illustrated in Figure 1B. This type of signaling is referred to as 2-element or fully developed signaling and the frequency at which exceptional response occurs will be adjusted to approximately 1.25 times the fastest reversal frequency.

If, however, the cable is very long, several hundred to one or more thousand miles, or if the speed of signaling is very high on a short cable, the relative attenuation between the fastest reversal frequency and the slower reversals is very high. The greater sensitivity to disturbance that would be encountered were the fastest reversal frequency used to operate printing apparatus is circumvented by suppressing this frequency, often referred to as the "singles" a.c., by tuning the shaping networks to a much lower frequency. These circuits are resonated to approximately 1.5 times the speed of the half-speed reversals, or "doubles" a.c., so called because each lobe consists of two sent impulses instead of one. Under these circumstances, the "singles" a.c. and the high-interference frequencies are suppressed to such an extent that they do not appear at the amplifier output. Figures 2-A and 2-B, respectively, show the suppressed "singles" a-c signal and the amplifier relay output signal. Of course, auxiliary equipment, either synchronous or asynchronous, but characteristically a vibrating circuit, serves to "fill-in" or interpolate the suppressed "singles" impulses. Figure 2-C illustrates such an interpolated signal.

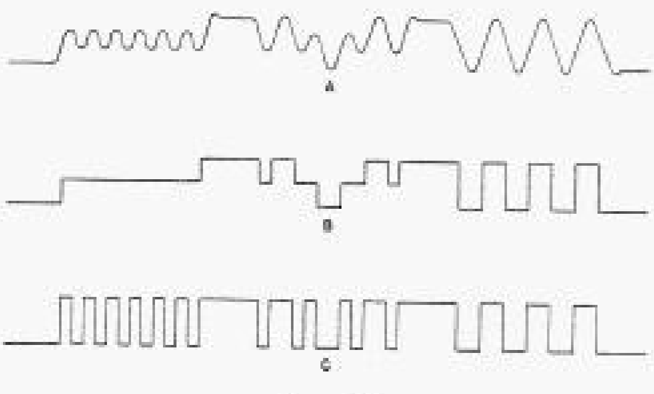


Figure 2.

In addition to the previously described shaping network and the amplifier unit, which is usually two or three push-pull stages, all ocean cable amplifiers of Western Union design include local correction networks which re-insert the extremely low-frequency components of the signal as well as the direct-current component.

Signal Shaping

When amplifiers are installed initially on ocean cables, or immediately following a repair by the cable ship, and from time to time as preventative maintenance, distortion correcting networks of the amplifier may require adjustment to produce desired correction. In this procedure, familiarly referred to as "signal shaping," the resonant circuits of the shaping unit are first tuned to the desired frequency based on a calculated value, and damping and local correction adjustments are determined by trial and error. These adjustments are made while observing oscillograph tracings of signal combinations called "shaping signals" which are repetitive patterns of positive and negative impulses. Figure 1-A shows a typical shaping signal combination composed of bursts of "singles" a.c., "doubles" a.c., and a combination of the two. In addition, these bursts are separated by long spacing and marking pulses to permit the technician at the receiving end accurately to adjust the amplifier for the low-frequency and d-c components of the signals as well as the higher frequency components. Figures 1-B and 2-A illustrate typical "shapes" for fully developed and suppressed singles operation with local correction.

Magnetic Tape Signal Transmitter

The usual method employed to generate these shaping signals requires the use of a multiplex distributor table and a specially prepared perforated loop of tape for each transmitter associated with the sending distributor. Since the "shaping" procedure may extend for a great length of time, these loops of tape are susceptible to tearing and, in addition, they must be stepped through the transmitter in a predetermined sequence in order to yield the desired signal combination. Occasionally, one transmitter might fail to step properly thus interrupting the "shaping" procedure until the situation is remedied. Transmitter 7439-A eliminates such occurrences since it employs no multiplex distributor nor transmitters, and hence no perforated loops of tape, but instead operates in conjunction with an ordinary commercial magnetic tape recorder at a tape speed of 7½ inches per second. In its present arrangement the transmitter is designed to send signals consisting of combinations of positive and negative potentials wherein for each unit impulse the battery is applied to the cable for the entire duration of the impulse. This type of signal is said to be 100-percent marking.

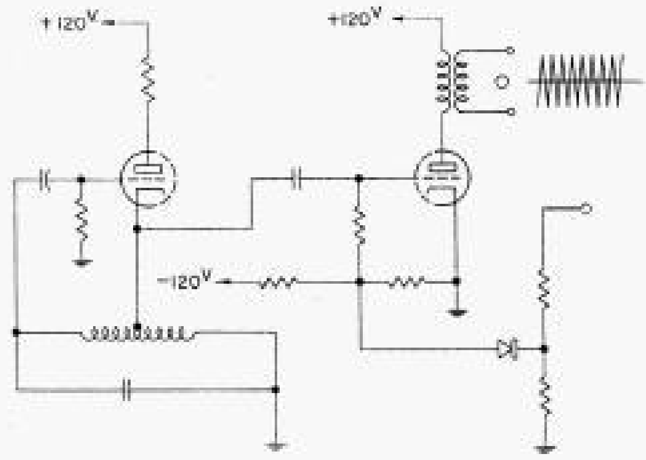


Figure 3.

The required shaping signal combinations, which are polar, are prerecorded on magnetic tape as a 100-percent modulated 5000-cycle tone. A 5000-cycle oscillator is built within the signal transmitter for this purpose. The transmitter unit converts the magnetic tape recorded signals into the original polar signals for transmission to the cable for shaping purposes.

The oscillator unit shown in Figure 3 employs twin triode vacuum tube as oscillator and keying amplifier. The oscillator section is of the Hartley type and is coupled capacitively to the amplifier section which is biased for class "A" operation. If no keying signal is applied to the input of the oscillator unit, a continuous 5000-cycle tone is seen across the output terminals. Keying is effected by virtue of a voltage divider network and a germanium diode. The arrangement is such that when a positive signal is applied to the keying input, the amplifier section remains conducting and a 5000-cycle tone appears at the output. If a signal of negative polarity is applied, the amplifier swings well below cutoff and no output appears. The minimum value of negative input voltage required to cut off the amplifier section is in the neighborhood of 30 volts. A typical keying signal and the resulting modulated tone are shown in

Figure 4. The keyed tone is applied to the recording input of the tape recorder and made permanent on an oxide-coated plastic tape.

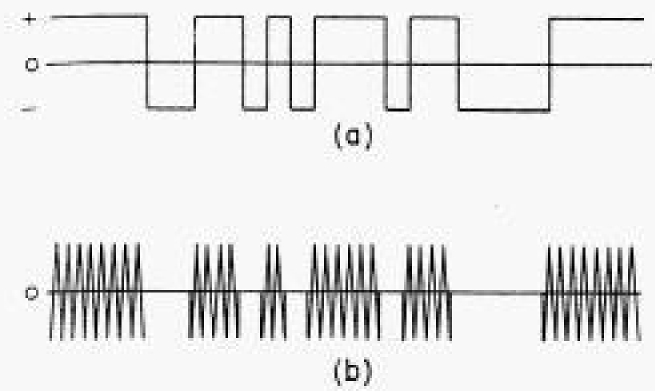


Figure 4.

To secure the original polar signals which are used to key the amplifier section of the oscillator unit, a multiplex distributor table, multiplex transmitters, and loops of multiplex tape still are required. This, however, usually can be done in the laboratory where several hundred feet of recorded tape can be produced in a few minutes thus eliminating that much work for the cable stations.

The reconversion of the tape-recorded modulated tone into the original polar signals is the function of the transmitter unit shown in Figure 5. The recorded tape consists of a series of tone periods indicating a spacing signal, and no-tone periods, indicating a marking signal. From the tape recorder output, these signals are fed directly into the transmitter unit which is essentially two tubes in push-pull with self-applied phase inversion. For a no-tone period, one tube is conducting thereby holding the tongue of the output relay to its spacing contact while the second tube is cut off. When a tone period appears, the 5000-cycle tone is rectified and applied to grid of the nonconducting tube causing it to become conductive. A feed-back path through two neon lamps drives a second tube to cut off and the tongue of the output relay goes to its marking contact. A meter in the tongue of the output relay indicates any bias in the signals appearing at the transmitter output. Signal bias can be corrected by adjusting the volume control of the tape recorder. The transmitter output relay drives a sending-on-relay which in turn applies the signals to the cable.

In cases where the attenuation difference between the low and high-frequency components of the signal is exceptionally great, the transmission of "curbed" signals, or signals of a form in which the cable is actually connected to earth for a fraction, usually 25 or 50 percent, of the time of duration of each signal impulse is advantageous. With curbed signals, smaller amounts of low-frequency components are transmitted and signal shaping is less difficult. The recording and transmitting of curbed signals involving the application of either pole of battery and a grounded interval would obviously demand a device of greater complexity and it is interesting

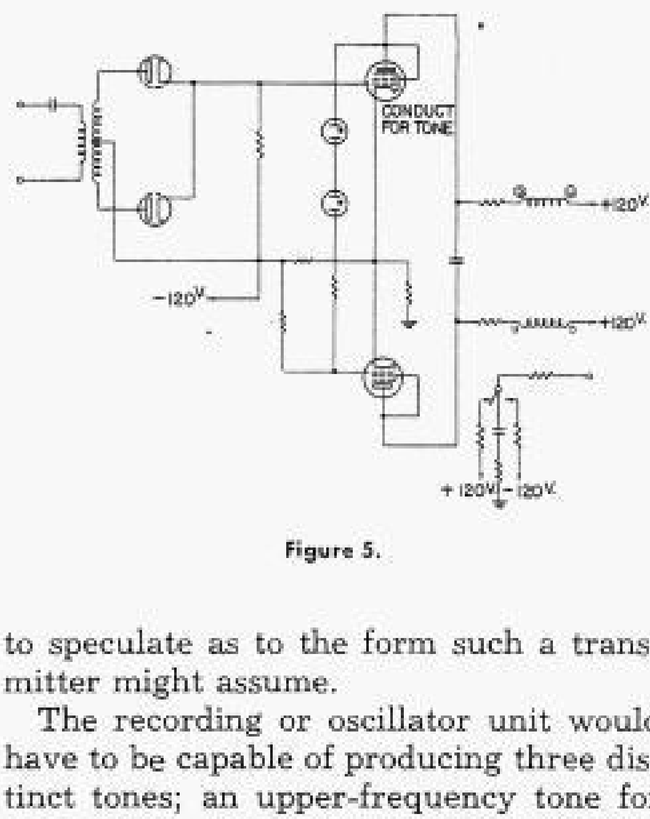


Figure 5.

to speculate as to the form such a transmitter might assume.

The recording or oscillator unit would have to be capable of producing three distinct tones; an upper-frequency tone for marking, a lower-frequency tone for spacing, and a mid-frequency tone for the curbing interval. The signal combinations would be recorded on the magnetic tape as frequency-modulated tones, rather than an amplitude-modulated tone as employed in the present transmitter. Transmission could be effected by the use of two relays, one marking in response to the higher-frequency tone, the other marking in response to the lower-frequency tone, and both spacing and grounding the cable in response to the mid-frequency tone.

Splicing the Tape

In Figure 6, which illustrates a typical arrangement for transmitting shaping signals, it will be noticed that a piece of magnetic tape has been formed into a loop. Rather than use a 1000-foot reel of recorded signals which would require interruption of the shaping signals every half-hour to permit the tape to be rewound, a loop of the magnetic tape is used which plays continuously without any special attention. Forming the loop requires precise splicing of the tape at a no-tone period so as not to disturb the repetitive pattern of the recorded signals. Each complete pattern of recorded shaping signals, such as shown in Figure 1-A, occupies a length of 54 inches on the magnetic tape. A small indentation to identify a splicing point every 54 inches along the length of the tape is made during a no-tone period by utilizing the circuit shown in Figure 7.

The recorded modulated 5000-cycle tone is converted into polar signals by the magnetic tape transmitter and fed to the splicing circuit input. The input signals to

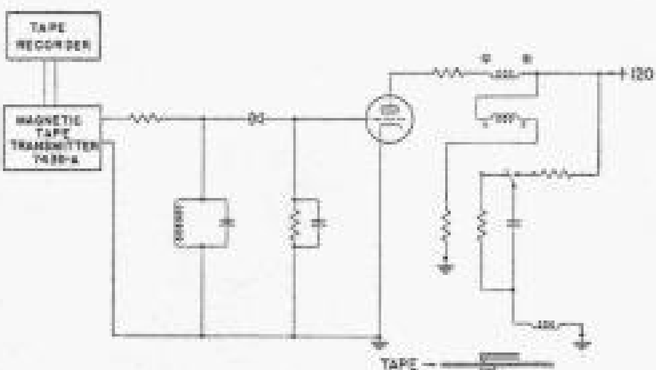
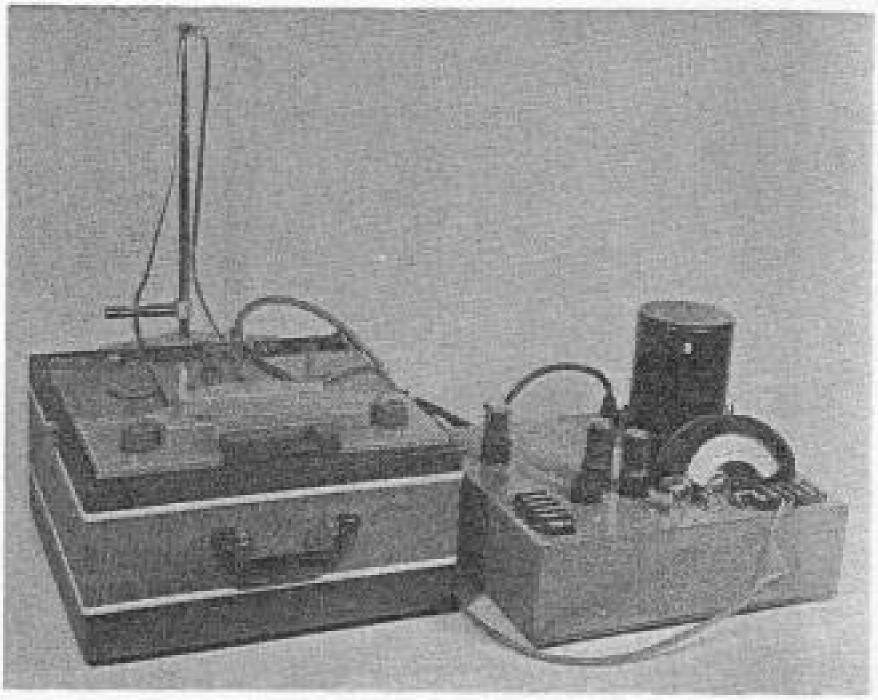


Figure 7.

this circuit are polar signals, as shown in Figure 1-A, consisting of "singles" a.c., combinations, and "doubles" a.c., separated by long marking and spacing pulses. The vacuum tube normally conducts 50 milliamperes through a main line winding of a polar relay holding the tongue to the spacing contact. The recorded signals are fed to the circuit input, and a tank circuit, tuned to the "singles" a-c frequency, shunts frequencies other



Photograph R-10, 168

Figure 6.

than this to ground. The appearance of the "singles" a-c frequency causes the tube to cut off, and the relay tongue goes to the marking contact by virtue of 28 milliamperes flowing in the other main line winding of the polar relay. The condenser in the tongue circuit creates a sharp impulse which results in a momentary operation of a single current relay. The magnetic tape rides between the relay contacts which are formed to produce a small indentation on the tape. When the "singles" a-c frequency no longer appears at the input, the tube conducts again, the plate current of 50 milliamperes returns the polar relay tongue to its spacing contact, and the condenser is discharged. The contacts of the single current relay are placed in relation with the reproducing coil of the recorder as in Figure 8, such that while the "singles" a-c modulated tone passes the coil, a no-tone period passes the relay contacts. Thus, a splice identifying point is made during a no-tone period, and a loop of tape spliced at this point can be repeatedly played with no disruption to the signal pattern.

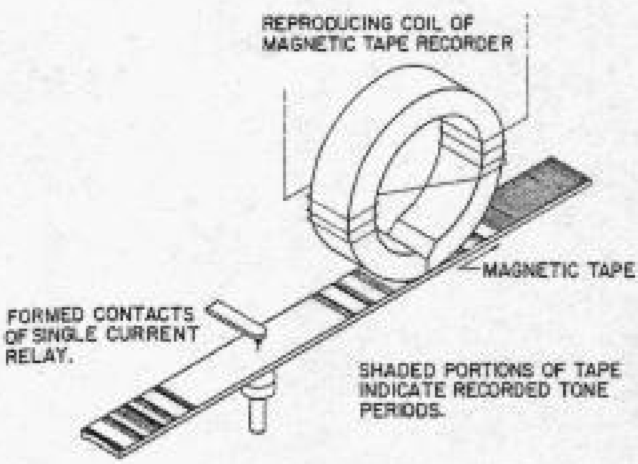


Figure 8.

Conclusion

The signal retentivity of the magnetic tape is very high and repeated use does not noticeably deteriorate the quality of the recorded signals. Some loops of tape have been played upwards of 100,000 times without any appreciable loss of signal quality. Whereas standard techniques for transmitting shaping signals require a great amount of preparation and constant attention, the magnetic tape signal transmitter requires very little in comparison. Aside from an occasional cleaning of the air gap of the reproducing coil, no attention is required once a loop of tape is started.

Extended field use of these transmitters during amplifier installations at Miami Beach, Key West, and Havana in the summer of 1955 proved their practicability. During that time tapes with "singles" a-c modulating frequencies of 50 cps and 100 cps were employed. On a cable project scheduled for the latter part of 1956 this same transmitter will be utilized for the transmission of shaping signals containing a "singles" a-c frequency of 150 cps.

The writer wishes to express his appreciation for the advice and guidance of H. F. Wilder, Assistant to the Electronics Application Engineer.

Edward T. Finnegan received his Bachelor of Electrical Engineering degree from the Brooklyn Polytechnic Institute in June of 1953; he had previously served in the U. S. Navy as an Electronic Technician. Upon graduation, he joined Western Union and was assigned to the Ocean Cables group of the Electronics Applications Engineering Division. Since that time he has worked on related cable equipment projects. Mr. Finnegan is an Associate Member of AIEE and IRE.

WILLIAM D. BUCKINGHAM, Assistant Electronics Engineer

A Flat-Bed Facsimile Telegraph Transmitter

One of a number of experimental "flat-bed" facsimile transmitters designed by Western Union engineers is described. As compared with "wrap-around" drum-type models, the flat-bed machines generally are simple to load and thus more adaptable for automatic operation. As in most flat-bed designs, however, return sweep of the scanning light spot, although fast, does waste some line time. The optical system described here is unique but a special lamp is required.

An EXPERIMENTAL flat-bed facsimile telegraph transmitter with a number of novel features has been developed at the Electronics Laboratory of The Western Union Telegraph Company. In the new machine, the message is placed on the flat bed of the transmitter and scanned by a series of closely spaced transverse lines as the sheet is advanced over the scanning position.

Such a device has several advantages over the more common type of facsimile transmitter which requires the message to be wrapped around a drum. With the flat-page or flat-bed transmitter, the message sheet requires no preparation or manipulation by the operator. It is simply laid on a table or dropped in a slot from which it is drawn by rollers through the machine. Furthermore, the sent message may be of any length. For example, copy from a telegraph teleprinter can be fed directly and continuously into the transmitter.

OPTICAL SYSTEM

The arrangement of the basic parts of the new Telefax machine is shown in the diagram of Figure 1.

Scanning is accomplished by sweeping a spot of light, 0.01 inch in diameter, horizontally across the message sheet from left to right at a uniform speed and returning the spot quickly, at nineteen times the forward speed, to the left margin to repeat the cycle again and again as the message is advanced slowly at a uniform speed transversely across the scanning line.

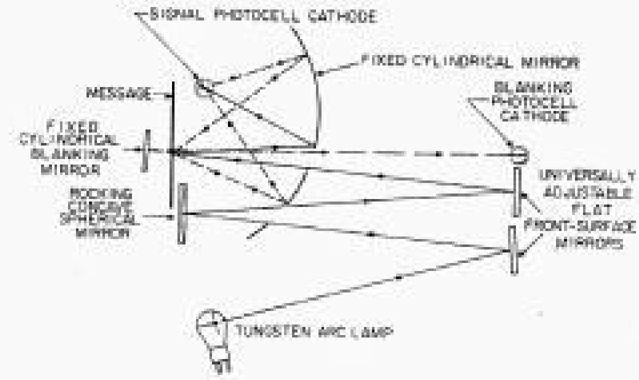


Figure 1. Diagram of optical system for experimental flat-bed facsimile scanner

Light reflected from the message is collected by a cylindrical reflector, concentrated on a photocell and converted into electrical currents whose intensities are proportional to the reflected light at each instant.

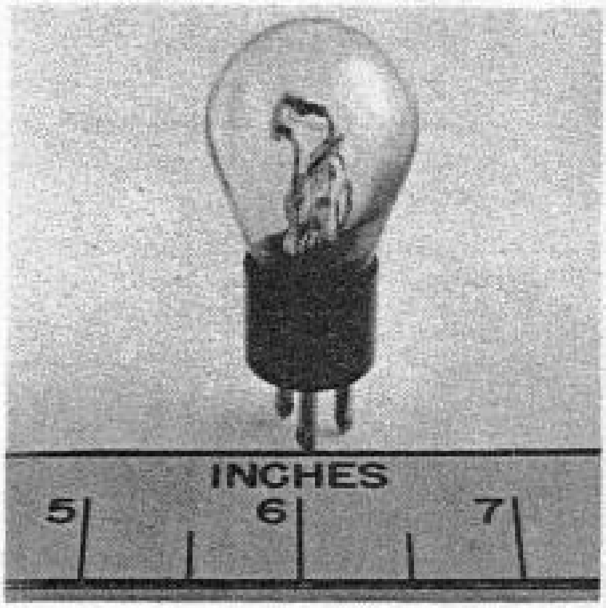
Tungsten Arc Lamp

The scanning light source is a miniature tungsten arc lamp, Figure 2, developed by Western Union specifically for facsimile use, and manufactured by Sylvania Electric Products, Inc. The lamp has a tungsten ball cathode, approximately ten-thousandths of an inch in diameter, supported on the end of a four-thousandths-inch diameter tungsten wire, and a molybdenum disc anode. These two elements are mounted in a small glass bulb filled with argon gas.

The lamp operates from a special rectifier power unit which first delivers a high-voltage pulse to start the arc and then supplies a direct current of about 100 milliamperes at 40 volts to maintain the arc.

During operation the tungsten ball is maintained at incandescence by the heat

A paper presented before the Winter General Meeting of the American Institute of Electrical Engineers in New York, N. Y. January 1956



Photograph WM-414-2-H

Figure 2. Tungsten arc lamp

of the arc to produce an extremely small, uniformly bright, stable and well-defined point source of light. It can be focused with a single lens or mirror directly on the message in the facsimile transmitter without the use of the condensing lenses and pinpoint aperture such as are required to produce an effective point source from the ordinary tungsten filament lamp usually employed in a "flying-spot" scanner. The elimination of these elements by the use of the new lamp avoids expensive optics, results in a brighter scanning spot and reduces the length of the optical path.

The new tungsten arc lamp offers an additional advantage over the tungsten filament lamp for facsimile transmitter use in that the light output of the tungsten arc is relatively constant with changes in lamp current. This comparison is shown by Figure 3. At 100-percent relative output, a 10-percent increase in current causes the light output of the tungsten filament lamp to increase 93 percent. Under a similar current increase, the light output of the tungsten arc lamp increases only 7 percent. Thus, it is not necessary to operate the tungsten arc lamp from a voltage regulator as is required for the tungsten filament lamp in this service.

During the life of the tungsten arc lamp, the tungsten ball gradually evaporates until it is reduced to the diameter of the supporting wire. This occurs after 200 to 300 hours of use. The lamp can then be renewed by reversing the polarity and sending ten times normal current through it for an instant so as to form a new tungsten ball on the end of the wire. This cycle can be repeated several times before the lamp is discarded.

Rocking Mirror

In this experimental flat-bed transmitter, light from the tungsten arc is collected by a concave spherical mirror which then reflects the image of the incandescent

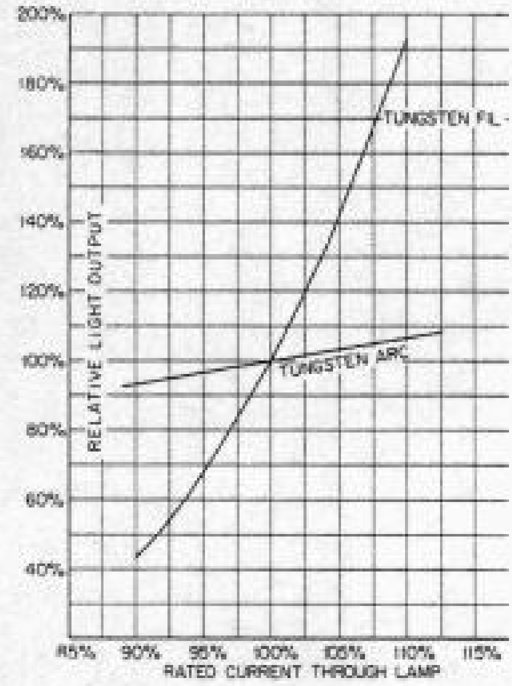
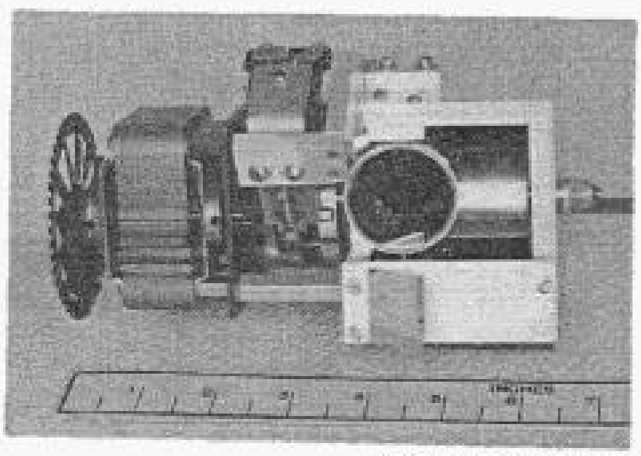


Figure 3. Light versus current curve of tungsten filament lamp and tungsten arc lamp

tungsten ball in the lamp as a small bright spot of light on the face of the message. This mirror is a simple plano-concave lens, 1⅜ inches in diameter, whose concave spherical surface has been coated with aluminum to form a concave mirror with a 20-inch radius of curvature. The mirror is placed so as to be substantially equidistant from the light and its image. Thus the optical system works at unity magnification and the high focal ratio of 14½. Under these conditions it is possible to produce a very high grade image of the source with very low cost optics. Flat mirrors are interposed in the optical path between the lamp and the concave mirror and again between the concave mirror and the message to direct the light beam back and forth so as to reduce the over-all space required for the optical beam.

The concave mirror is mounted on supports so that it can be rocked through an 11-degree arc by a motor-driven cam. This motion causes the image to sweep across the message at a uniform speed during 95 percent of the time of one revolution of the cam and to return to the starting point in the remaining 5 percent of the time. The cam is made of nylon impregnated with molybdenum disulfide. This material combines the advantages of quiet operation and long life of the nylon with the low-friction properties of the molybdenum compound. The mirror mount is



Photograph WM-411-10-H

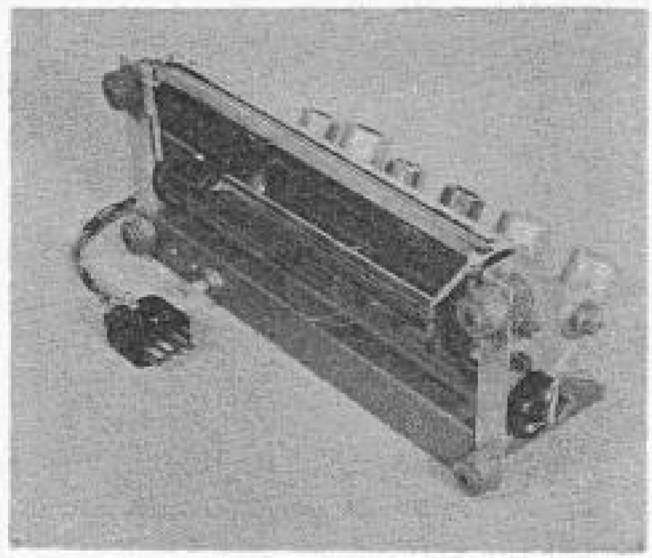
Figure 4. Swinging mirror, cam, and light chopper assembly

made of aluminum to have little mass. As a result, it has been found possible to operate such a rocking mirror at speeds up to at least 30 times a second or 1800 rpm. The cam-operated mirror with the associated motor, light chopper, speed-reducing gears and clutch of a unit which operates at 180 rpm is shown in Figure 4.

Cylindrical Mirror and Photocell

While the spot of light scans the message from left to right for a distance of about eight inches and returns quickly to repeat the cycle, the message is advanced transversely across the scanning position at a speed which produces 100 scanning lines to the inch of the message sheet. As the spot scans across the sheet, the light which is reflected from the message is collected by a cylindrical reflector and brought to a focus as a line of light on the photocell cathode.

The photocell is of a type which has a long narrow light-sensitive surface so as to pick up as much as possible of the line of light generated by the cylindrical reflector. With this combination of cylindrical reflector and photocell, the whole length of the photocathode collects light all of the time, regardless of the position of the spot of light along the scanning line, and thus avoids the usual requirement for such service—that the photocathode be equally sensitive at all points.



Photograph WM-411-12-H

Figure 5. Photocell, reflector and amplifier assembly

The cylindrical mirror collects the reflected light over an average solid angle of more than 90 degrees. If the reflected light is assumed to have a Lambert cosine spatial distribution, it can be shown that the cylindrical reflector collects more than 50 percent of the total reflected light. This collecting system is so efficient that an ordinary gas photocell provides ample signal output.

If the message being sent through the new machine is narrower than the scan line length, the scanning spot falls on a cylindrical mirror back of the message during the part of its sweep when it is off the message. This mirror sends the light into a photocell which operates to blank the inverter signal. This arrangement automatically provides a white background over the entire width of the received copy regardless of the width of the transmitted message.

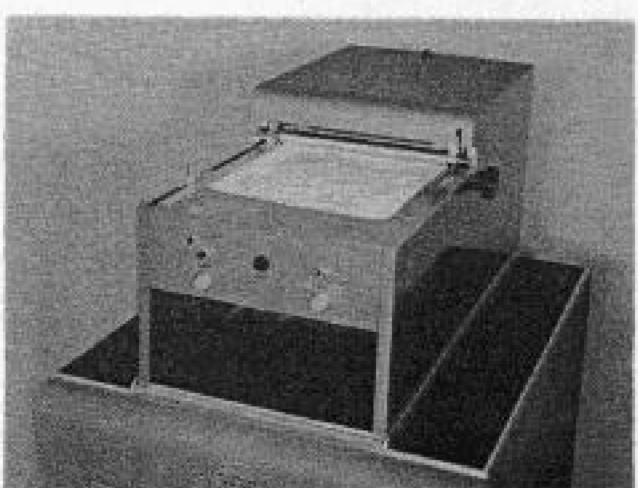
ELECTRICAL SYSTEM

A chopper wheel interrupts the light from the lamp at 2700 cycles per second to produce a modulated signal from the photocell that can be handled by an a-c amplifier. This 2700-cycle carrier frequency is sufficiently high to transmit the 1200-cycle frequency produced by the 180-rpm scanner. A 5400-cycle chopper is used on 360-rpm machines.

A resistance-capacity coupled amplifier is used to amplify the modulated signal from the photocell. The amplifier is equipped with a time-delayed automatic volume control which holds the output of the amplifier constant within 1/10-db as the input changes slowly over a 10-db range. This arrangement assures that the amplifier, over its range of control, will produce a constant signal from the message background, regardless of its color. Thus the amplifier adjusts itself automatically to the correct gain to produce a copy from the recorder which will have a white background and yet not fail to record light copy such as pencil marks that may be on the original message. The photocell, cylindrical reflector and amplifier assembly is shown in Figure 5.

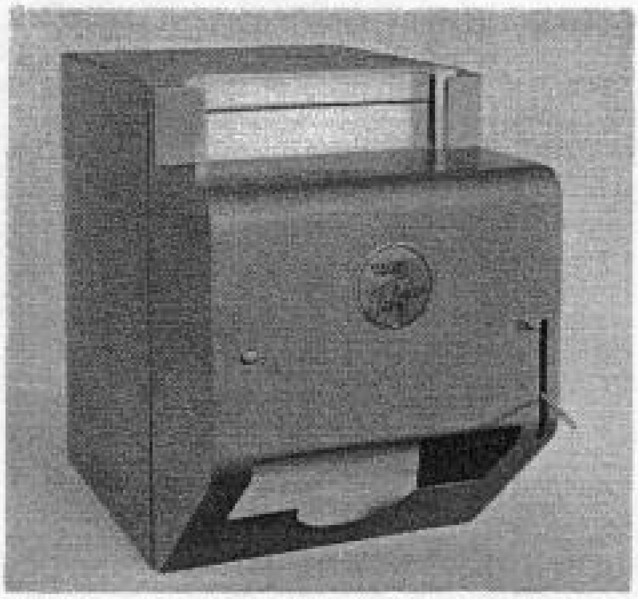
MECHANICAL SYSTEM

The various elements of this model flat-bed scanner may be selected and arranged in convenient form to fit the requirements of the particular service in which it is to be used. Figure 6 shows a machine designed to handle copy up to 8½ inches in width for private wire service, for example. In use, the message is placed on the flat table of the machine with the feed roller resting directly above the part of the message at which transmission is to start. A pointer at the edge of the table is adjusted to the line on the message where transmission is to end. If a message longer than the standard 11-inch sheet is to be sent, the end-of-message pointer is drawn to the extreme end of its travel. The machine will then transmit the copy, whatever its length, until the end of the sheet has passed the scanning line.



Photograph WM-411-2-H

Figure 6. Private wire transmitter



Photograph WM-411-3-H

Figure 7. Concentrator-type transmitter

When the machine starts, the sheet is fed at high speed to bring the message quickly to the scanning line. The rate of feed is then reduced to normal during transmission and at the end is again increased to feed the message sheet into the "sent" message compartment.

A flat-bed machine designed for Western Union concentrator service is shown in Figure 7. Here, standard length 8 or 8½ inch wide telegrams are dropped into a slot on the front of the transmitter. If the message does not fill the entire message box, an indicator bar set just below the signature will cause the machine to terminate the transmission at that point. When the start signal is received, the message is time-stamped on its face automatically and then fed at high speed to bring the top of the message box to the scanning line. At the end of the transmission, the sheet is fed at high speed into the sent message box at the bottom of the machine.

Further Development Scheduled

Since these experimental flat-bed transmitters require little of the operator, it becomes possible to equip them with automatic message loaders. The operator then puts the messages which are to be sent into the automatic loader and it in turn delivers the messages to the transmitter as required, one at a time and in sequence.

Although models have been made of the transmitter described here, further experimentation and considerable laboratory and field testing will be done before any decision is made to undertake production of this type of Telefax device. Evaluation studies based on such tests are in progress.

William D. Buckingham was born in Toledo, Ohio, and was graduated from the Case Institute of Technology with a B.S. degree in Electrical Engineering. He joined Western Union as an Engineering Apprentice in the Traffic Department at Toledo. At the completion of his training course in 1927 he was transferred to the Electronics Research Laboratory at Water Mill, N. Y., where he has been active in applying electronic techniques and equipment to land-line and cable devices. His activities have included ocean-cable balancing methods, the development of frequency standards, the design and production of special vacuum tubes including the brilliant zirconium concentrated-arc lamp, and work in optics and facsimile telegraph equipment. Mr. Buckingham is a Member of IRE, Eta Kappa Nu and Sigma Xi.

H. F. KRANTZ, II, Project Engineer, Electronics Applications

Power for Ocean Cable Amplifiers

Designed and built especially for the ocean cable repeater station at Horta (Azores) by Western Union engineers in New York, this one king-size power supply unit develops 115-volt alternating current which it converts to direct current at all the various voltages required by the station's electronic signal shaping amplifiers. Included are rotary converters with motor controls and switching panels, vacuum tube rectifiers and germanium rectifiers.

The first such voltage stabilized rectifier rack met with disaster when an inter-island vessel on which this equipment was being trans-shipped struck a submerged obstacle and sank in several fathoms of water near the island of St. George, necessitating return of the watersoaked equipment to New York for salvage.

THE CABLE station at Horta, located on the Island of Fayal in the Azores group, houses the terminal equipment of Western Union transatlantic cables to Hammel, New York, Bay Roberts, Newfoundland, and a connecting cable to Cherbourg, France, as well as those of foreign cable companies. The increased transatlantic message volume brought about by the cementing of relations between the European Continent and the United States requires increased cable speed on at least one of the cables through Horta. This increased speed is easily obtained with a suitable signal shaping amplifier. Supplying the necessarily well-regulated, ripple-free and uninterrupted voltages for the amplifier has, until recently, presented a problem of considerable perplexity.

In the past, shaping amplifier plate and screen potentials have been supplied by "banks" of 45-volt dry cells. However, at this remote station it is extremely difficult to maintain a schedule of replacement batteries with sufficient "shelf life" to be reliable as replacements for these banks totaling 300, 255 and 210 volts. In addition to this consideration is the fact that each time the service batteries are replaced, traffic continuity is broken, and slight readjustments must be made in the amplifiers following each change. These interruptions are most unwelcome since the cables are set up for a routine maintenance only once each week.

Two Sources Available

Except for the dry cells, only two sources of power are available at Horta; commercial 440-volt d.c. and the large storage cells which are maintained in every cable station as an uninterrupted, reliable source of power. Until recently neither of these has been recognized as a possible source of amplifier plate and screen potential. The commercial d.c., while being entirely satisfactory for normal usage, was not felt to be of sufficient reliability nor stability to drive motor-generator sets which then would power amplifiers demanding, for satisfactory operation, precise and uninterrupted voltages. The station battery provides a potential, nominally 112 volts, which gradually drops during use from 116 volts at full charge to 108 volts before removal for recharging. This battery also has a maximum load rating which cannot be exceeded. The station local battery, however, was decided to be the best available source of power to provide the amplifier potentials. This article describes a "package" power rack designed by Western Union engineers and the methods used to derive the necessary well-regulated plate supplies.

To the uninitiated, a proposal for using a 112-volt storage battery to drive an inverted rotary converter and produce 115 volts, 60 cycles, which can be rectified and then regulated to provide 300, 255, 210 and 105 volts d.c., seems quite elaborate and unconventional. However, in order to power high-speed ocean cable signal shaping amplifiers at as remote a location as the Azores, the idea is completely rational and realistic.

station bus bars by a fully charged set. Any method to supply the amplifiers from these batteries must also include a switching arrangement from one set to the other without interference of any sort. Figure 1

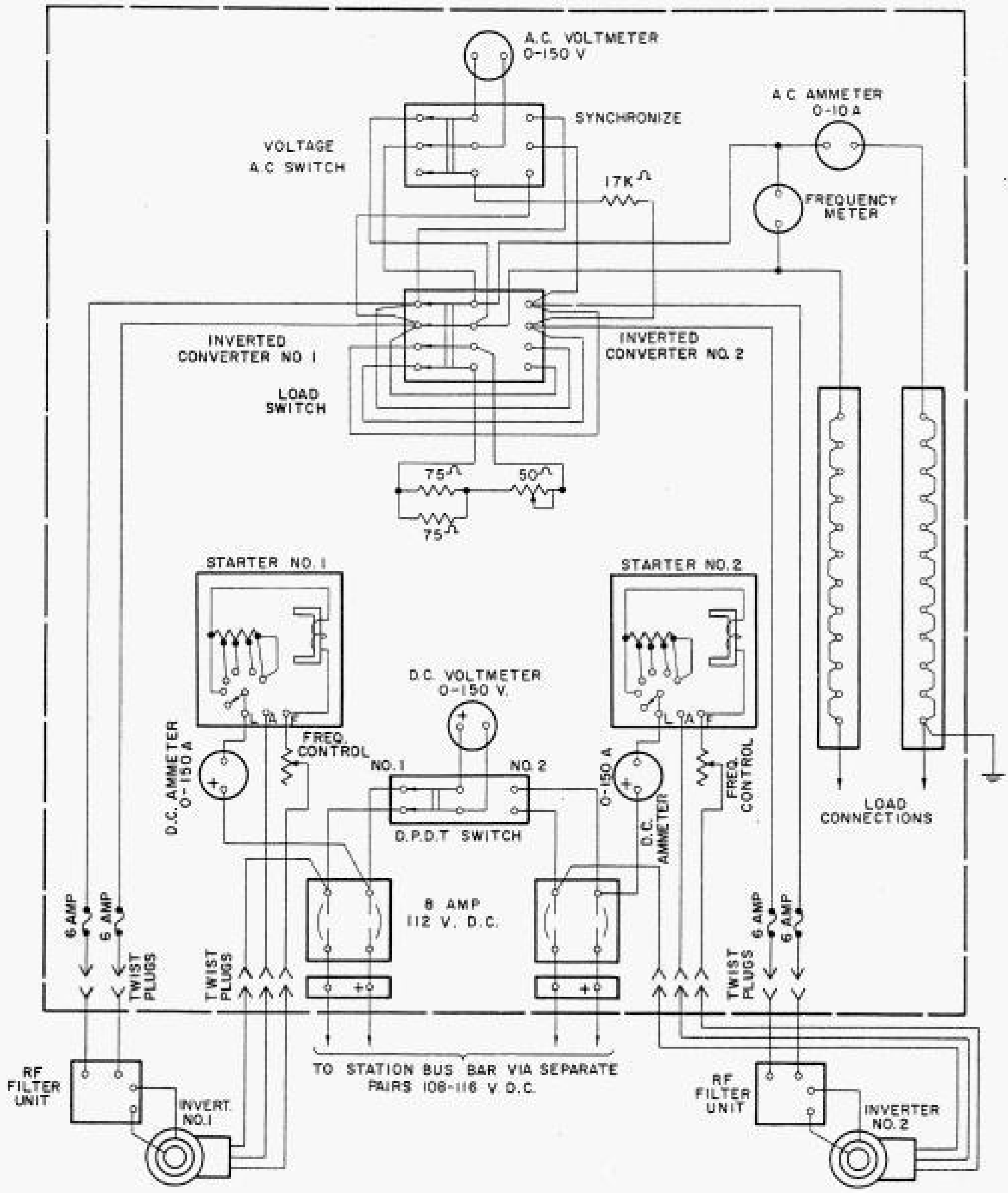


Figure 1. Control circuits—theory

Each station has two sets of storage cells which are alternately being charged or supplying the load. Consequently, the working set is periodically replaced on the

is the theory of the control and switching devices. The station bus bars are connected to the rack via two separate lead-covered pairs where they are fused, metered and applied to conventional motor starters for both machines. Each machine, an "inverted" rotary-converter, is connected to its starter, and in like manner to the load, by means of a twist-lock type plug and receptacle to facilitate maintenance. The output of each machine is equipped with a radio-frequency interference eliminator to reduce brush noise radio interference, since the people of the island depend a great deal on the radio both for news of the world and for entertainment. The converter outputs are connected to a load switch which is used to select the working inverter.

Switching Without Interruption

The switching controls provided with the load switch have proven under test to be quite accurate, permitting the switching of supply without a perceptible voltage deviation on any of the various outputs. Assuming that converter No. 1 is supplying the load and must be taken out of service for one reason or another, the switching procedure can be followed on the diagram of Figure 1. The four-pole double-throw load switch is in the left position, connecting the load to converter No. 1, and the a-c voltmeter switch in the VOLTAGE position, indicating the voltage across the load. Inverter No. 2 is started, working into the dummy load which previously has been adjusted to match the current drain of the rectifier loads. The a-c switch, when thrown to SYNCHRONIZE, parallels the two inverter loads with the meter in series with 17,000 ohms. The meter then "beats" as the two voltages swing in and out of phase. By adjusting the frequency of No. 2 inverter, the beat is reduced until it is just perceptible, and the load may be switched at the moment of zero deflection. When switched at this exact instant, no noticeable change is evident in the rectifier outputs.

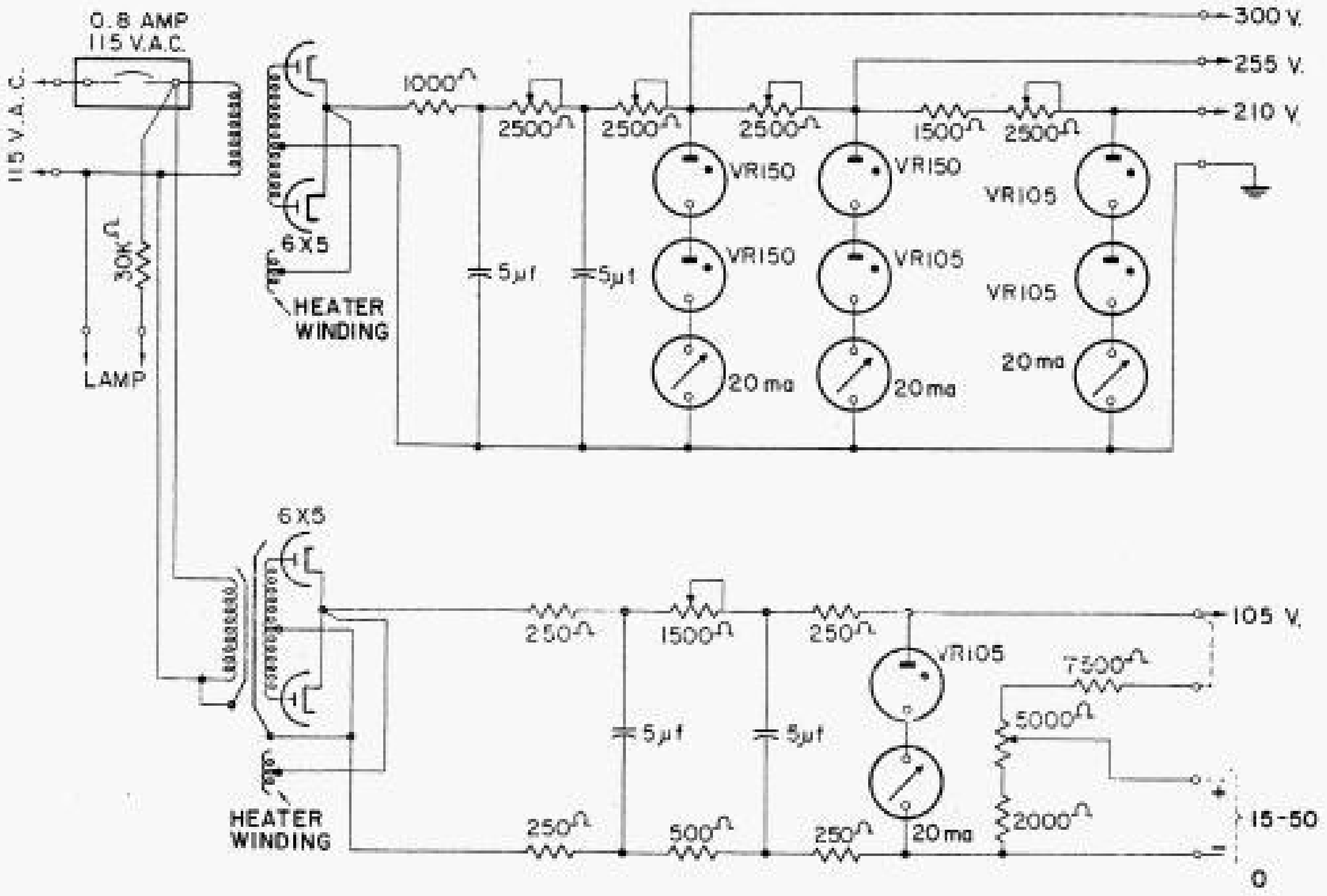


Figure 2. Rectifier 7230—theory

These procedures were used to determine the effect of replacing a discharged battery with a fully charged one at the bus bar, and the same results were noted even though the two primary station battery voltages differ by their maximum amount. No variation consistently appears when the inverters are switched somewhere near synchronism. If they should be switched 180 degrees out of phase, shifts of only 0.127, 0.076, 0.0095 and 0.114 volts are seen on the 300, 255, 210 and 105-volt outputs, respectively, of the vacuum tube rectifier. After switching the load, the a-c voltmeter switch is thrown to VOLTS to monitor the output of No. 2 inverter, and the vibrating reed meter indicates its frequency which may be refined if necessary with the frequency control. The replaced No. 1 inverter may now be stopped for maintenance.

Constant A.C. Available for Rectifiers

With this arrangement of an inverter on the working station battery, constituting a fixed additional load of 5 amperes, there is available for rectification a constant supply of 115-volt, 60-cycle power. While primarily designed to power the new high-speed cable amplifier at Horta, these arrangements make possible the elimination of other dry-cell banks, and the final rectifier rack includes outputs to meet all of the following conditions:

a. 300 and 210-volt plate and screen potentials for Western Union designed amplifiers.

b. 105-volt local correction relay battery for Western Union designed amplifiers.

c. 300-, 255- and 210-volt plate potentials for the Western Electric amplifiers.

d. 35/40-volt bias battery for Western Electric amplifiers.

e. 200 and 100 volts for compensated output stage of the Western Electric amplifiers, driving the output relay.

Two Rectifiers Provide All Potentials

Two rectifiers designed with standard repeater rack spacing provide all the required potentials for amplifiers at the cable stations. Both types are required on the special rack for Horta, and proposals for other stations include provision of both types for separate rack mounting.

Vacuum Tube Voltage Stabilized Rectifier 7230, providing the 300-, 255-, 210- and 105-volt plate, screen and local correction relay battery, is shown in theory by Figure 2. This unit consists of two conventional full-wave vacuum tube rectifiers; one with three cascaded voltage-regulated outputs of 300, 255 and 210 volts; the second with one voltage regulated 105-volt output and potentiometer for use with the 35/40-volt bias required by the Western Electric amplifiers.

The particular features of this *second* rectifier including the double shielding of the transformer and a high insulation resistance to ground should be explained

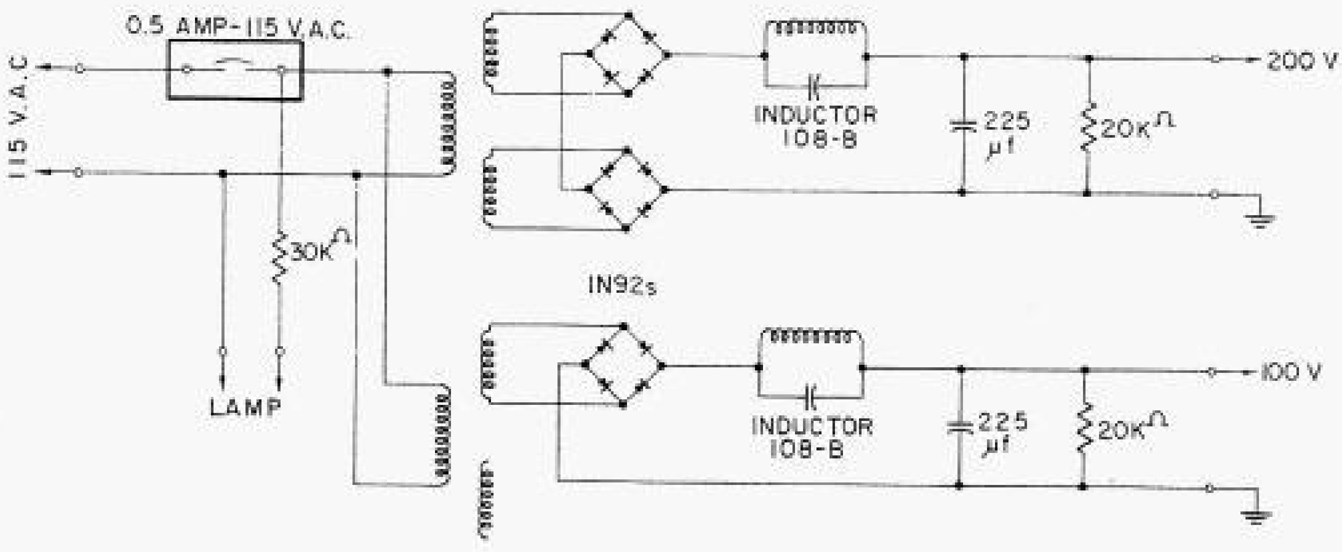
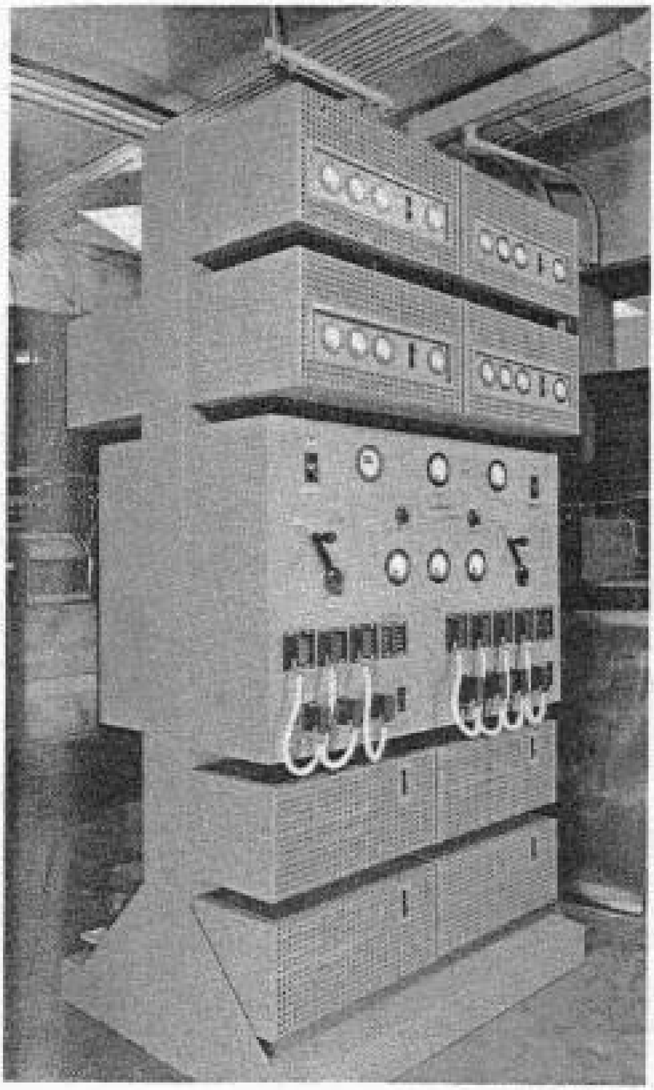


Figure 3. Rectifier 7231—theory

here. Western Union shaping amplifiers are provided with a network which is designed to restore d.c. and low-frequency components which have been suppressed by the primary shaping networks in order to eliminate the effects of earth currents on the cable signals. This local correction must be completely isolated from ground



Photograph R-9847

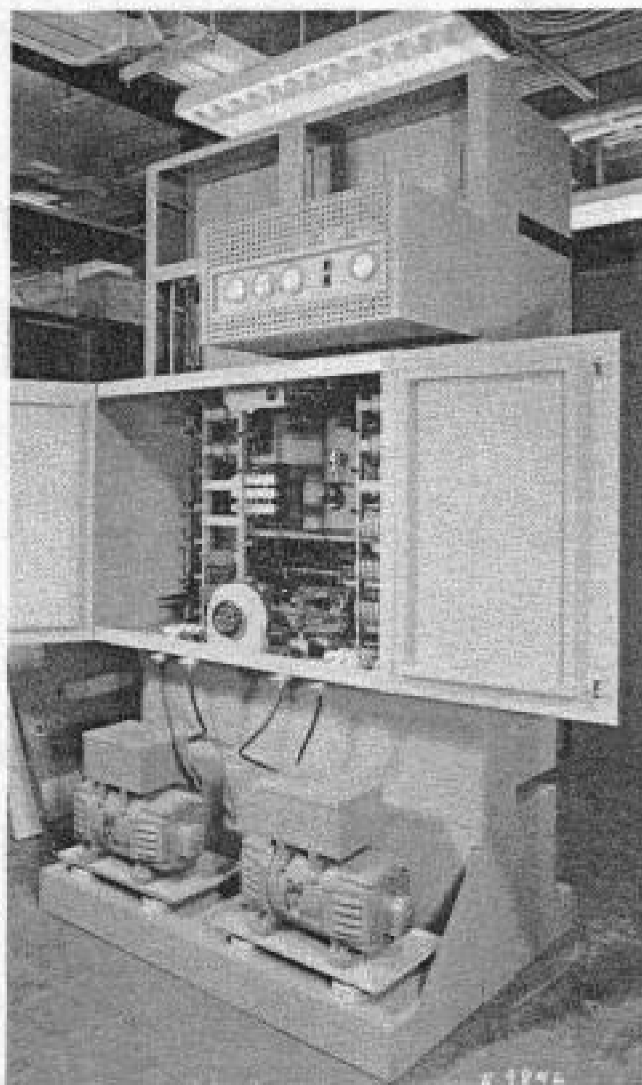
Figure 4. Rectifier Rack 7234—front

and free of stray capacity, hence the insulation and shielding in the rectifier. This 105-volt potential is used to energize auxiliary amplifier output relays driving the local correction network. The second use of this rectifier (connections shown dotted on Figure 2) is to provide bias voltage on the output stages of Western Electric shaping amplifiers. The cascaded voltage-regulated supply showed excellent stability in the final stage as might be expected, varying only 0.0088 volts in 210 for maximum changes in the station battery. For the same variation the 255-volt supply was regulated within 0.143 volts and the 300-volt within 0.773 volts.

Measurement of the residual ripple in each supply showed the following values before and after being filtered by an external filtering network.

SUPPLY	RIPPLE	
	WITHOUT FILTER	AFTER FILTER
300 volts	0.577 volts	1.29 millivolts
255 "	0.08 "	negligible
210 "	0.01 "	"
105 "	0.056 "	not filtered

Voltage Stabilized Germanium Rectifier 7231 is shown in theory by Figure 3. As can be seen, these are two standard full-wave bridge germanium rectifiers with filtered outputs. The regulation of the two



Photograph R-9846

Figure 5. Rectifier Rack 7234—rear

outputs is satisfactory, and the ripple voltage does not exceed one-tenth of one percent for either supply.

A front view of the assembled equipment is given in Figure 4, showing the vacuum tube rectifiers above the control cabinet, with the germanium rectifiers below. The rack is designed with sufficient flexibility to be used at stations other than Horta if it should be desired, permitting various combinations of the panels to be made. Figure 4 shows the face of the control cabinet with all meters, switches and controls. Mounted at the bottom of this cabinet is the patching panel with Jones type sockets for connecting the rectifiers to their amplifier loads, and for patching the spare rectifier to any amplifier should the working rectifiers go bad. This panel is replaceable when the rack is used at another station, being designed in each case to fit the particular needs of the locality. The socket which is cabled to an amplifier is wired in parallel with another socket, which may in turn be patched to the spare rectifier prior to removing one which is suspected of being in need of maintenance. Each rectifier plug is adjacent to an indicating lamp which shows when power is being applied to the rectifier. (See Figures 2 and 3.)

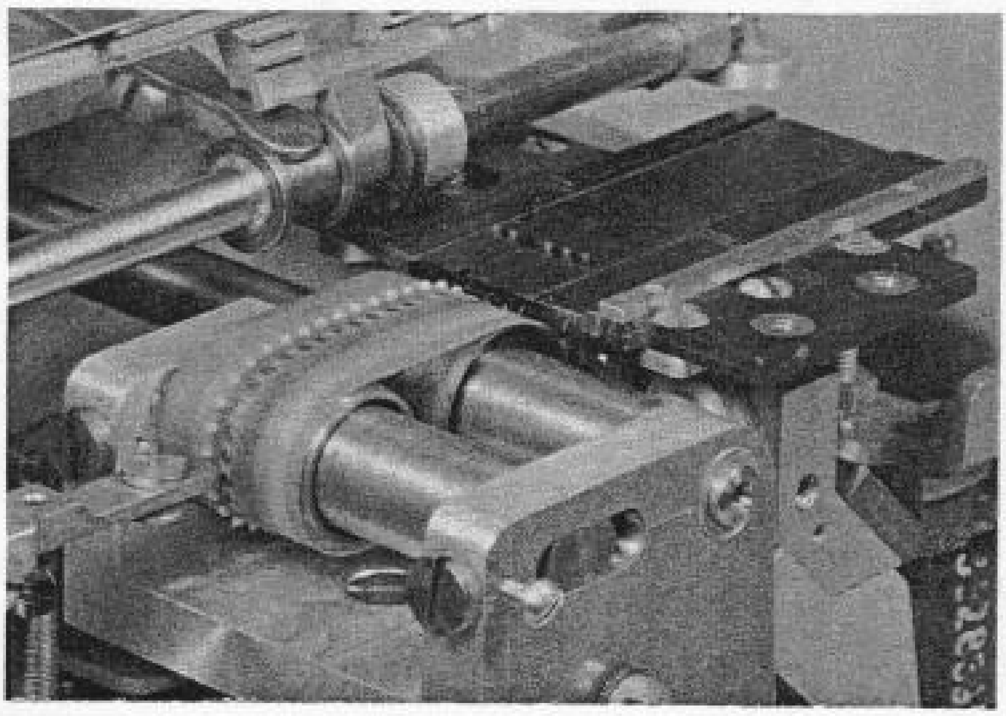
Figure 5 shows a rear view of the rack assembly with the vibration control mountings for the inverters, and the "ladder" mounting of terminal blocks for connection to the amplifiers. These mountings permit ready changing of the amplifier termination, or removal for test should these moves be necessary.

This equipment has undergone satisfactorily the most stringent laboratory and field trials in the New York laboratories.

In closing, the author wishes to acknowledge the over-all planning and design of these units by H. F. Wilder, Assistant to the Electronics Applications Engineer.

Mr. Krantz's biography appeared in the October 1955 issue of TECHNICAL REVIEW.

A FLEXIBLE NYLON FEED BELT



An unusual application of nylon as a flexible tape feed belt to meet a special requirement in which perforated tape must be kept in one plane and stepped through a transmitter with a maximum pull.

F. LESLIE CURRIE, Assistant to Systems and Equipment Engineer

Automatic Local Sending from Telephone Recording Positions

On trial at Philadelphia is an arrangement to provide perforated message tapes simultaneously with typewritten recordings of telegrams received by telephone. The tapes permit automatic transmission of such telegrams into the Western Union nationwide switching system and the typed copies serve for record purposes. Operation of the equipment has been satisfactory but economic aspects of the plan require further study.

THE GENERAL evolution of message handling which resulted at offices converted from the manual to the reperforator switching type of operation did not apply fully to the messages received at the telephone recording positions from the public, because of the inherent random manner in which those messages customarily are dictated. They continued to be recorded with typewriters as before and, like the messages received from customers across the counter, continued to be conveyed to local sending positions where they are manually converted into perforated tape form for automatic processing through the reperforator switching system.

In order that the effects of that irregular condition might be obviated sufficiently to permit also integrating this segment of the traffic directly into the reperforator switching system from the original recordings, a new recording and switching arrangement was evolved for attaining that objective. It, in effect, converts the telephone recording position into a form of reperforator switching local sending position.

This new arrangement, which is based upon the usage of a new recording device, termed Flexowriter, provides for recording the messages, or any part of them, either manually by means of a keyboard, or electrically by a remote transmitting means such as an automatic numbering machine, and for producing the recordings simultaneously in two forms, a typewritten page copy and a perforated tape. The typewritten page copy serves for monitorial and accounting purposes, and the perforated tape for automatic transmission into the reperforator switching system.

The Flexowriter is a commercially available item and, in addition to containing a keyboard for manual operation and selector printing means for electrical operation from a remote transmitting means, it also contains special features for effecting rubouts, punch tape cutout, switching controls, and so forth.

Since the efficient utilization of the reperforator switching equipment, and of the personnel, is attained when the circuits are loaded to capacity, a study was made of the average loads involved to determine the number of recording positions whose aggregate normal load would constitute proper loading for one reperforator switching system receiving position.

The results of that study indicated that five telephone recording positions is the proper number and consequently the plan outlined in Figure 1 was developed. That plan constitutes an operational unit containing five Flexowriters and associated transmitting and control equipment, a common automatic numbering machine, a common cross-office circuit to a reperforator switching system receiving position, and common control switches and relays.

Each operational unit functions to cause the messages recorded with the five Flexowriters to be numbered with one series of numbers, and to be sent into the reperforator switching system over a single cross-office circuit. Thus, the output of five telephone recording positions is processed into the reperforator switching system like the load from one heavily loaded tributary trunk.

Two Transmitters Employed

Two transmitters and two groups of control relays are associated with each character in that transmitter. When transmission starts the first transmitter operates first and sends the top line and then the second transmitter starts operating and sends the address, text, and signature. When the message transmission is finished, the second transmitter idles the top line through itself until the end of top line switching characters, FIGURE LETTER, are sensed. Then it will idle through itself

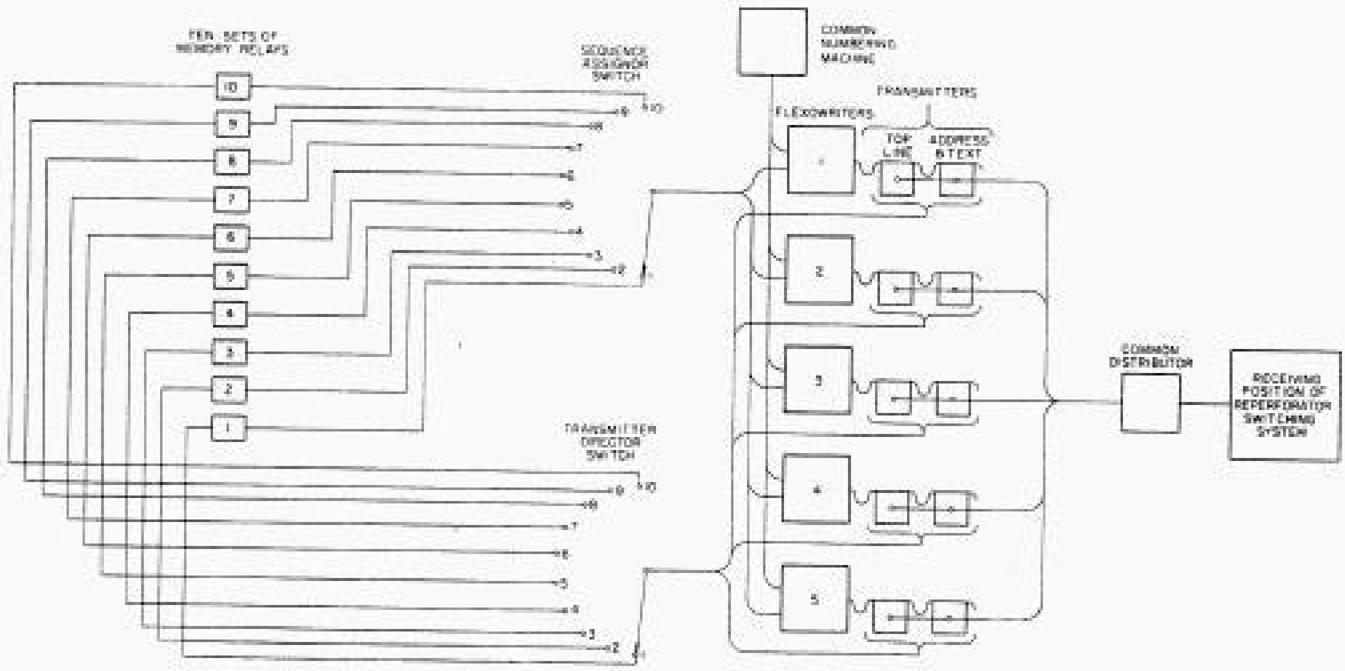


Figure 1. Schematic of telephone receiving position with Flexowriter

Flexowriter. The two transmitters function for each message transmission, the first for sending the top line information and the second for sending the balance of the message, i.e., the address, text, and signature. Because the top line cannot be determined until after the address, text, and signature portion of the message is finished, the top line is the last part of the message completed, and hence appears as the last of the perforations in the tape. In the message transmission, however, it must be the first part sent.

The two transmitters permit the sending of the two portions of the message in their proper order. The first part of the message in the tape (address, text, and signature) and all periods and blanks which may next follow are idled through the first transmitter so that the first character of the top line appears as the first character in that transmitter, and the second transmitter idles all blanks and periods so that the first character of the address is the first all ensuing blank and period characters.

The two groups of control relays, individual to each recording position, function for each message but not at the same time for the same message. The first group functions as the message is being recorded and controls the connecting and the releasing of the automatic numbering machine for the message number. The second group functions with the two transmitters to cause each of them to operate at the proper time, to read for the pertinent switching character combinations, to effect switching operations at the proper time, to idle tape through the transmitters when no transmission is required, and to terminate the connection when transmission is completed.

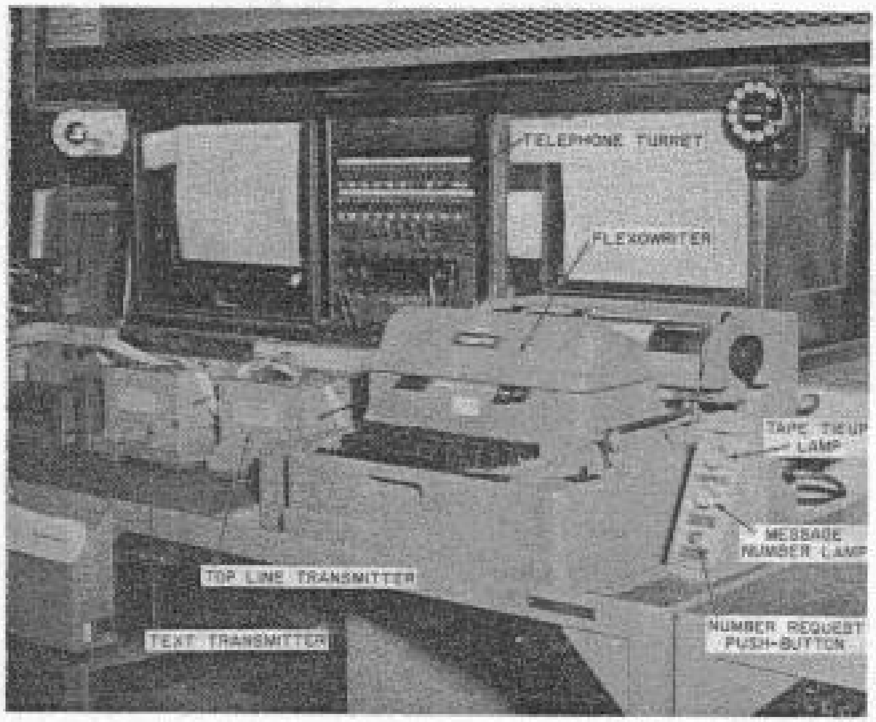
Automatic Message Numbering

The message numbers are furnished by a common automatic numbering machine and form a part of the top line of each message. They are assigned to the messages in the order in which they are requested by the different telephone recording positions, and consequently may appear among the five recording positions in any random order. Although the numbers may appear in any random order, the messages must be transmitted cross-office in the exact order of their numerical sequence for reasons of message protection and proper operation of the reperforator switching system. That requirement is satisfied by employing a group of common equipment which registers the order in which the different recording positions are connected to the automatic numbering machine and causes the transmitters of those respective recording positions to be connected to the common cross-office circuit in the same order.

That group of common equipment consists essentially of ten sets of memory relays which serve to denote the recording position identity for each message; a sequence assignor switch for associating the memory relays, one set at a time, in their numerical order, with the recording positions as the latter receive message numbers from the automatic numbering machine, thus harmonizing the numerical order of the memory relay sets with the numerical order of the message numbers; and a director switch for advancing from one set of memory relays to the next, after each message transmission is completed, to effect the connection between the cross-office circuit and the recorder position with the next sequentially numbered message.

The ten sets of memory relays facilitate the readying of ten messages for transmission and those ten messages may be scattered among the five recording positions in any order, or all ten may be contained in only one of the positions. This feature permits operating flexibility by enabling the recording of messages with all, or any portion of the five Flexowriters, at the same time, and also by enabling the message load to vary widely between the recording positions without interfering with each other.

The cross-office transmission is actuated by means of a distributor which is switched to the transmitters of the different recording positions when transmission is to be made from them. It converts the pulse combinations of the character above the transmitter pins into properly-timed single-line transmission pulses and repeats them into the cross-office circuit.



Photograph H-1907

Figure 2. Recording position at Philadelphia trial installation

The switching character combinations used to execute automatically the switching operations are two successive fourth pulse selections (fourth pulse only) and the pulse combination for selecting the FIGURE LETTER characters. The two fourth pulse selections, which also may be a period or a carriage return selection, signify the end of the address, text, and signature portion of the message, and the FIGURE LETTER combination signifies the end of the top line portion. The two successive fourth pulse only selections also function in the reperforator switching system operation to denote end-of-messages. The FIGURE LETTER combination functions only in the telephone recording operational unit and serves no useful purpose in the reperforator switching system.

Operation

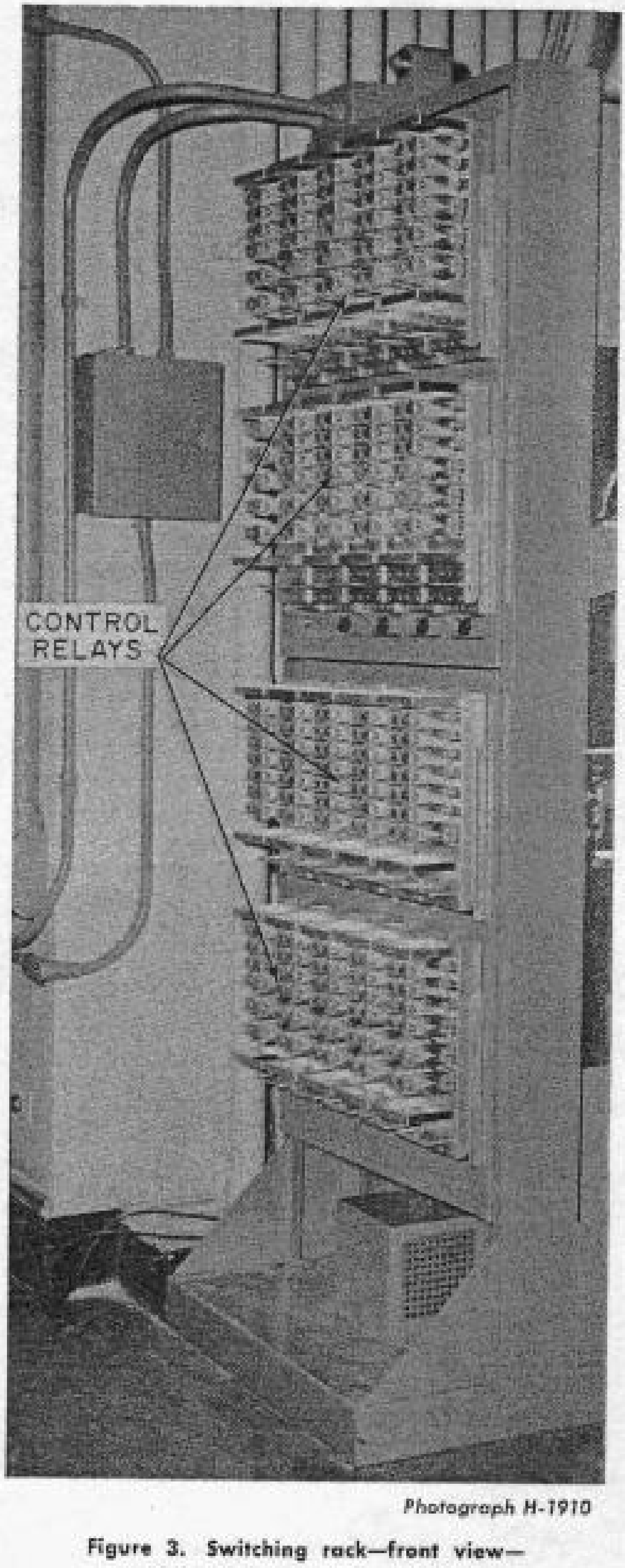
While the recording practice used with this arrangement is quite similar to that employed where typewriters are used, it does differ from the latter in some respects since the messages must be completed in proper form for automatic processing through the reperforator switching system.

The recording operator at a telephone recording position equipped in accordance with this plan answers incoming calls by inserting her telephone plug into the jack of the calling line and requesting the patron to proceed with the message. The message is recorded as previously described in both typewritten page and perforated tape form. When the patron completes his dictation of the message, the necessary billing information is obtained and typed on the ticket portion of the blank in typewritten page form only. This is accomplished by deactivating the punch tape mechanism while the billing information is being recorded. When the transaction has been completed and the patron has been released, the punch tape mechanism is reactivated and the digit and the end-of-message switching control signals are typewritten on the page and punched into the tape.

The top line is now prepared. It includes the office selection characters; the identifying number which is automatically typed on the typewritten page and punched in the tape in response to the operator pressing the number request key; the message check information; the office of origin; date; filing time; and the switching characters, FIGURE LETTER, to signify the end of the top line.

The typewritten page copy, normally, is used for accounting purposes.

The first portion of the perforated tape contains the address, text, and signature of the message and is stepped through the first transmitter as it is prepared. Each character is examined as it passes over the transmitter pins by character-reading means, watching for the end-of-message selection until that selection is sensed. The first transmitter then proceeds to idle

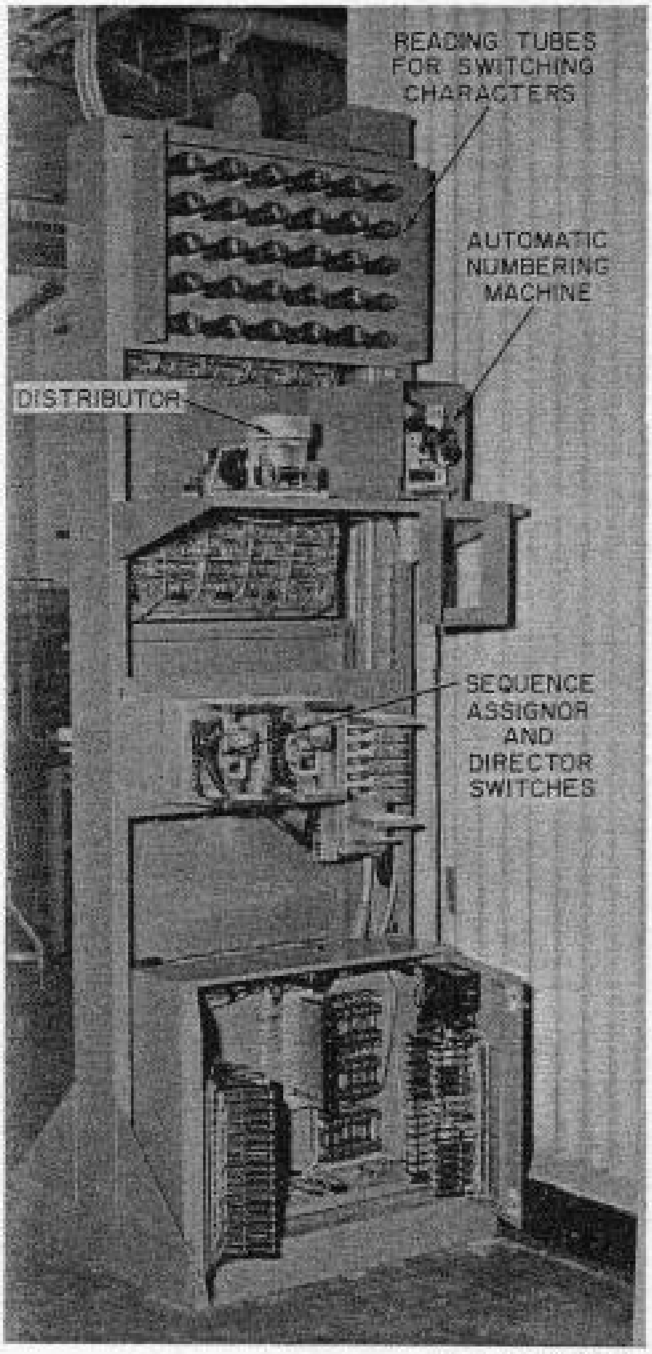


Photograph H-1910

Figure 3. Switching rack—front view—Philadelphia trial installation

through itself all successive blank and period characters until some different character appears. The latter is the first intelligence character of the top line. The address, text, and signature of the message now have been stepped through the first transmitter and the top line portion is properly positioned in that transmitter for sending.

As the address, text, and signature of the message are being stepped through the first transmitter, the second idles through itself all preceding tape containing periods and blanks until the first intelligence character appears above its pins. That character is the first address character and a tape loop containing the address, text, and signature portion of the message is formed between the two transmitters.



Photograph H-1909

Figure 4. Switching rack— rear view— Philadelphia trial installation

When the message appearing in these two transmitters becomes the next sequentially numbered message to be sent, the wiper contacts of the director switch are advanced automatically to the set of memory relays associated with the message number and a circuit is completed through contacts of those relays to connect the respective pair of transmitters to the common distributor of the cross-office circuit.

The first transmitter starts operating under control of the distributor and continues to operate until the switching characters, FIGURE LETTER, are sensed by the character reading equipment. The sensing of those switching characters results in the first transmitter stopping operation and the switching of the distributor from the first to the second transmitter. The second transmitter, now under control of the distributor, starts operating and continues until the end-of-message switching characters are detected which stops the operation and causes the cross-office circuit to be disconnected. The cross-office circuit, now, is available for immediate connection with the transmitters of the recording position containing the next message.

Each recording operator may proceed to record another message after one is finished without waiting for the first to be transmitted and all five operators may be recording simultaneously without interfering with one another. The aggregate number of messages that may be readied for transmission in any one operational unit of five Flexowriter recording positions is restricted to ten.

Field Trial Installation

Before proceeding with any comprehensive programs of installing this arrangement, an experimental unit was installed in the Philadelphia office to enable determining its over-all practicability and to obtain pertinent operational data. Figures 2, 3 and 4 are pictorial views of the equipment assemblies.

Figure 2, which shows a telephone

recording position, illustrates the positioning of the telephone jack turret and the two transmitters with respect to the Flexowriter recorder. Figures 3 and 4 are front view and back view respectively of the equipment control rack. That rack contains practically all of the control equipment required both for the individual recording positions and for the common equipment.

Experience with the experimental installation at Philadelphia has demonstrated satisfactorily the operational practicability of the arrangement. At the time of this writing, however, an expansion of that installation is contemplated so as to afford a better collection of data for evaluating the economic aspects of the plan.

F. Leslie Currie, Assistant to the Systems and Equipment Engineer, started work for Western Union in Mississippi in 1917 and, except for a military furlough during World War I for service in the U. S. Navy, has been with the telegraph company ever since. In 1924, after receiving a B.S. in E.E. degree from the Milwaukee School of Engineering, he was transferred from the Traffic Department in Milwaukee to the Engineering Department in New York. Since that time he has been engaged in the development and design of both apparatus and circuits; the more noteworthy of the latter includes the circuitry for teleprinter subcenter switching systems, automatic facsimile concentrators, and for the push-button switching, the dial switching teleprinter monitor, the multiaddress book switching, the CND multisend switching, and the automatic local sending from telephone recording positions, of reperforator switching systems—Plans 20 and 21.

Patents Recently Issued to Western Union

Metered Circuit for Effecting Repeated Recording Operations

A. E. FROST
2,735,491—FEBRUARY 21, 1956

Apparatus for automatically inserting into perforated message tape a desired number of spaces or other characters particularly useful when preparing tape representing columnar material for reproduction on page teleprinters. Depression of the space bar or other key lever sends pulses from a relay type oscillator through both the perforator punch magnets and the stepping magnet of a counting rotary switch arranged to count a predetermined number of spaces. Upon the last step the circuit is restored to normal.

●

Telegraph System

W. B. BLANTON, F. L. CURRIE
2,735,884—FEBRUARY 21, 1956

Manual switching arrangement for transmitting over selected groups of patron's telegram tie lines, periodic news items, e.g., commodity quotations. Common push buttons, supplemented by individual line push buttons, connect the idle lines by selected groups to a common transmitter for subsequent simultaneous transmission. Busy lines may be added by subsequent attempts before transmission finally starts. An end-of-message signal automatically restores the lines to normal.

●

Process for Welding Thin Sections of Spring Steel

C. B. ROUNTREE
2,737,568—MARCH 6, 1956

Method of joining ferrous material, e.g., the end of a facsimile stylus belt, by electrical resistance welding by capacity discharge which includes the addition of pellets of nickeliferous material at the weld spot. The nickel penetrates the ferrous stock, reduces resistance and excess heat and serves firmly to bond the parts while avoiding burning, warping, embrittlement and weakening.

Synchronous Power Supply Apparatus for Facsimile Systems

C. JELINEK, A. A. STEINMETZ
2,737,622—MARCH 6, 1956

Means for producing synchronous power at a facsimile or other receiver under control of a frequency sent from the transmitter which comprises an electromechanical vibrator having a natural frequency slightly higher than the synchronous frequency and with its driving magnet and contact in series with the anode circuit of a thyratron. The incoming synchronous frequency controls the thyratron to exert a sufficient retarding effect on the vibrator to maintain synchronism. A tuned amplifier may precede the thyratron.

●

Telegraph System

G. S. VERNAM, B. V. MAGEE
2,738,376—MARCH 13, 1956

A duplex way-station selection circuit in which operation of a way-station calling key sends a timed open to signal the central office, connect the way-station transmitter to line, and lock out other way-stations through operation of two-relay combinations thereat. Central office selection of a way-station by transmission of a selection character, a figures-shift character and the message sequence number, either from a message numbering machine or from a teleprinter, is described together with the method of locking out undesired stations and final release of all stations. By a suggested improvisation of way-station equipment, a way-station can directly select another way-station in a somewhat similar manner.

●

Stylus Facsimile Recorders

L. G. POLLARD, G. H. RIDGE, A. HOFER
2,739,029—MARCH 20, 1956

A facsimile recorder mechanism designed for automatic unattended use which after recording a message feeds out a fixed length of paper, shears it off and ejects it into a message compartment. The machine is principally supported by a pair of spaced vertical plates with the stylus recording mechanism mounted on a panel hinged to one of the plates for ready accessibility. When the gate is closed, the styli are aligned with the platen and when open the paper feed rollers separate for convenient loading of the paper supply.

Direct Coupled Amplifier Circuit

W. D. Cannon

2,740,849—April 3, 1956

A power amplifier push-pull output stage employing a pair of screen grid tubes whose anodes each receives positive potential via a resistance and a coupling tube connected in that order in series. The coupling tube may be a triode and its grid connects around the resistance to the anode of the associated output tube while the load connects between the cathodes of the two coupling tubes. With the resistance values properly related to the impedance of the coupling tubes, the power output can be more than doubled for a given anode supply voltage. An impedance network may be substituted for the resistance.

Two-Way Facsimile System with Improper Operation Alarm

G. H. Ridings

2,742,526—April 17, 1956

A two-way facsimile system comprising two transceivers, each equipped with independent send and receive push-buttons. Pressure on a send button establishes that machine as a transmitter and sounds a signal at the other where, upon pressing the receive button, the machine starts, drifts into phase and recording proceeds. When finished, pressure on the stop button at each machine restores normal conditions. If both send buttons are inadvertently pressed at the same instant, both signals sound, and the first receive button to be pushed converts that machine into a receiver and the other into a transmitter so that message sending can proceed.

Two-Way Facsimile System between a Main Telegraph Office and a Plurality of Out-Stations

G. H. Ridings

2,747,015—May 22, 1956

A two-way facsimile system employing separate transmitters and recorders at the out-station as well as at the main office, all operated over a two-wire line. Connection of the main office transmitter to line, for example, at a concentrator, starts the out-station recorder and this in turn initiates scanning at the main office transmitter. The out-station transmitter is controlled from the main office recorder after connection responsive to a calling signal. Incidental features include, at the out-station, automatic opening of the transmitter message chute, shearing of the message and a message receipt acknowledgement.