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WESTERN UNION Technical Review

Ticketfax System

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Ticketfax Transmitters and Recorders

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Ticketfax Electronics

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High-Speed Teleprinters

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Power Failure Protection

VOL. 9 NO. 3

WESTERN UNION

Technical Review

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W/U

A Portable Telegraph Bias and Distortion Measuring Instrument

W. DALE CANNON

In the modern telegraph system, signals are transmitted over various trunk facilities derived from wire lines or radio relay systems. The trunk telegraph channels furnish facilities between a number of switching centers located at strategic points throughout the country, and these centers then distribute traffic to the local points of destination. In addition, various other services must be accommodated by suitable network configurations. These services comprise such arrangements as are involved in leased network circuits, private switching systems, and so forth. It is necessary that flexibility be maintained in this complex network of circuits in order that circuit patching and routing may be accomplished without making undue alignment changes in the circuits themselves.

In the operation of a telegraph network, it is often necessary to interconnect telegraph circuits indiscriminately to form through trunks and local distribution circuits. It is essential not only that circuits and equipment be compatible with each other, but also that signals as measured from point to point do not exceed a permissible tolerance with regard to signal distortion. The signal quality as measured at interconnecting points permits prediction of the behavior of the interconnected circuit. With the aid of a signal distortion indicating device, adjustments can be made to provide the best possible circuit operation.

Bias and Distortion

Bias is usually the most important of the several types of distortion that may be present in telegraph circuits. Bias results in a uniform displacement of like signal transitions so that all marking signal intervals are uniformly lengthened or shortened and all spacing signal intervals are correspondingly shortened or lengthened. In start-stop teleprinter operation, bias results in a uniform displacement of space-to-mark transitions with respect to the start pulse mark-to-space transition. For this reason, bias is sometimes measured by observing the time of occurrence of space-to-mark transitions with respect to the beginning of the start pulse. Since bias displaces the mark-to-space transitions uniformly, it is possible to measure bias not only with respect to the beginning of the start pulse, but also with respect to the position of any other mark-to-space transition occurring in the signals. If the measurement is made of the space-to-mark transitions of single-unit spacing signals with respect to their corresponding mark-to-space transitions, the bias indication is based upon the average duration of a spacing unit interval. The bias measurement is accomplished by measuring the average time interval occupied by single-unit spacing signals in comparison with the time interval of a perfect unit-length spacing signal. Measurements are made of spacing single-unit signal intervals rather than of marking signal intervals because in start-stop operation the duration of the marking stop pulse can vary greatly and such variations are not indicative of the presence of bias. This method of measurement then is applicable not only to circuits using start-stop transmission but also to synchronous transmission systems. Examples of bias measurement for zero, 25-percent mark-

A paper presented before the Winter General Meeting of the American Institute of Electrical Engineers in New York, N. Y., February 1955.

ing, and 25-percent spacing bias are given in A, B and C of Figure 1 in which the duration of the measured single-unit signals is indicated by the letter *t*.

In much of the equipment used in the transmission of telegraph signals, bias can generally be removed from the signals by simple adjustments. The other forms of distortion are not so readily corrected, and are generally considered as a separate procedure. It therefore seems desirable to measure bias and to measure distortion exclusive of bias as separate quantities. Total distortion then is the summation of these separate quantities. Therefore, for use in this paper, the term distortion will exclude distortion due to bias. The distortion measurement to be described is based upon the minimum duration of a spacing unit interval. The distortion indication is obtained by observing the particular unit spacing signal whose length differs most from the average time interval, and then measuring its departure from the average. An example of the measurement of distortion when the bias is 15-percent marking and the distortion other than bias is 25 percent, is shown in Figure 1-D in which the short signal indicated for code element 4 is a unit interval of minimum duration. The amount that its length differs from the average is taken as a measure of distortion other than bias.

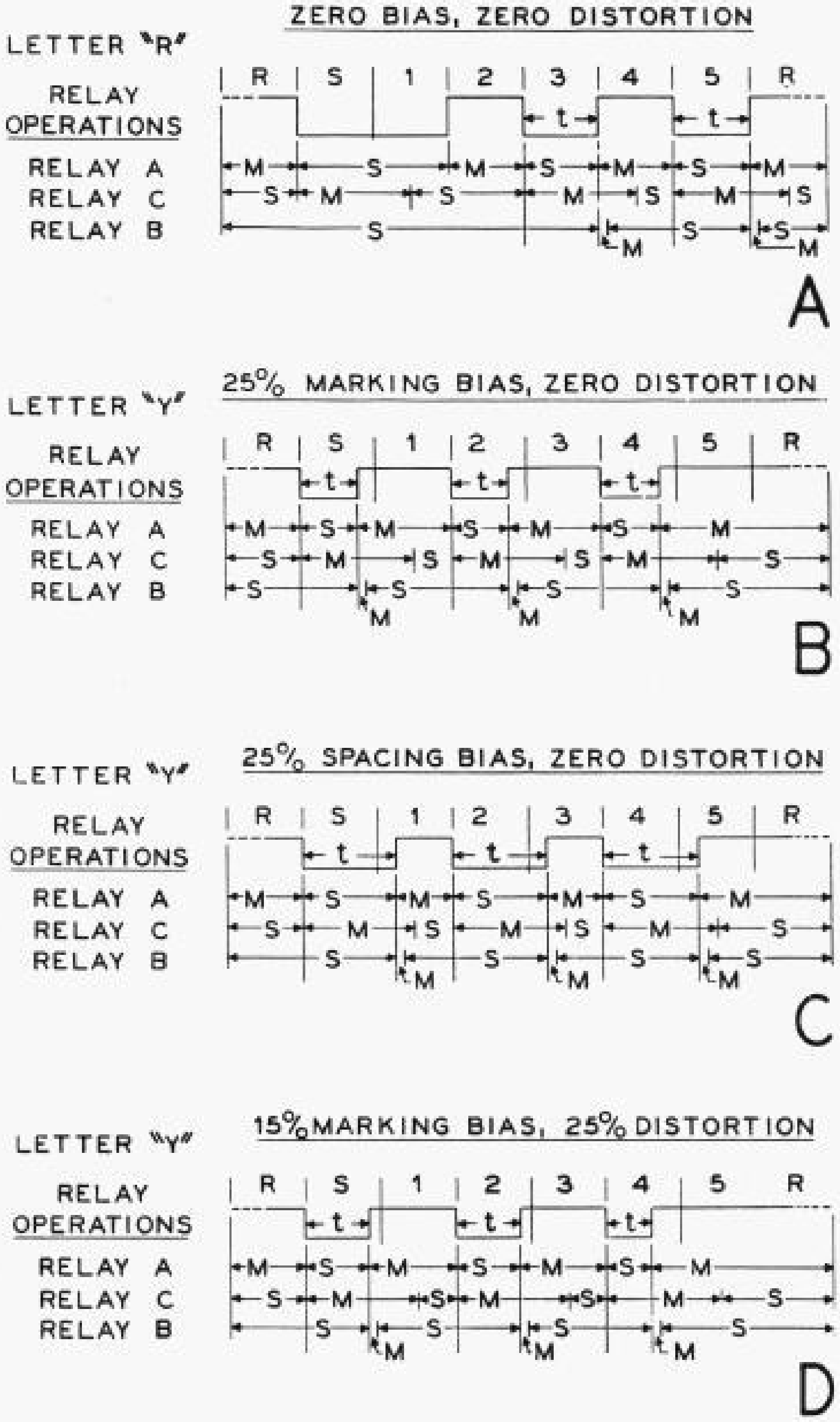


Figure 1. Theory of bias and distortion measurement

General Description

The bias and distortion measuring instrument, as designed for general application in field offices and using the operating principles described above, is shown in the view of Figure 2. The instrument is a portable device capable of measuring signal bias and distortion on working telegraph circuits which employ 7- or 7.42-unit code, operating at speeds of 65 or 61 words per minute. Measurements can also be made at 75 or 100 words per minute. The instrument was

The Ticketfax System

ARCHIE S. HILL

THE NAME TICKETFAX has been given to facsimile transmitters and recorders designed by Western Union to meet the unique communication requirements of an improved method of controlling and selling reserved accommodations on railroad passenger trains. The ticketing problems of no other operation approach in complexity those of a large railroad with its many trains carrying a variety of accommodations between so many stations.

Current General Practices

There is keen competition among travel services. Endlessly they endeavor to make their services more conveniently available. In spite of this, procurement of tickets entitling the bearer to claim and occupy a particular space, on a particular carrier unit, on a particular day, and between particular points, may be annoying and time consuming. Many business organizations include a transportation clerk who procures reservations, plus one or more persons to pick up the reserved tickets at ticket offices.

Large city terminals control a great percentage of reserved space from which local city ticket offices and nearby stations draw their requirements. Depending upon demand, some space allotments are made to intermediate stations which can draw upon the terminal for additional space when necessary. A portion of the space unsold at the time of train departure is wired to the next boarding point. The remainder is turned over to the conductor for "on train" sale. Except in emergencies, however, few people will embark on a long trip without first having been assured of comfortable accommodations. In larger cities sales are made at station ticket offices and branch ticket offices operated by the railroad and by travel agencies, and at hotels.

The procedure of handling reservations and sales of space with the car diagram system is described briefly as follows:

In making a reservation, the customer or a ticket office clerk telephones the reservation bureau which assigns the space and records the name of the customer on the car diagram and specifies the limit of time in which it must be purchased. Within the specified time limit the customer or his messenger goes to the ticket office to pick up the ticket.

In making the actual sale, the ticket seller calls the reservation bureau confirming the space assignment. He fills in a ticket, which is prenumbered and color-coded for the type of accommodation, with the designations of the space assigned and the car in which it is located, the price, tax, and total cost, date and time of train departure, and in some cases the "on" and "off" stations. The reservation bureau records in the car diagram the number of ticket under which the accommodation is sold, the ticket seller's identification number, and "on" and "off" stations, and the "make down" information, that is, the number of persons for whom the space is to be prepared.

With the car diagram method of space control it is difficult to obtain complete information on space availability especially during peak sales activities.

A paper presented before the Summer General Meeting of the American Institute of Electrical Engineers in Swampscott, Mass., June 1955.

Figure 1. New ticket office in the Pennsylvania Railroad 30th Street, Philadelphia, station, showing coupon files and availability board in the background

Improvements Sought

Robert Heller and Associates of Cleveland, Ohio, were retained by the Pennsylvania and New York Central systems to develop an improved method of reserved space control and sale. All phases of travel information, space reservation and ticket selling were examined with the view to devising means whereby reserved space would be brought under complete control and all operations involved would be more closely coordinated and simplified. Two main objectives were (1) to make it easier for the customer to secure reservations and obtain tickets therefor, and (2) to make possible more nearly complete sale of accommodations.

A study of practices disclosed that the car diagram, which tied up all units of space in a particular car in one record, was the bottleneck which impeded all operations involved in reserving and selling space, and making available for resale space released through cancellations.

The scheme by which the car diagram method is improved upon and the sale of reserved space simplified and speeded up is basically quite simple. Instead of the car diagrams there is a coupon to represent each unit of reserved space available on all trains as far into the future as necessary. A coupon is coded with all pertinent information about the space it represents, such as location in the car, connecting bedrooms, crosswise and lengthwise berths, window or aisle seat, and so forth. Thus replacing the diagram by coupons representing its component parts permits separation of clerical recording functions, ready accessibility to available space, and fast processing of cancellations. Most importantly, the data on a space coupon can be rapidly reproduced, by facsimile, onto a ticket at an outside agency where a customer is waiting. Furthermore it permits reproductions of data on reserved space coupons, by facsimile, onto tickets in offices of customers.

Early in 1953 the coupon method for control and sale of space was put into operation by the Pennsylvania Railroad at Pittsburgh. Many of the equipments employed in that installation, including those supplied by Western Union, were hurriedly devised modifications of machines originally designed to serve entirely different purposes. Nevertheless, the results of the operation of the installation were so unmistakably beneficial that Robert Heller and Associates were further retained by the railroad group to make desired refinements, and assist in a more extensive application of the system.

During January 1955 system installations were made for the New York Central Railroad at their Cleveland terminal station and for the Pennsylvania Railroad at their 30th Street Station (Figure 1), Philadelphia. In these installations two types of Western Union Intrafax equipment provide the special communication features vital to the operation of the system.

Specially designed Ticketfax machines, which are fully described in companion papers, provide the high-speed transmission necessary between the reservation bureau and ticket clerks. In addition, standard speed Western Union Intrafax message type equipments, slightly modified, are employed on the direct circuits to customers' business offices.

The Improved System

Starting with the space coupon as the cornerstone, the important features of the system are described here, with emphasis on the communication requirements served by the facsimile equipments.

The space coupon is of white cardboard 4½ by 1½ inches. While the coupon (Figure 2) always remains in one piece, it is printed in three sections containing respectively the information required by (1) the agent selling space, (2) the Pullman conductor on the train, and (3) the customer before and while on the train, and later for expense records.

Across the front and back of one end of the coupon, there is a ⅜-inch wide strip of the color indicating the type of accommodation it represents. Printing on the coupon is in black. The designations of the car and space unit are printed in large bold type. The stations between which the car travels and other data are printed in smaller type. There are spaces in which can be written "on" and "off" stations when the space is sold for trips starting and/or ending at intermediate points.

The control center, a subdivision of the Ticket Sales and Service Bureau, has custody of coupons.

Figure 2. Top—Space coupon; Middle—Pullman ticket form; Bottom—Pullman revenue ticket

The coupons are completely printed in advance in large quantities, except for dates and departure times, and the printer assembles them in car sets. Before being placed on sale, coupons are imprinted with the use date in each of the three sections plus the train departure time in the customer's section. The tiered coupon files for all space on all trains weeks in advance are convenient to all control center personnel. By a file dating arrangement and the coupon color-coding, the desired coupon can be readily located and extracted.

The coupon, which is the sole control of the space it represents, does not leave the custody of the control center. Reposing openly in the "for sale" file, it represents a space available for immediate sale or reservation. When reserved it is enclosed in a color-coded paper jacket but remains in the file. When sold it is relayed to a "sold" file from which it can be quickly recovered and restored to the "for sale" file in case of cancellation.

The Blank Pullman Ticket Form: Ticket sellers at the main ticket office, satellite stations, city ticket offices and agencies served by the control center are supplied with blank Pullman ticket forms printed on "Teledeltos"* facsimile recording paper (Figure 2). The forms are printed with colored inks for accommodations type coding. A ticket form is in three sections separated by perforations. The printed heading of each section includes the price, tax and total charge for the space which it will represent when sold. Although the ticket forms are serially numbered and must be accounted for, they are not negotiable until processed as described further on. Blank Pullman ticket forms supplied to private business subscribers are very similar to those described above except that the printing does not include the price.

The Pullman Space Revenue Ticket: When the information in each of the three sections of a coupon is reproduced respectively under the printed headings of the three sections of a properly priced and color-code printed Pullman ticket form, a valid Pullman reserved space revenue ticket results (Figure 2). The reproduction is accomplished by the Ticketfax machines and by telegraph message type Intrafax machines in the case of private customer service.

Rapid Facsimile Transmission: As stated before, one of the main objectives of the

* Registered Trademark, W. U. TEL CO.

system is to make it easier for the customer to procure his Pullman space ticket. This includes reducing his waiting time to the lowest possible minimum. Since, as in the older system, the Pullman ticket is not produced until the customer calls for it, it then must be produced as rapidly as possible. Reproduction by the facsimile method is accomplished by optically scanning successively, in a predetermined pattern, minute areas of the subject copy, and reproducing the optical effects of these minute areas in the same pattern. The time required to transmit a document is related to its size. In this system the size of the coupon was held to the absolute minimum possible for the purposes to be served. Ticketfax machines operating at 30 scanning strokes per second and reproducing the coupon data in about six seconds are employed for transmission from the control center to ticket clerks across the counter and at satellite stations several miles away. Machines operating at six scanning strokes per second, requiring about 30 seconds to reproduce the coupon, are employed on circuits connecting more distant satellite stations.

In addition to coupons, other forms are transmitted over the Ticketfax circuits. Satellite stations transmit order and cancellation forms to the control center. The control center sends space availability forms to satellite stations. Since at satellite stations coupons are received on printed Pullman ticket forms and other messages are received on unprinted recording paper, two different calling signals are provided so that the called station will know what recording form to use in answering a call.

Operation

It is deemed sufficient for the purposes of this paper to discuss in detail only that phase of the system by which reserved Pullman space tickets are provided to satellite stations in the Pennsylvania Railroad installation. This phase includes all of the operations involved in providing tickets to ticket sellers in the main ticket office adjacent to the control center.

The ticket sale transaction starts at the satellite station. A customer there wants a certain type of accommodation on a particular train between two particular stations for one or more persons. The station ticket seller fills in an order form with the necessary information including the name of the customer and the ticket seller's individual code symbol. He places the form on the transmitter and presses the message-send start button.

As the satellite station ticket seller presses the start button, a relay is actuated in the control center concentrator causing the lowest numbered idle and readied recorder to be connected to the line. The recorder starts, phases with the calling station transmitter, both machines start, and transmission is completed in six or eight seconds. End-of-message signals are actuated on the machines at both ends of the circuit.

At the control center a space distributor attends the recorder showing an end-of-message signal. He removes the recorded message from the recorder and, if he is able to identify the sending station from the message, he extinguishes the end-of-message signal and the recorder is disconnected from the circuit. At the satellite station the ticket seller attends his transmitter by extinguishing the end-of-message signal and removing the transmitted request form from it. (The line is automatically transferred from his transmitter to his recorder.) The ticket seller then selects from a rack a Pullman ticket form printed in the color representing the type of accommodation requested and of the proper value for the number of persons to occupy the space, in anticipation of a call from the control center to send him the space.

At the control center the space distributor takes from the file a coupon representing a unit of the type accommodation requested on the desired train. He marks it with his code symbol and places it on an idle transmitter, presses the coupon-send start button and the proper line-select (Figure 3) button to cause the concentrator to connect his transmitter to the satellite station line.

At the satellite station the calling buzzer sounds and the "coupon-receive" lamp glows indicating to the ticket seller that he is to receive the space requested. He places the Pullman ticket form on his recorder and presses the start button. His recorder phases with the control center transmitter and transmission proceeds. At the end of transmission the end-of-message signals are again actuated at both ends of the circuit.

Figure 3. Line-select push-button unit

At the satellite station the ticket seller extinguishes the end-of-message signal, removes the completed Pullman space revenue ticket form, detaches the agent's stub section and sells the remaining two attached sections to the waiting customer.

At the control center the clerk extinguishes the end-of-message signals on the transmitter, causing it to be disconnected from the line. He inserts the transmitted coupon into an automatic stamp which puts on the back the word "sold" and the time and date of sale. The coupon is then relayed to the "sold" file.

Ordinarily the time required for the complete transaction described is measured in seconds.

Desired Space Not Available: If in the above transaction the type of accommodation requested was not available, the space distributor would have filled in an availability form to show the types of accommodation available on the desired train and transmitted it to the requesting station in lieu of a coupon. In this case he would start his transmitter by pressing the message-send start button. At the satellite station the calling signals would have included the glowing "message-receive" lamp, and the ticket seller at the satellite station would place a blank sheet of recording paper on his recorder instead of the printed ticket form. Assuming that the waiting customer indicated which of the types of available accommodations he would accept, the transaction would be completed on this basis as before.

The customer purchasing accommodations in the transaction just described presents the two attached sections of his Pullman space revenue ticket to the Pullman conductor on his train. The conductor separates the two sections, retaining the proper section for his purposes, and returns the smaller remaining section to the customer as evidence of his right to occupy the space described thereon.

Station Line Identification: As mentioned in describing the transaction above, an incoming call on any of the many lines is automatically connected to an idle and readied recorder. There is no indication on the recorder as to the identity of the line to which it is connected. If the prescribed routine is followed, and equipment units involved perform properly, the sending station can be identified by the recorded copy of his message. In the event that a received message does not include the identification of the sending station, the Line-Identification push button is held depressed to light the lamp in a Line-Identification panel which is associated with the line to which the recorder is connected. (The Line-Identification panel is situated to be visible from all concentrator recorder positions.)

Service to Private Business Customers: Under the coupon system, as mentioned above, Pullman tickets can be delivered by wire to the offices of private business customers. Arrangements can be made to furnish such customers with supplies of rail fare tickets on a deferred payment plan. Western Union telegraph type Intrafax equipments with minor modifications are employed in this phase of the system. Desk-Fax transceivers are employed by the customers for ordering Pullman accommodations and receiving Pullman revenue tickets.[1]

At the Ticket Sales and Service Bureau there is a concentrator comprising a turret with a capacity of 30 lines, and consoles accommodating four removable drum transmitters and four continuous paper roll page recorders.[2,3,4]

In sending to customers two types of transmitter drums are used; one to send messages and forms other than coupons, and the other to send coupons with price figures. Around the latter type drum, steel bands form guides into which are inserted the space coupons and a price strip. One of these latter type drums (Figure 4) is prepared for each subscribing customer. The coupon and price strip do not completely encircle the drum. On the otherwise unused scanned aréa of each drum is permanently imprinted the name of the customer for whom the drum is exclusively used. The customer's name is transmitted with each coupon and is recorded on two sections on his ticket along with space and price data. At the same time the ticket is being delivered in the customer's office, one of two monitor recorders in the control center is producing, for billing purposes, a facsimile reproduction of the transmission including the customer's name.

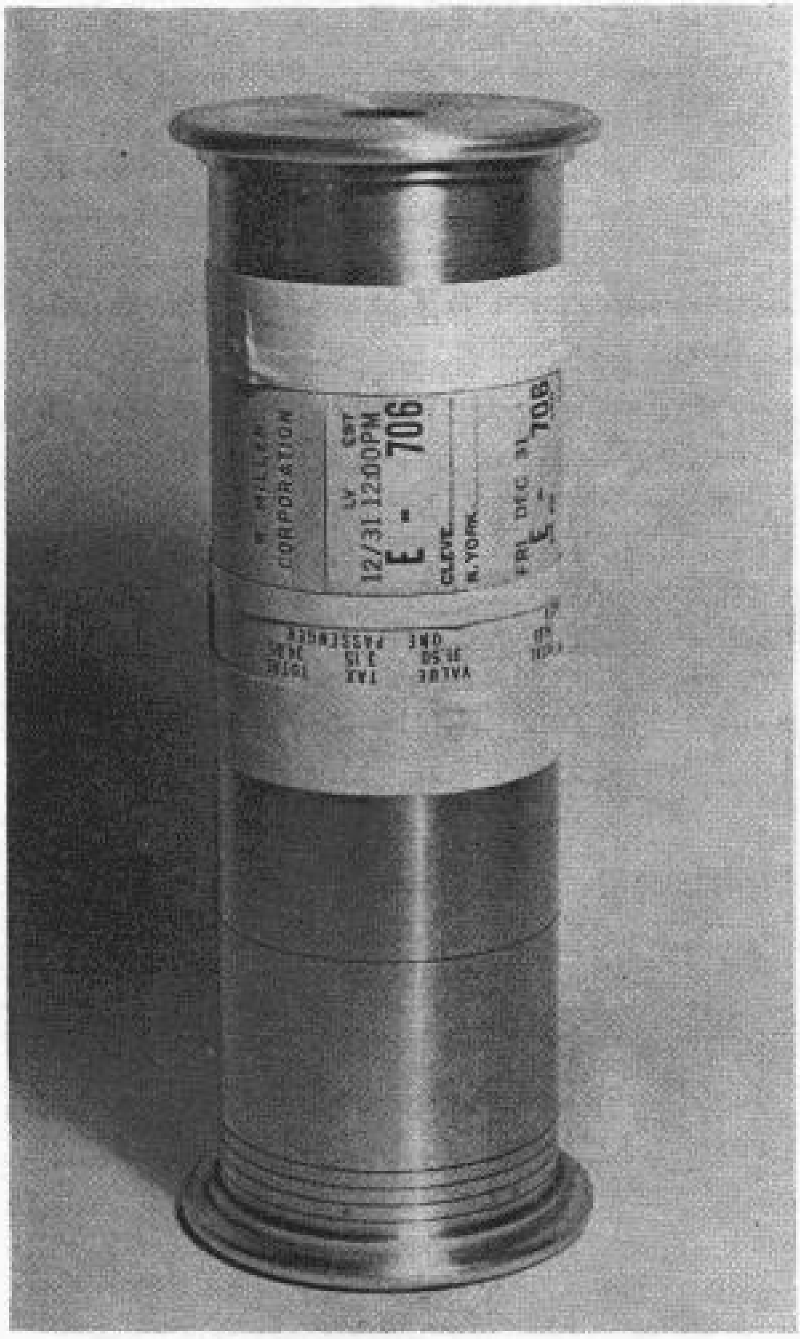


Figure 4. Special transmitter drum for sending coupons to industrial customers

Availability Board

Many very important features of the over-all ticketing system do not fall within the scope of this paper and have been omitted. An exception is made in favor of one such feature, namely, the manually operated, mechanical availability board, because of its helpfulness to both railroad people and customers.

The availability board is a framework divided into 36 rectangular sections each in the order of 18 inches wide by 2 feet high. Each section shows the up-to-the-minute availability of the types of reserved accommodations on one regular train which is prominently designated at the top of the section by name, number and departure time. The area in the section under the heading is divided into 49 small squares about 2 by 2 inches, arranged in seven vertical columns for seven days starting with the current day and seven rows across for types of accommodations carried up to a maximum of seven.

A small square shows a type of accommodation on a white background if there are many units of that type available. When there are only a few units left of the type of accommodation represented, the background of the square is changed to yellow. When the type of accommodation represented is completely sold the square becomes blank. With the aid of a long-handled tool changes in a small square are made by manipulating a small lever associated with the square. The vertical columns of squares can be removed as units for daily rearrangement.

The entire board is suspended above and spans across the entire office (see Figure 1) so as to be visible to the ticket sellers and customers from the front, and to telephone clerks and other personnel from the rear. A glance at the board gives a complete picture of accommodations availability, on all trains, for the next seven days.

Conclusion

As this is being written the systems at Cleveland and Philadelphia have been in operation about five months. Robert Heller and Associates have closely observed performances and are working to bring about minor changes which experience indicates to be desirable. The coupon supplier originally had some difficulty in cutting coupons to the rather close tolerances necessary for good performance of the Ticketfax machines. Otherwise the machines have performed quite satisfactorily. The main objectives of the system having been realized to a great degree, it is expected that installations in other large city terminals will follow.

Paul H. Greer of the Western Union Private Wire Sales division cooperated closely with the Robert Heller people in working out details of refinements proposed, particularly with respect to requirements to be met by Intrafax machines. Requirements agreed upon by them could not be satisfied by any facsimile machine previously constructed. Groups of Western Union engineers under the direction of Raleigh J. Wise, Telefax Research Engineer, starting from scratch designed and produced models of Ticketfax transmitters and recorders involving novel mechanical, optical and electronic features in the remarkably short period of six months.

References

1. An Improved Desk-Fax Transceiver, G. H. RIDINGS and R. J. WISE, *Western Union Technical Review*, Vol. 6, No. 3, July 1952.
2. A Vertical Drum Telefax Transmitter, J. H. HACKENBERG, *Western Union Technical Review*, Vol. 4, No. 1, January 1950.
3. Three-Stylus Facsimile Recorder for Concentrator Service, F. G. HALLDEN, *Western Union Technical Review*, Vol. 4, No. 1, January 1950.
4. Thirty-Line Concentrator for Private Facsimile Systems, H. H. HAGLUND, *Western Union Technical Review*, Vol. 6, No. 4, October 1952.

Mr. Hill is Assistant to the Systems Development and Statistical Engineer, D. & R. Department. His biography appeared in the October 1954 Technical Review.

Ticketfax Transmitters and Recorders

DOUGLAS M. ZABRISKIE

PULLMAN SPACE reservation tickets are now being rapidly transmitted from one place to another by Western Union's new Ticketfax system which employs facsimile transmitters and recorders designed especially for the purpose. Ticketfax is equipment engineered and designed by Western Union as a part of a reservation system developed by the Pennsylvania and New York Central Railroads, and Robert Heller and Associates, business consultants.

Conventional facsimile equipment usually employs a cylinder around which a message is wrapped and held by garter or clamp. The cylinder rotates past stationary optical devices or recording styli, which act upon the message from the outside. This method, satisfactory for some applications, is not favorable where automatic loading and unloading of the cylinder is involved.

Internal Scanning Employed

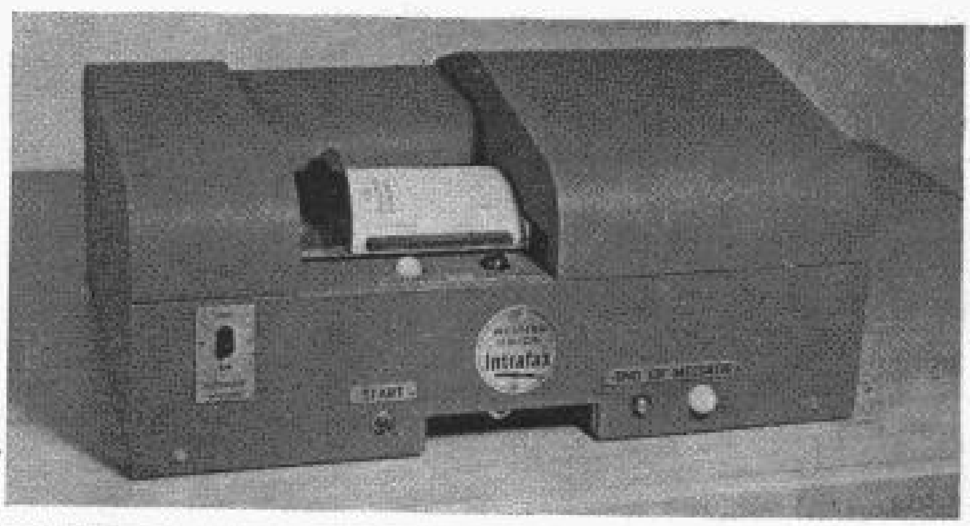
Transmitters and recorders designed for Ticketfax service employ internal scanning from within the cylinder. The message is automatically wrapped on the cylinder and scanned on the inside by rotating optical or stylus components. Each machine is mounted upon a console 29½ inches high which occupies a floor space 18 by 18 inches. Each console, having two shelves, houses the control equipment

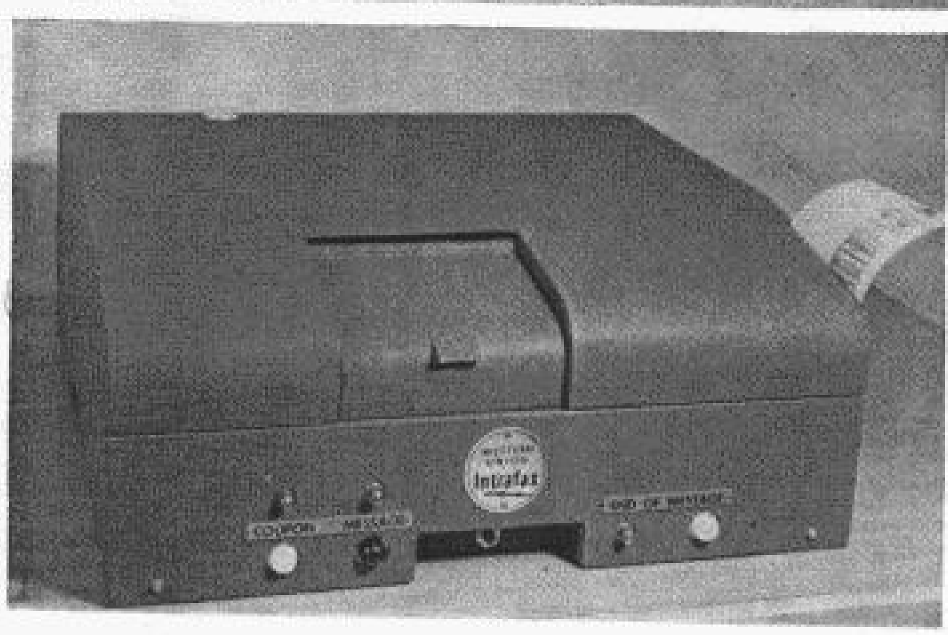
A paper presented before the Summer General Meeting of the American Institute of Electrical Engineers in Swampscott, Mass., June 1955.

Below—Ticketfax equipment developed by Western Union research engineers employs internal scanning at high speed to reproduce tickets or messages locally in about six seconds.

Lower left—Transmitter for Pullman coupons or other small forms has three signal lamps and four buttons to indicate and control its functions.

Upper left—Recorder reproduces train reservations or short messages by facsimile process using dry, electrosensitive "Teledeltos" paper.





Forms used in Ticketfax transmitters expedite railroad reservation services. Facsimile recording on preprinted, perforated sheet is separated into agent's stub, standard car ticket and passenger's check.

associated with the machine it supports; the machines are slip-connected to the control circuits permitting rapid removal and replacement.

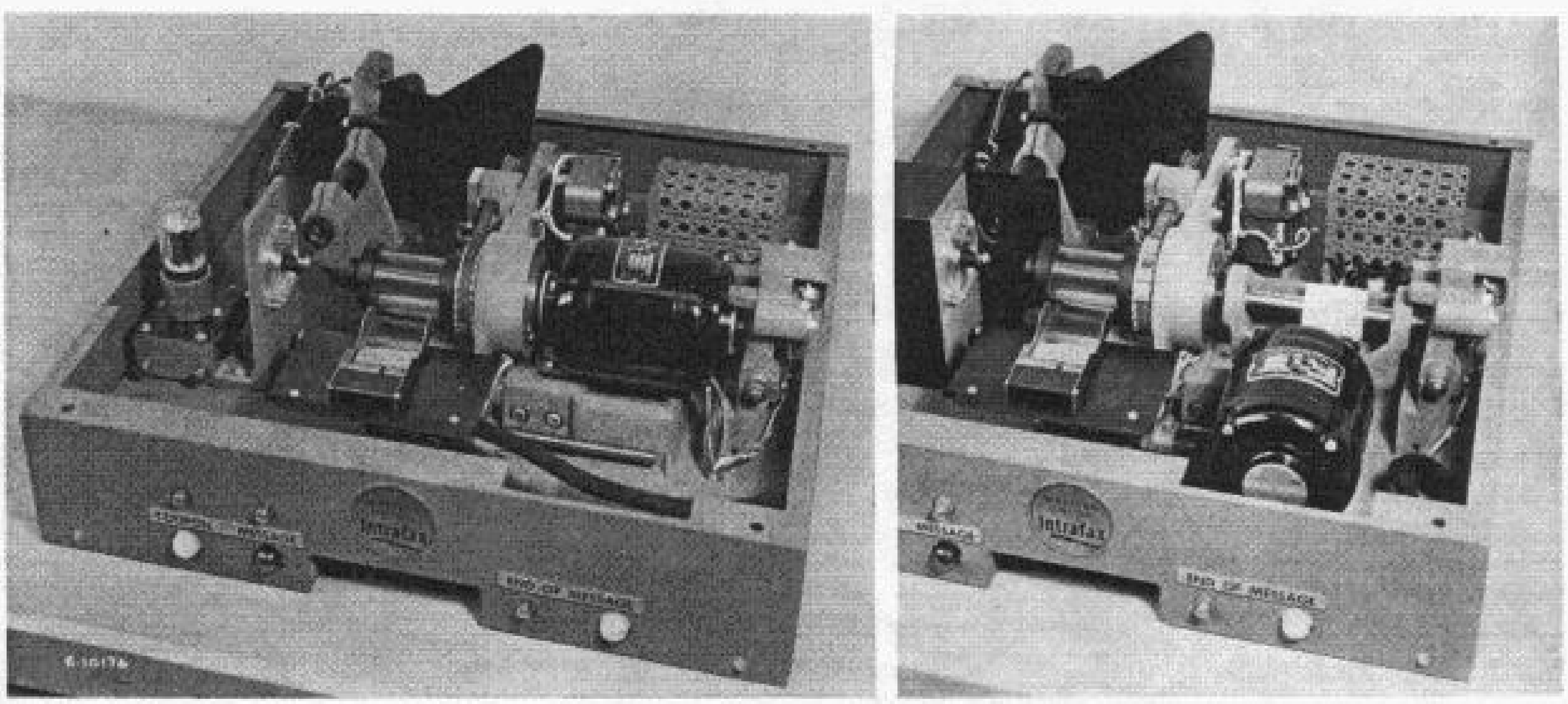
Transmission facilities available for the initial installation prompted the selection of two speeds of operation, namely, 1800 and 360 revolutions or scans per minute. Line feed for both speeds, based upon the use of a recording stylus 0.008 inch in diameter, was established at 120 lines per inch. Thus the high-speed sets, scanning at the line feed rate of ¼ inch per second, require 6 seconds to scan the 1½-inch width of the ticket or Pullman space coupon employed; the lower-speed sets require 30 seconds. Loading and phasing add 2 seconds in each case.

An illustration shows a typical coupon and other forms used in these transmitters, as well as a typical "Teledeltos"* preprinted receiving blank that has been validated with a facsimile recording of the coupon. The coupons are of white card stock, 1½ inches wide and 4½ inches long; for rotary internal scanning they are automatically wrapped into cylindrical form by the transmitter.

Transmitter Description

Inasmuch as all transactions start with a transmitter, this machine will be described first, beginning with the high-speed unit. All transmitters, 7 inches high,

* Registered Trademark, W.U. TEL CO.



Both transmitters (above) and recorders feature motor mounting design which allows either direct drive (left view) for 1800-rpm scanning or use of reduction spiral gears (right view) for 360 scans per minute if circuit facilities are inadequate for higher speed.

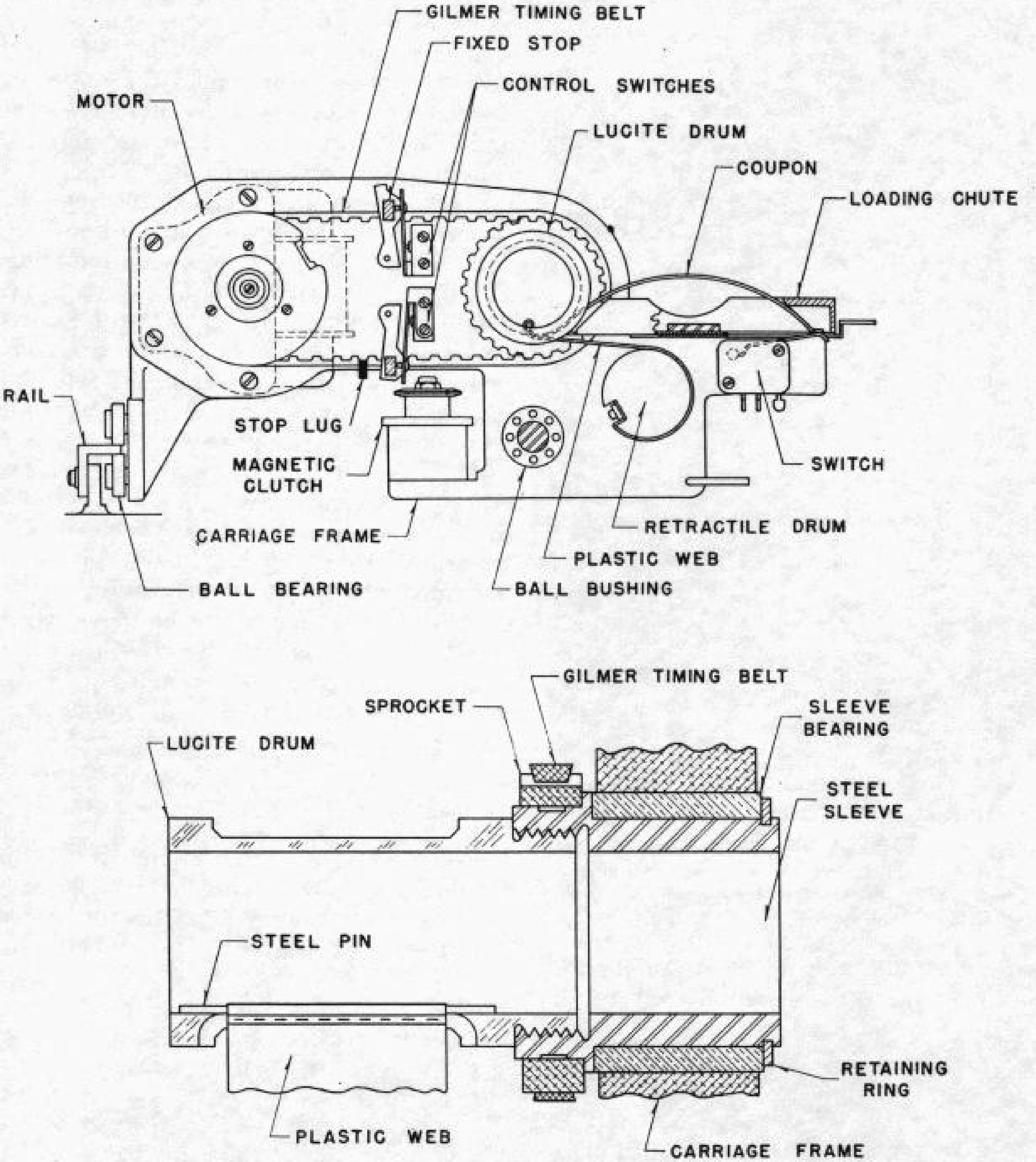


Figure 1. Transmitter carriage

17½ inches wide and 17¼ inches deep, consist of a cast aluminum base upon which is mounted a motor, a voltage supply unit, a carriage, an optical system, push-button controls and signal lamps.

The shaft of the 1/75-hp synchronous motor protrudes at both ends. One end supports and drives a scanning mirror; the other end, equipped with reduction gearing, drives a chain in one direction to effect a line feed for the carriage. Also mounted on this end of the shaft is the rotary element of a phasing pulse generator.

The voltage supply unit powers the photomultiplier, and is mounted on the transmitter base to utilize available space. Its proximity to the photomultiplier permits interconnection with short leads.

A carriage subassembly travels for line feeding purposes from right to left, on linear ball bearings over a stationary shaft, and is guided by roller bearings, engaged with a parallel rail. The carriage subassembly comprises a rotatable transparent lucite cylinder, over which the coupon to be scanned is automatically wrapped, a wrapping mechanism with control switches, loading chute, magnetic clutch, and a multiple plug connector for internal wiring. (See Figure 1.)

The transparent cylinder, threaded at one end to facilitate convenient replacement, is screwed into a steel sleeve which rotates in a bearing pressed into the carriage frame. The assembly is held endwise with a retaining ring. A sprocket attached to the cylinder assembly is rotated by a positive drive timing belt which is driven by a similar sprocket on the shaft of a reversible, stallable motor.

Rotation of 380 degrees is required to wrap the coupon. The interval of rotation is controlled by means of a lug attached to the timing belt, the travel of which is limited by stops fixed upon the carriage frame. These stops are combined with switches which are actuated by the lug, just before reaching the stop position. The switches are used to detect, for the benefit of the control circuit, the "wrap" and "unwrap" positions of the cylinder.

Plastic Wrapper Holds Copy

The wrapping mechanism is comprised of the transparent cylinder, a plastic web, a rotatable spring-driven retractile drum, and a loading chute. For mounting purposes, the plastic web has one end folded over and stitched to form an eye. The eye is inserted into a slot cut in the transparent cylinder, and is retained by a length of straight wire inserted in the eye. The opposite end is clamped to the retractile drum, which is driven by an adjustable torsion spring and rotates in a direction tending to keep the web taut at all times.

The loading chute is a stainless steel channel slightly wider than a coupon, open at the front end adjacent to the cylinder but closed at the back. A sensitive switch is mounted underneath the chute, the actuator of which protrudes into the space eventually occupied by the coupon. The coupon, when inserted, operates the switch which permits the beginning of a transmission cycle. A call cannot be made if there is no coupon in the chute.

Distance betwen the back stop of the chute and the vertex formed by the web and the cylinder is ¾ of an inch shorter than the length of a coupon; thus when a coupon is inserted between these points it is bowed upward. The spring effect of the bow causes the leading end of the coupon to follow the vertex until it is gripped between the cylinder and the web and completely wrapped.

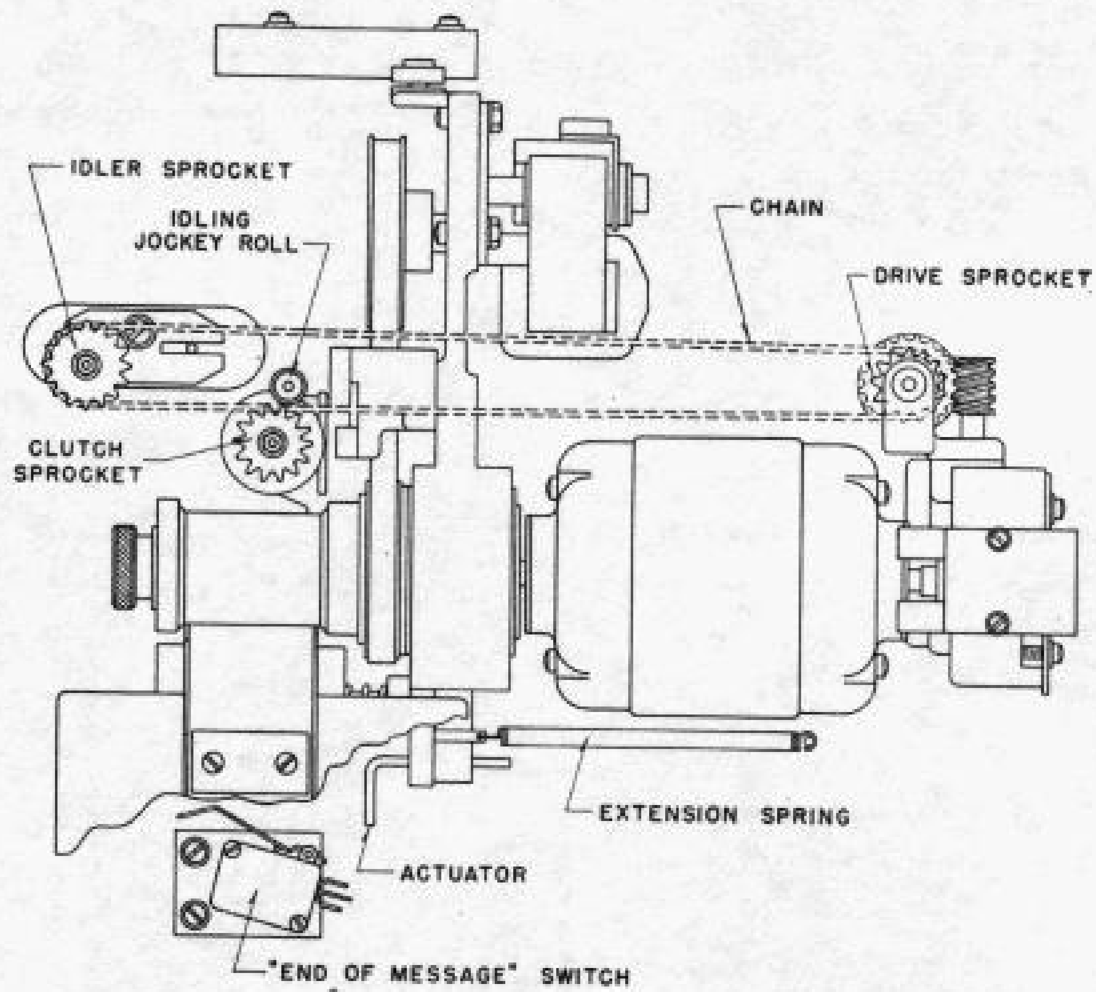


Figure 2. Carriage drive

Carriage Line Feed

The carriage assembly is held against a bumper, in stand-by position, by an extension spring. A chain running on two sprockets moves parallel to the mirror shaft at a rate of 0.008 inch per revolution of the mirror shaft. It is driven by worm gear reductions, taken off the motor shaft extension. A third sprocket, compounded with the armature of a magnetic clutch attached to the carriage, is held in engagement with the passing chain by an idler roll. In stand-by position this sprocket, rotated by the chain, idles on the carriage. At the instant of phasing, however, the magnetic clutch is energized, locking the sprocket to the carriage which then is carried along by the chain. (See Figure 2.)

After the carriage has traveled laterally to the extent required to scan the width of the coupon, an actuator on the carriage operates an "end-of-message" switch which, through control circuit connections, deenergizes the magnetic clutch, permitting the sprocket to idle backwards and the carriage to be retracted to its starting position by the extension spring.

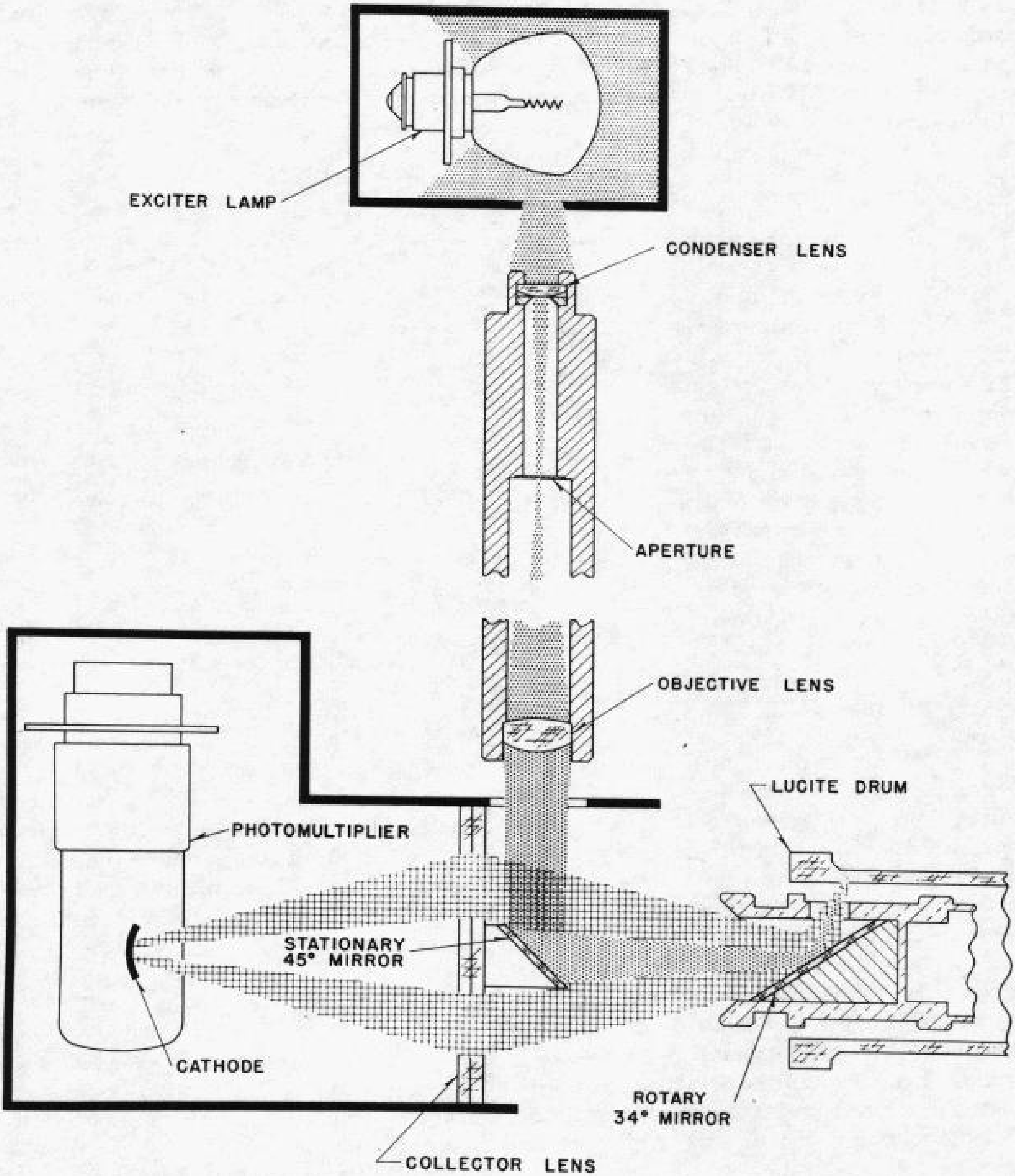


Figure 3. Optical system

Optical System

The purpose of the optical system is to focus a spot of intense light 0.008 inch in diameter upon the inside face of the wrapped coupon through the wall of the transparent cylinder, and to collect reflections therefrom, again through the cylinder, and project those reflections to the light-sensitive element of a photomultiplier. On these transmitters all optical components are stationary on the base, with the exception of one mirror which is mounted on the motor shaft. (See Figure 3.)

A 32-cp tungsten filament lamp is used as an exciter. Light from this source is projected through a tube containing a condensing lens, an aperture and an objective lens. The converging beam is reflected to the copy by two front surface mirrors, one rotating.

The beam of light describes a circle on the wrapped coupon; this action in combination with the axial feed of the carriage scans the surface of the coupon in approximately six seconds.

A portion of the reflected light, radiating through an aperture of the mirror shield, impinges upon the rotating mirror from which it is reflected in a diverging cone, now limited by the concentric aperture comprising the end of the mirror shield, to the surface of a double Fresnel lens which collects the light and converges it onto the cathode of the photomultiplier.

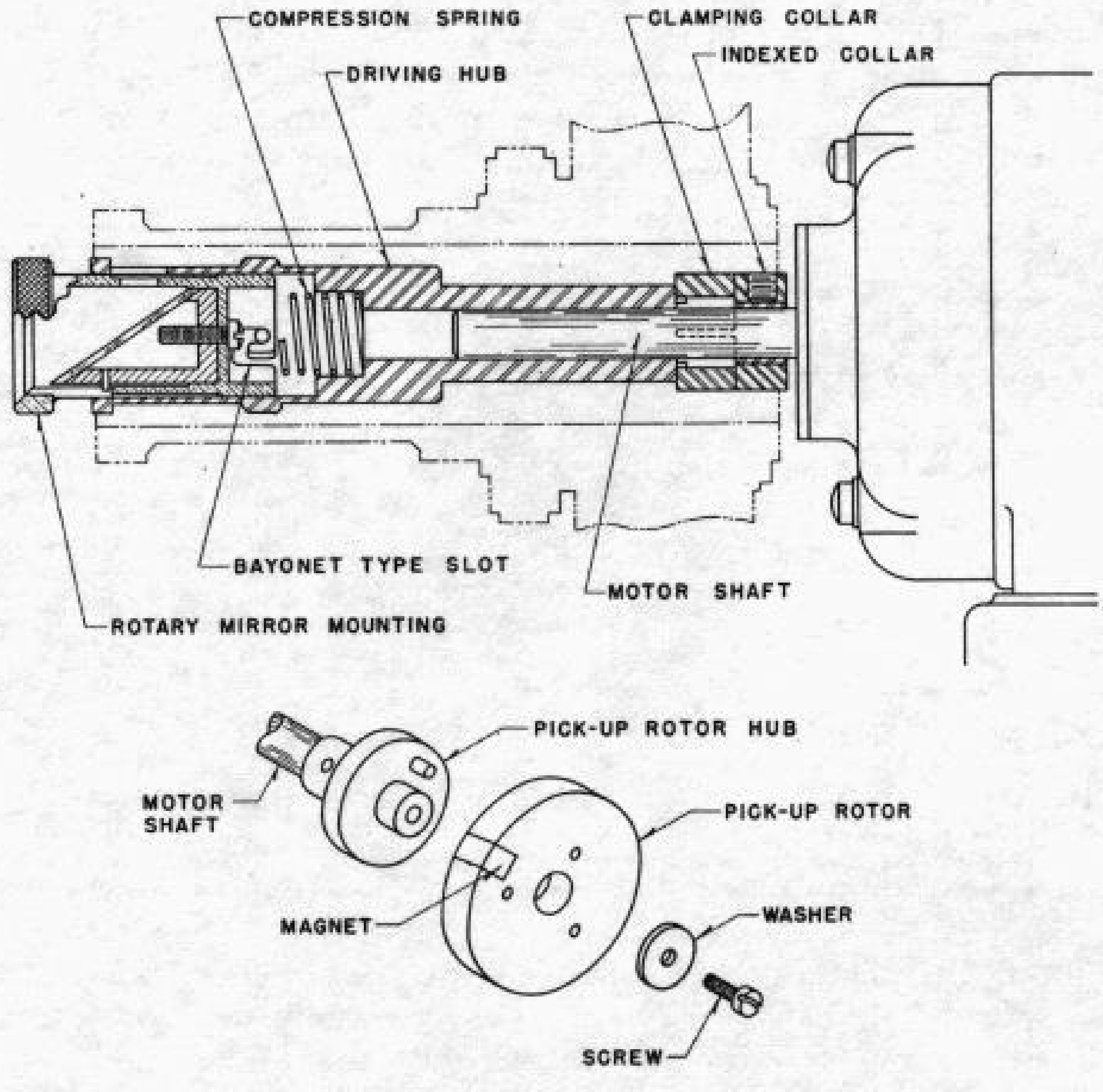


Figure 4.
Phasing rotor and rotary mirror

The rotary mirror is placed at an angle to prevent glare reflections of glossy tickets and of the inside wall surface of the cylinder from returning to the mirror; instead they are directed harmlessly in the opposite direction.

The exciter lamp, rotary mirror and photomultiplier are separately shielded to prevent interference from internal transient light. Complete protection from exterior transient light is obtained with the main cover which is equipped with a hinged access lid for loading and unloading purposes. The lid is automatically latched so that it cannot be lifted during transmission.

Phasing Pulse Generator

The phasing pulse generator comprises a conventional magnetic pickup coil, wound on a core having an air gap traversed by a permanent magnet, which generates a pulse used for phasing and blanking. (See Figure 4.)

In order for transmitters and recorders to cooperate for phasing purposes, the magnet, imbedded in a brass disk, must be accurately located in relation to a motor pole, in a specific position common on all machines. This relationship is established at the factory before the components are assembled.

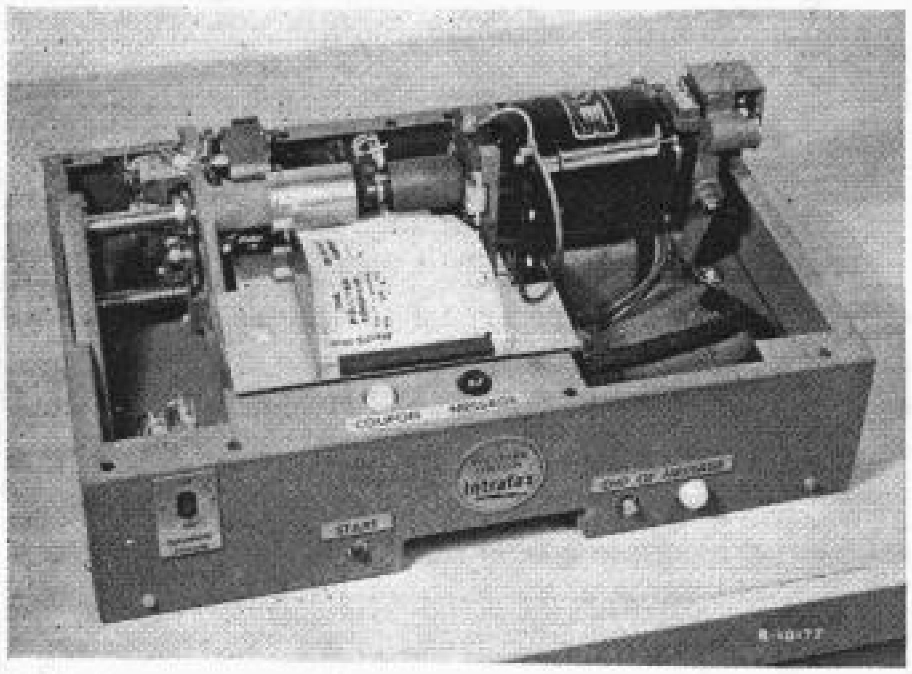
Furthermore, if a remote transmitter should be powered from a phase of alternating current unlike that used to power an associated recorder, the machines will not cooperate in phasing, due to the time lag between the unlike phases. Therefore the pulse generator magnet disk is designed to be adjustable to three positions, each 120 degrees apart. Inasmuch as this is a field adjustment which must be made without disturbing the motor pole relationship established at the factory, the magnet assembly is made in two parts. The assembly comprises a steel hub with a key pin, and a brass disk containing the permanent magnet and having three holes, 120 degrees apart, matching the key in the steel hub. The steel hub, being pinned to the motor shaft at the factory, retains its relationship to the motor poles, while the brass disk can be adjusted to match any of the three phases of alternating current.

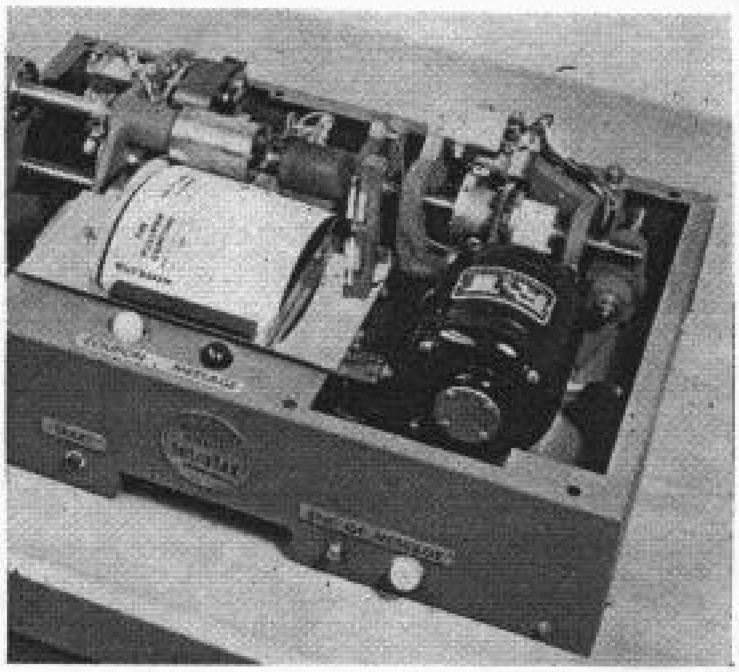
At this point it should be noted that the rotary mirror, in order to maintain proper horizontal framing, must also be shifted to match the shift of the magnet.

Rotary Mirror Subassembly

Mountings for the rotary mirror have been designed to facilitate angular and lateral adjustment. For maintenance purposes, the mirror component may easily be removed without disturbing previously established adjustments. The mirror of this subassembly is held in place by a compression spring and a bayonet type slot, requiring pressure and a slight twist to detach it from the driving hub.

The driving hub fits snugly over the motor shaft; the left end is slotted and a clamping collar is placed over it and keyed to the driving hub, so that the hub and collar rotate together. A setscrew in the collar squeezes the slotted portion and securely grips the motor shaft. The clamping collar has a single engraved index line. Adjacent to the clamping collar, a second collar is fastened to, but is adjustable on, the motor shaft. It is engraved with three





Ticketfax recorders, like transmitters, are designed for either 1800-rpm direct drive (left view) or 360-rpm reduction-gear drive (right view). Phasing clutch for latter is mounted on stylus shaft adjacent to spiral gear.

index lines, spaced 120 degrees apart. These indexed collars are used to gauge the shifting of the mirror to coincide with shifts made in the pulse generator, as previously described.

After the mirror mounting has been adjusted angularly to frame the ticket horizontally, it is fastened to the shaft with the clamping collar. The second collar is then moved so that one of its index lines coincides with the line on the clamping collar and is then fastened. The mirror mounting may now be moved in steps of 120 degrees to coincide with similar shifts of the pulse magnet without losing the framing relationship.

The 360-speed transmitter is identical with the high-speed unit with one exception. A shaft and bracket are mounted upon the cast pad normally used for the motor in the high-speed unit. A motor with a single shaft extension is mounted at right angles to the mirror shaft, upon a second base pad provided for the purpose. Reduction spiral gears now couple the motor to the mirror shaft and, inasmuch as the line feed drive is obtained with gearing from the mirror shaft, the rate of feed is proportional.

Signals and Manual Controls

Each transmitter is equipped with four push buttons and three signal lamps. Two push buttons, each associated with a lamp of distinctive color, are used for starting. One, labeled "Coupon," operates similar signals on the called recorder, notifying the operator that a coupon is to be transmitted; the other, labeled "Message," serves notice that a message such as a space request form or handwritten message is ready for transmission.

After a transmission is complete a lamp signal labeled "End of Message" lights and must be extinguished by pressing the third push button, which restores the transmitter to stand-by. The fourth push button, located obscurely under a hand hole in the base, is used as a manual end-of-message switch. This control, however, is used only when the operator wishes to halt transmission upon discovery of an error in the selection of matter being transmitted.

Recorder Description

Recorders, like the transmitters, are designed for two scanning speeds, 1800 and 360 revolutions or scans per minute. Recorders are 7 inches high, 17¼ inches wide and 11⅜ inches deep.

The operation and mechanical arrangement of the recorder is similar to that of the transmitter. Many of its parts, such as motors, line feed drive, phasing pulse generator, and so forth, are interchangeable. A recording stylus is used in place of an optical pickup system. A mechanical phasing clutch is used on the 360-speed recorder in place of a phasing pulse generator.

The ticket form is a preprinted "Teledeltos" sheet 4 by 5½ inches on which an area in the lower right-hand section is reserved for recording. It is perforated so that it is separable into three slips. The ticket is inserted in a loading chute; the left side of the leading edge abuts a mechanical stop and establishes phase relationship with the stylus. This stop is flexibly mounted inside the wrapper drum, so that beyond 360 degrees of rotation the ticket pushes the protruding stop flush with the drum and the cylindrical form is not distorted.

The trailing edge of the ticket form abuts a back stop in the chute. The space between front and back stop, being shorter than the ticket length, causes the ticket to bow upward. Spring effect of the bowed ticket is used to urge the leading edge forward until it is firmly gripped between the drum and the plastic wrapper web.

Wrapping Action

When the start button is pressed a reversible, stallable motor drives the wrapping drum through a spur gear train, carrying the wrapper and the ticket along with it. As it is wrapped on the drum, the web is unreeled from a take-up drum under the loading chute.

The extent of rotation is limited by stops rotating with the gear train which engage a fixed stop on the frame. At this point the wrapper motor goes into a stalled condition, holding the ticket in the wrapped position for scanning. Upon unwrapping, the validated ticket is discharged into the loading chute.

Associated with the gear train are two cam-operated switches used to detect, for the control circuit, the "wrap" and "unwrap" positions. A detector switch, with its actuator placed in the path of the leading edge of the ticket as it is being wrapped, is used to inform the controls of the presence of paper for recording. If inadvertently the start button is operated, causing the mechanism to wrap with no paper in it, failure of the detector switch to operate causes the drum to unwrap immediately upon operation of the "wrap" switch, thus restoring the mechanism to stand-by.

The wrapper drum supports, at the left side, only 1¾ inches of the 4 inches of ticket width, leaving a substantial portion of the cylindrical "Teledeltos" paper tube unsupported and available for internal scanning. Rigidity, sufficient to support stylus pressure without distortion, is derived from the overlapping cylindrical form and the supporting effect of the drum and wrapper.

Stylus Assembly

Problems encountered in the design of a stylus mechanism to operate within the limits of a cylinder approximately 1-5/16 inches in diameter involved provision for such features as:

1. Light pressure
2. Maximum stylus life
3. Adequate insulation
4. Retraction and release
5. Rapid convenient replacement of worn styli
6. Maximum venting for the passage of air for exhaust purposes

The protruding stylus, if left in its normal recording position, would be damaged from interference with the paper during the wrapping and unwrapping operations. Therefore it is necessary to retract the stylus, while in motion, from the circle of contact with the paper. This is accomplished with a brake mechanism associated with the stylus assembly.

The stylus assembly comprises a brass hub mounted, and rotatable, on a nylon sleeve which serves the double purpose of an insulator and a dry bearing. The sleeve is eventually clamped to the motor shaft. (See Figure 5.) Integral with the hub, a stainless steel cylinder serves the dual purpose of a braking surface and a slip ring which engages a brush and conducts the incoming facsimile signals to the rotating stylus.

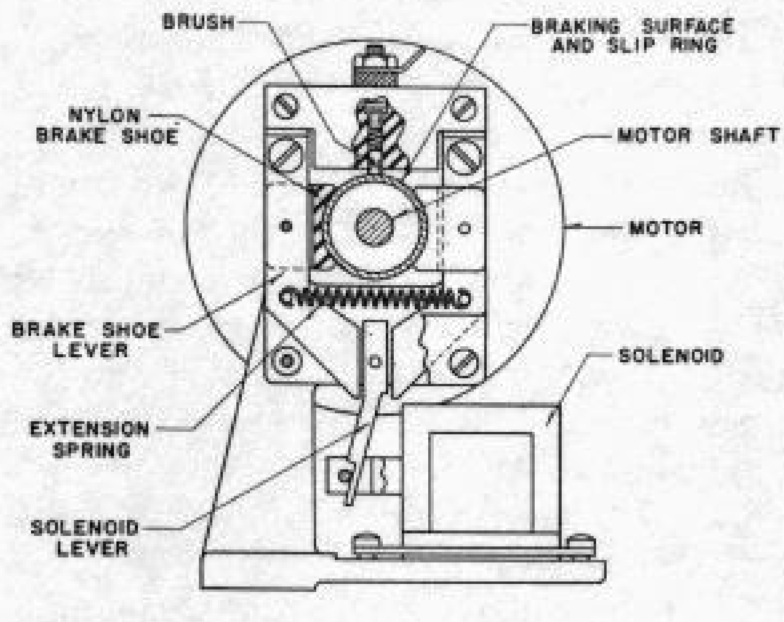


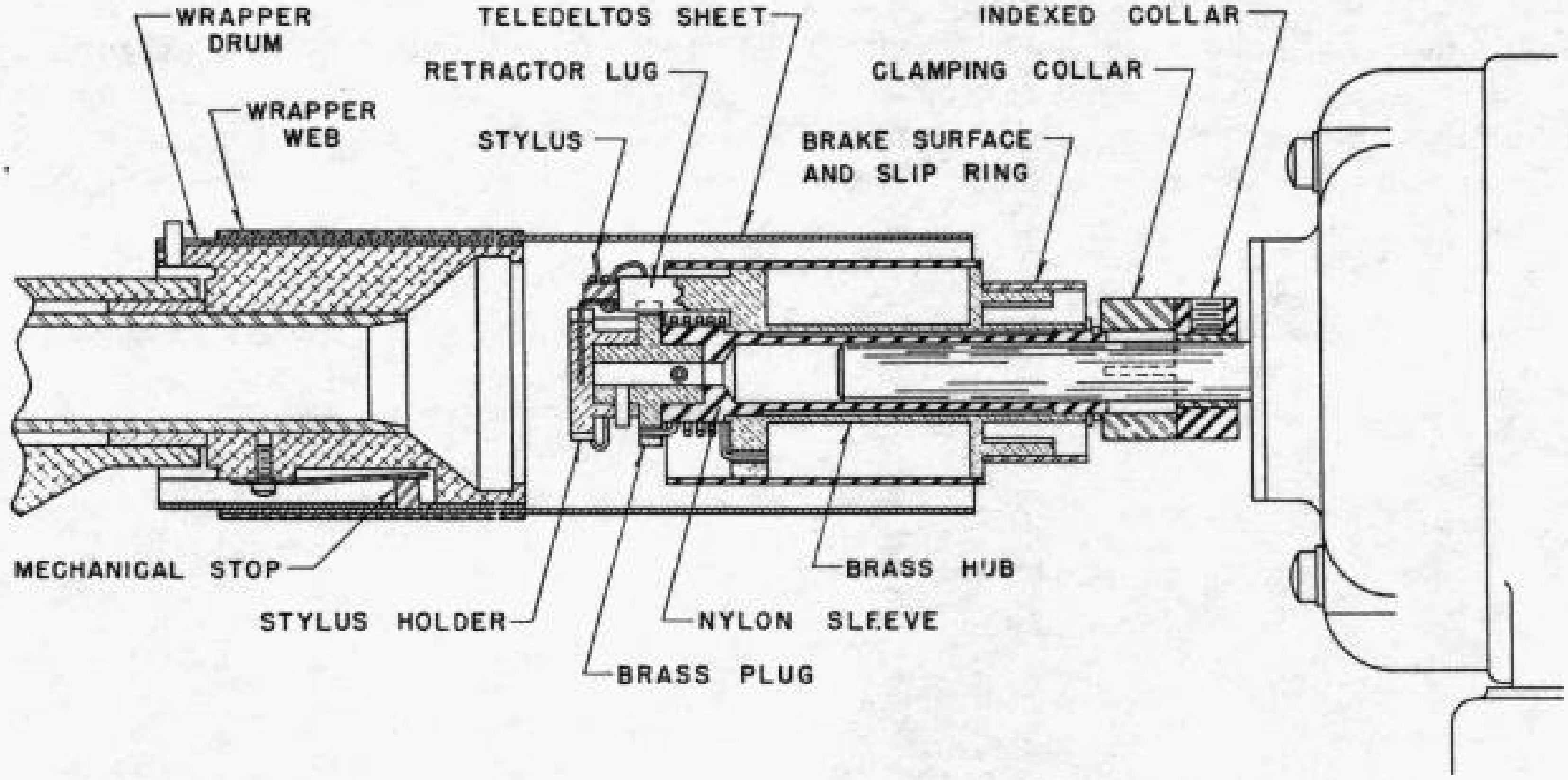
Figure 5. Stylus retractor brake

Acting upon the braking surface of the cylinder are two nylon brake shoes, pivotally mounted on levers so as to be self-centering. Again the nylon serves as a dry bearing and also as an insulator. The brake levers are drawn together with an extension spring which causes the brakes normally to exert braking force upon the hub. This force tends to rotate the hub backward, with respect to the motor shaft rotation, increasing the tension of a torsion spring. One end of the spring is fastened to the hub, the other to the sleeve, thus indirectly to the motor shaft. The spring also serves to conduct the facsimile signals from the hub to the stylus. Brakes are released by the movement of a lever, actuated by a solenoid, which spreads the brake shoes apart. (See Figure 6.)

Stylus and Mounting

A brass plug, fixed by pinning to the end of the insulating sleeve, serves as a mounting for a stylus holder. A portion of this plug is flanged and notched. The sides of the notch act as stops for a retractor lug protruding from the brass hub. In this manner the rotational effect upon to facilitate easy removal. The lever rotates about a pivot and is biased toward a stop pin by means of an extension spring.

The stylus is formed of tungsten wire 0.008 inch in diameter, eyeletted at one end and attached to the lever with a single screw. A wire extension from the lever supports the stylus sidewise. Pressure



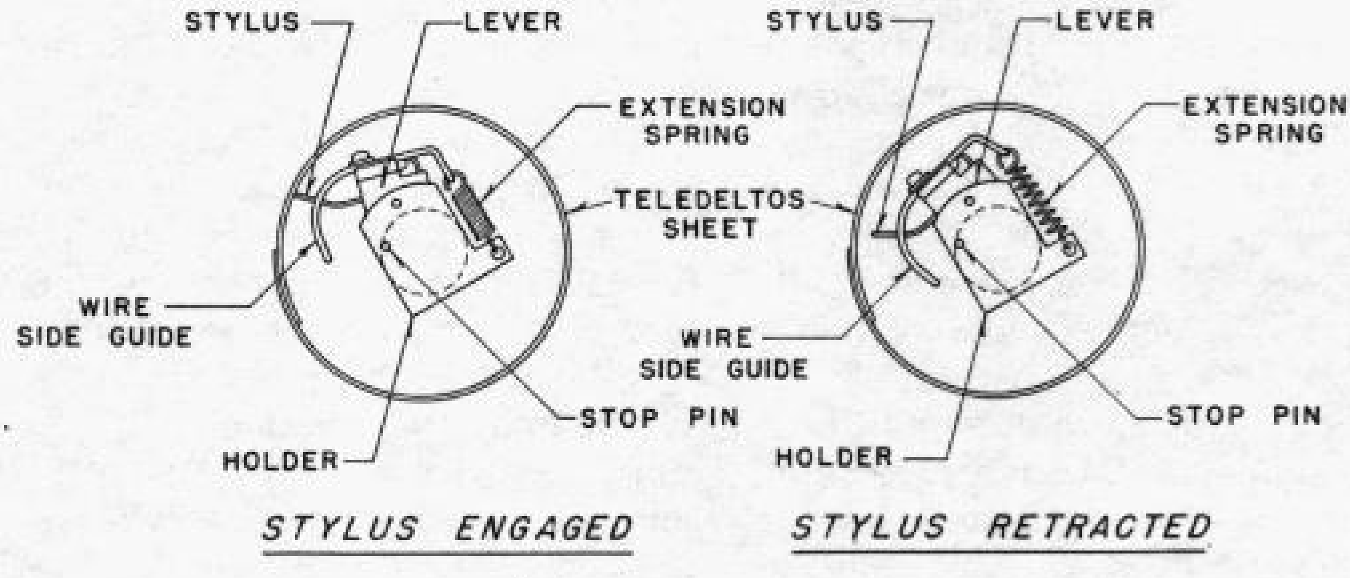


Figure 6. Stylus mechanism

the brass hub, obtained by the alternate action of the brake shoes and torsion spring, is limited.

The stylus holder is a detachable subassembly consisting of an L-shaped lever, pivotally mounted and guided in a brass cap which fits over the plug on the end of the insulator, and is snap-fastened thereto against the recording paper is derived entirely from the resilience of the tungsten form, and averages five grams.

Vibration is prevented by utilizing the resilience of the tungsten wire to bear in a transverse direction against the side guide. Normally, the brakes are engaged and the stylus is held retracted while the recording paper cylinder is being formed, after which the brakes release, permitting the stylus to engage the paper. In laboratory tests, one stylus has recorded 20,000 coupons.

Exhaust Filter

Recording, especially when testing at high current levels, may develop a certain amount of smoke and soot, which on these recorders is exhausted through a filter by a blower located in the console. (See Figure 7.) The intake of the blower is coupled to the recorder by means of a duct and a telescoping tube inserted in the tubular wrapper. This passage, extended further by the cylindrical form of the ticket, causes air to be drawn past the recording stylus with a considerable velocity, to convey any smoke and soot to the filter.

Other functions of the recorder such as line feeding, phase pulse generation, and so forth, are identical with those of the transmitter, permitting use of identical parts.

The 360-speed recorder is identical with the high-speed unit with one exception. In the former a stylus shaft is supported in a bracket occupying the space normally used for the motor of the high-speed unit. The bracket supports reduction gears and a conventional phasing clutch, which substitutes for the pulse generator used in the other machines.

Signals and Manual Controls

An incoming call sounds a buzzer and lights one of two lamps, signifying the kind of message to be recorded. After the chute is loaded with the proper form, a push button is depressed to start recording.

At the end of recording, the buzzer again sounds as an "end-of-message" lamp lights. Depression of a push button silences the buzzer, extinguishes the lamp and restores the recorder to stand-by.

If a particular type of message can be anticipated, the operator may load the chute and depress an automatic answer relay, after which the recorder is under the control of the transmitting operator. No further attention is required of the receiving operator until the buzzer sounds indicating completion of the recording.

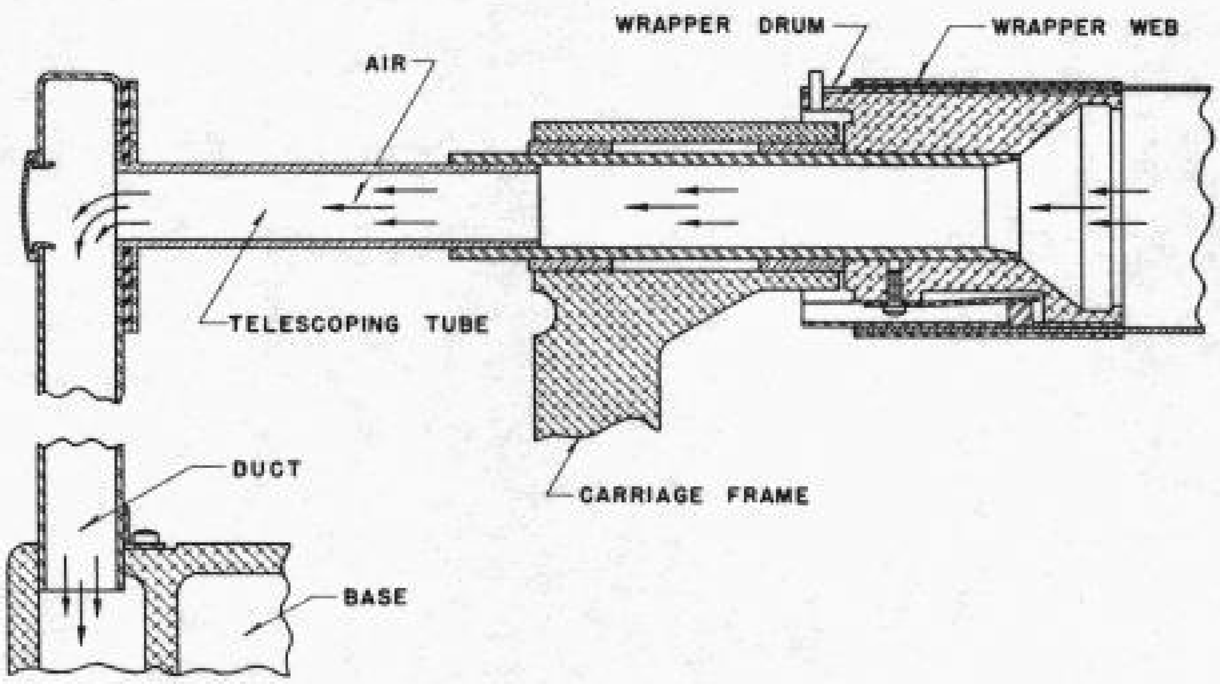


Figure 7.
Recorder exhaust

Douglas M. Zabriskie, Assistant to the Telefax Research Engineer, came to the company with the Western Union-Postal merger. He had joined the Engineering Department of Postal in 1922, after two years in the U.S. Army, and in 1925 was appointed chief draftsman. From 1940 until the merger, as chief designer he directed the design of mechanical equipment for Postal's semiautomatic tape reperforator switching system, which was installed in many cities and later adopted by the U.S. Signal Corps for their administrative network. Mr. Zabriskie continued in the same capacity for Western Union and worked on the Signal Corps project until its completion in 1945. He was then assigned to the Telefax Research Engineer's staff and subsequently placed in charge of machine design. His activities in Telefax equipment design have resulted in two patents issued and eight applied for.

Charles Jelinek, Jr., of the Telefax Research Division, obtained his education in communications engineering at the Newark College of Engineering, Columbia and New York University. Prior to coming to the Telegraph Company in 1946, he had served as Electronic Technician's Mate in the U.S. Navy, and had gained valuable experience in facsimile development with Finch Telecommunications and the Federal Telephone and Radio Corporation. His work with the Telefax Research group has been concerned with the development of facsimile apparatus of all kinds. Mr. Jelinek has been closely associated with the Ticketfax development described in this paper, and has contributed much toward the development of the mobile and central office Telefax equipment. He is an Associate Member of AIEE.

Ticketfax Electronics

CHARLES JELINEK, Jr.

TICKETFAX is a special purpose facsimile equipment developed by Western Union and used primarily for the reproduction of the intelligence from a specific size of copy. It is used by the Pennsylvania Railroad in Philadelphia and the New York Central at Cleveland, to facilitate the handling of Pullman space accommodations.

Modern systems of reservation handling require high-speed communications, so wherever transmission facilities permit, rotary-scan 1800-rpm Ticketfax equipment is used; this, to the communications engineer, represents an area speed equivalent to 700 words per minute if elite type is used. On longer circuits, or those with restricted bandwidth, 360-rpm machines are used. Because of some novel features of the 1800-rpm equipment, it will be described in detail. Figure 1 shows the transmitter to the right and the recorder to the left, mounted on consoles which contain the electronic and control units.

Figure 1. Ticketfax transmitter and recorder consoles showing placement of electronic and control units:

1. Recording amplifier
2. Recorder control unit
3. Transmitter exciter lamp transformer
4. Low voltage regulated power supply
5. Transmitter control unit
6. Modulator chassis

A paper presented before the Summer General Meeting of the American Institute of Electrical Engineers at Swampscott, Mass., June 1955.

Pertinent data for the 1800-rpm Ticketfax system are:

Copy size	1½ by 4½ in.
Useful area	1½ by 4 in.
Speed	1800 rpm
Highest modulation frequency	7.2 kc approx.
Carrier frequency	10 kc
Definition	120 lines per in.

The modulation frequency range is from a fraction of a cycle per second to 7.2 kc, i.e., an 0.008-inch spot or stylus can resolve 60 alternate black and white lines, or 60 cycles per inch by 4 inches by 30 rps equals 7.2 kc. The lower limit is derived from scanning a black area for say 15 revolutions and a white area for 15 revolutions to generate a frequency of one cycle per second. At 120 lines per inch definition and 30 revolutions per second, the lineal scanning rate is ¼ inch per second so that a 1½ inch wide ticket is scanned in six seconds. With a carrier frequency of 10 kc and modulation on a double-sideband basis, a bandwidth of at least 14 kc is required, extending from 3 to 17 kc.

Transmitter Functioning

A paper by Douglas M. Zabriskie[1] describes in detail how a ticket to be transmitted is wrapped around a transparent cylinder and scanned from the inside by a rotating mirror (Figure 2). To review briefly, a converging light from an exciter lamp is focused onto the copy by means of a lens and two mirrors. The light spot is rotated around the inside of this cylinder of copy by one of the mirrors which is mounted on the end of the motor shaft. Reflected light is picked up by this same rotating mirror, brought out of the end of the cylinder and focused onto the cathode of a photomultiplier by means of a Fresnel lens.

The photomultiplier is a conventional 931 and light signals (variations of reflected light from the copy being scanned) are amplified to cause a voltage swing as high as 20 to 30 volts across the anode load resistor. A cathode follower is used to bring these signals down to the modulator on a low-impedance basis. A preamplifier chassis containing a small RF power supply and the cathode follower is mounted in the transmitter proper.

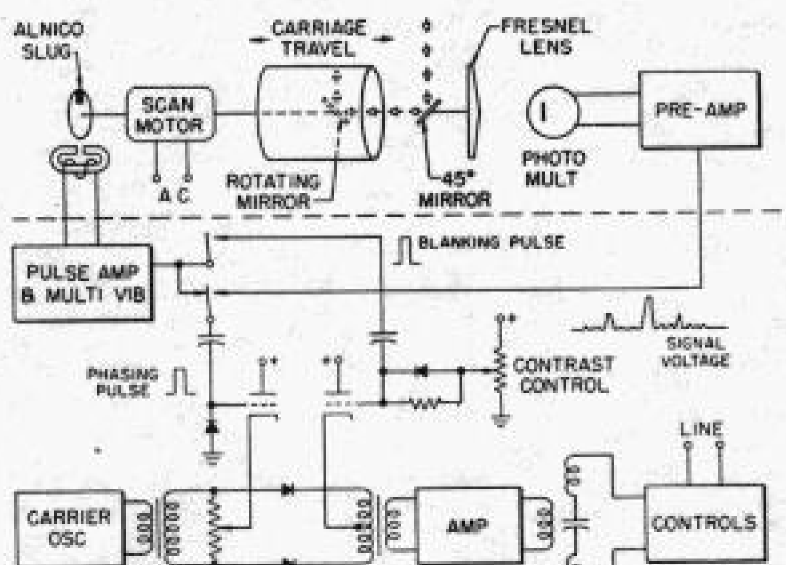


Figure 2. Transmitter simplified schematic

Phasing pulses which can be called horizontal framing pulses are generated by a magnetic slug traversing a gap in a pickup coil core. The brass disk which contains the magnetic slug insert is mounted on one end of the motor shaft and aligned so that as the light spot from the scanning mirror crosses the overlap of the paper, the slug passes the gap in the pickup coil core. A phasing pulse of about 5-volt amplitude and a duration of 1 millisecond is thus generated, and its leading edge coincides with the front edge of the copy being transmitted. This pulse is also used in the modulator for blanking out the colored area at the end of the ticket as well as for phasing.

Modulator Action

The modulator chassis contains the carrier oscillator, balanced modulator and amplifier circuits, the blanking pulse amplifier, the multivibrator and the changeover relay. The oscillator and the accompanying filter and line equalizer are plug-in units, making the modulator a basic unit which can be used with facsimile apparatus operating at other speeds.

The circuits operate as follows:

As soon as the message is wrapped and the scanning motor running, signals and phasing pulses appear on the contacts of the changeover relay. The signal contacts are normally open so that before the changeover relay operates only the phasing pulses appear at the input to the modulator diodes. The pulses, as derived from the pickup coil, are first amplified and inverted and then used to trigger a monostable or one-shot multivibrator. This multivibrator stage serves to sharpen the edges of the pulse and also, because it contains an adjustable R/C circuit, to make the same modulator chassis usable when different blanking areas are required and/or when a longer phasing pulse is needed as in the 360-rpm equipment. The positive pulses on the anodes of the modulator diodes cause the diodes to conduct and thus provide a burst of carrier to the amplifier stages and thence to the line each time the magnetic slug passes the gap in the pickup coil core.

When the changeover relay operates, phasing pulses are removed from the input to the modulator diodes and signals generated by the intelligence scanned are substituted. At the same time another pair of contacts connects the phasing pulses to the cathode side of the modulator.

When positive phasing pulses are connected to the cathodes of the modulator diodes and if these pulses are equal to, or greater in amplitude than the pulses of intelligence which are on the anodes of the diodes, no modulated carrier can appear at the output, and any intelligence scanned during the phasing pulse duration is said to be blanked.

Clamping to Background

To insure freedom from drift and to limit unbalance and frequency discrimination due to distributed capacitance and so forth, a low-impedance modulator is used. Clamping to background or d-c restoration is accomplished in the grid side of the cathode follower feeding the modulator, thereby providing a long time discharge path for the coupling capacitor. The charging time, however, is very short, since the charging current is taken from the output of the cathode follower in the preamplifier. This circuitry insures proper clamping even at low scanning speeds.

In order to provide a high degree of linearity for both large and small signal input levels, the modulator diodes are operated at high bias and signal amplitudes. This type of operation causes considerable third and higher order harmonics to be generated; therefore, a filter is used in the output. The filter is a band-pass type, thus it also attenuates modulation frequencies which may be present in the output due to modulator unbalance. With the use of matched diodes and sensitive instruments for balancing procedures, 50-db ratios of modulation products to modulation frequencies in the output have been attained. Balance ratios in the average production model are of the order of 40 to 45 db.

The output of the modulator filter is fed into an attenuation equalizer and from there to the line through two stages of amplification. Because most of the lines used by the railroads are large conductor pairs, amplitude equalization is not difficult even though the transmitted frequency band is from 3 to 17 kc.

Phasing Theory

Before describing in detail how the receiver operates and how the phasing pulses are used to phase, or horizontally frame the message, the phenomenon of phase position of the armature of the synchronous motor should be discussed.

The armature of a 4-pole 1800-rpm salient pole synchronous motor has four possible phase positions. That is, *if* the angular position of a mark on the shaft of this motor is observed with a stroboscope locked to the 60-cycle line frequency, the mark will appear in one of four positions each time the motor is started. These positions are 90 degrees apart, corresponding to the four poles, and if the line voltage and load conditions remain the same each time the motor is turned on, this phase position is maintained with a high degree of accuracy. By using the Alnico instead of the mark on the motor shaft, and by angularly positioning this slug in respect to a particular angle of current flow through the motor, the scanning motors used in this system are aligned so that the phase positions of their armatures are identical.

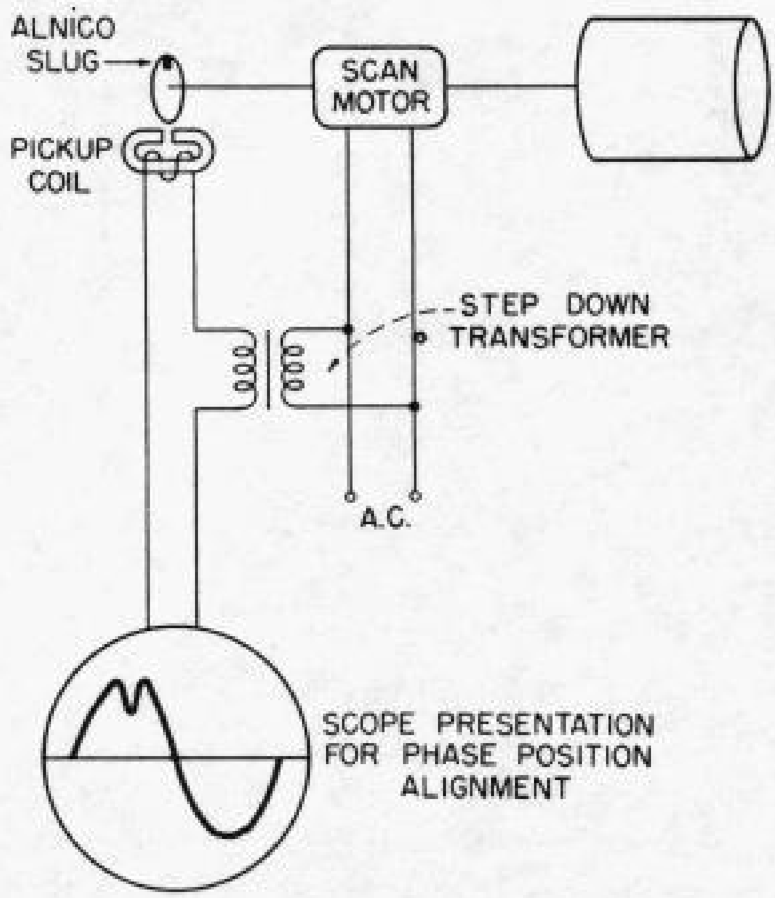


Figure 3. Method of phase position alignment

One way of making this alignment (Figure 3) is to connect the vertical deflection plates of an oscilloscope to a voltage taken from across the 60-cycle line feeding the motor connected in series with the output of the pulse coil. The presentation will show the pulse at a particular angle of current flow through the motor. The Alnico slugs on the shafts of all scanning motors are aligned in this way and pinned to the shafts.

Recorder Synchronization

Of course only one of the phase positions of any motor armature is correct in respect to the phase position of a second and duplicate motor. If one motor, for example the recorder (Figure 4), is momentarily interrupted so as to cause it to slip one pole at a time while the transmitter motor continues to run synchronously, a condition will be established where the magnet slugs on both shafts will be at the exact same angular position. At this time the pulses derived from the pulse pickup coils will be in coincidence and if no further interruption of the motor circuit is made, the recorded message will be properly framed.

This is the method used to phase the recorder to the transmitter in the Ticketfax system. Actually, an adjustable width motor-driven commutator is used to interrupt the recorder stylus motor. For proper pole slippage it was found that the

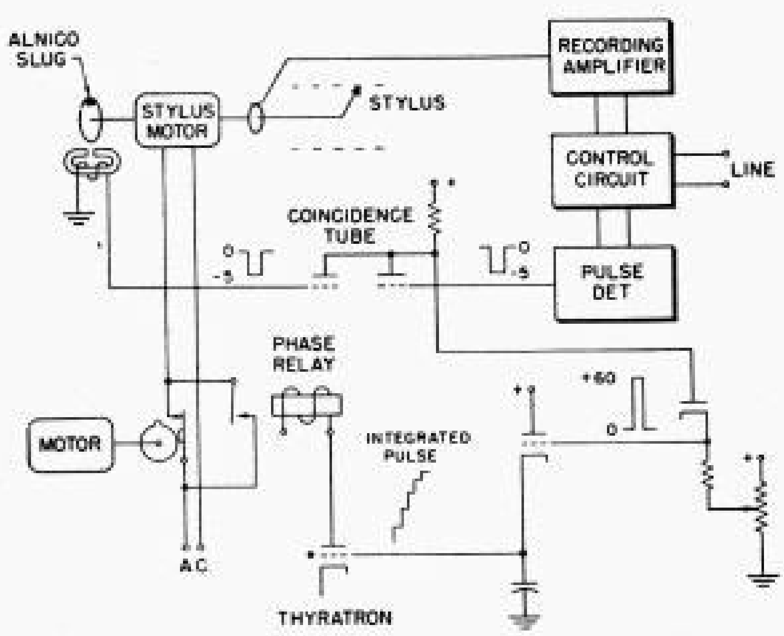


Figure 4. Recorder simplified schematic

stylus motor can be interrupted for a period of approximately 35 milliseconds. The interrupting motor rotates at 120 rpm or two per second; thus as many as 15 coincidence pulses may be generated during the condition when the magnets on both shafts are in the same angular position.

At the receiver the phasing pulses coming in from a remote transmitter are first amplified, and detected; a filter removes most of the carrier frequency, thus a negative going pulse of about 5- to 6-volt amplitude is provided at one control grid of a coincidence tube. The second control grid of this tube is connected to the local pulse coil. The tube circuit values are such that neither pulse alone can bias the tube to cut-off, but when the grid pulses coincide, no plate current can flow and the plate voltage rises to very nearly the B+ value. A diode is connected to the plate of this coincidence tube and so biased that no conduction can take place until the high coincidence voltage occurs, at which time a large voltage drop is present across the diode load resistor. The coincidence pulse thus generated has an amplitude of about 70 volts, a duration determined by the narrower of the two pulses from which it was derived, and a repetition rate of 30 per second.

To make sure that the coincidence pulse is not due to a severe line hit or a fortuitous output at a time when the recorder motor is about to be interrupted, the coincidence pulses are integrated and a portion of this delayed voltage is used to trigger the phasing relay thyratron.

A pair of contacts of the phasing relay shorts out the interrupting commutator so that no further pole slippage can take place. A second pair of contacts on this same relay energizes the line feed clutch and recording of a properly framed message takes place.

It should be pointed out that in an area of 3-phase power distribution, a transmitter connected to phase one may have to send to a recorder connected to phase two or three. It must be remembered that the angular positioning of the phasing slug is made in respect to a particular angle of current flow through the motor. This alignment, however, is done using one phase of alternating current, so a field adjustment is provided to index the angular position of the magnetic slug in steps of 120 degrees.

Control Circuit

Control circuit operation (Figure 5) is on a metallic loop basis because of the very heavy ground currents encountered along an electrified railroad way. A line battery of 120-volt direct current is used for calling and signalling and for this reason the primaries of all line bridging transformers are split and a capacitor inserted to block the d-c path. The line battery source is at the transmitter and it is connected to the line through the coil of a line relay. This transmitter line relay is adjusted to operate at 35 ma.

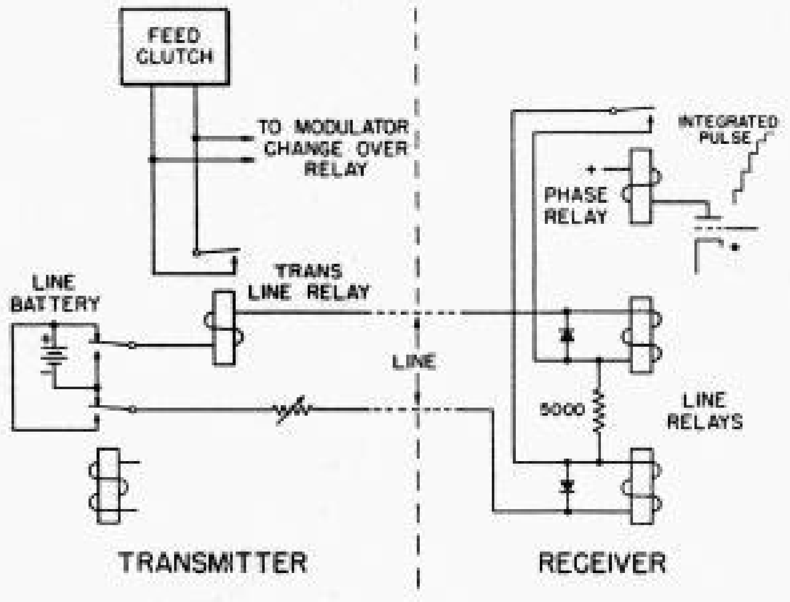


Figure 5. Control circuit

Depressing either the "message" or "coupon" button of the transmitter serves to reverse the line battery polarity and thus bring up either the "message" or "coupon" line relay at the receiver. At the same time the message or coupon is wrapped around the transparent cylinder of the transmitter, and the exciter lamp and scanning motor are energized. As described previously, the modulator changeover relay is not energized, so only phasing pulses appear on the line.

The line current at this time is limited to a value of less than 20 ma by the line, a 5000-ohm resistor in the receiver, and an adjustable resistor in the transmitter.

At the receiver, the operation of one of the line relays brought up either the "message" or "coupon" lamp and a buzzer indicating an incoming call. The receiving operator is thus advised to insert either a blank message form or a preprinted coupon form. Upon depressing the start button, the "Teledeltos"* recording blank will be automatically wrapped around the transparent cylinder, and power will be turned on to all receiving circuits. Phasing now takes place and a third pair of contacts on the phasing relay short-circuits the 5000-ohm current limiting resistor in the line.

The line current is thus increased to more than 40 ma and operates the line relay of the transmitter. Battery is now disconnected from the line, the feed clutch is energized, and the modulator changeover relay operates to remove phasing pulses and transmit the message.

Modifications for 360-RPM

Lower speed machines are used for longer circuits or for circuits which will not handle the 14-kc bandwidth of the 1800-rpm gear.

The 360-rpm transmitter uses a carrier frequency of 2000 cycles and a frequency band extending from 560 to 3440 cycles. Since oscillator and filter circuits of the modulator are on a plug-in basis, the 1800- and 360-rpm transmitters are alike except for motor gearing.

At 360 rpm the low velocity of the recording stylus permits the use of a mechanical clutch for phasing. The incoming phasing pulses are amplified and detected and directly used to trigger a relay tube which in turn energizes the phasing clutch.

Ticketfax machines are relatively new so that maintenance and operating logs for several months only are available. These records show only minor troubles, most of which can be attributed to personnel unfamiliarity with new equipment.

Reference

1. Ticketfax Transmitters and Recorders, DOUGLAS M. ZABRISKIE. *Western Union Technical Review*, Vol. 9, No. 3, July 1955.

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Modern High-Speed Page Teleprinters

FRED W. SMITH

PART II—TELETYPE MODEL 28 TELEPRINTER

THE DESIGN of the Teletype Corporation's new Model 28 teleprinter is radically different from that of any teleprinter currently used in Western Union. A large number of new principles of operation are used in the keyboard and in the typing unit. Space will not permit a detailed description of all of the new features incorporated in the design but some of the features of special interest will be described.

Internal-Expansion Friction Clutch

The Model 28 teleprinter (shown in Figure 10) uses an all-metal internal-expansion friction clutch which disengages in the stopped position. The driving member is a steel drum with a grooved inner surface (Figure 11). The driven assembly consists of two shoes, a shoe lever, an adjusting disc, a driven disc, and a clutch sleeve bearing. The position of the adjusting disc, which is clamped to the driven disc by means of two screws, is adjustable. The shoe lever fits into the left-hand slot of the clutch sleeve bearing and the two shoes fit into the right-hand slot of the bearing. In order to disengage the clutch (Figure 12A), a clutch throw-out lever is placed in the path of lug C on the lower end of the shoe lever.

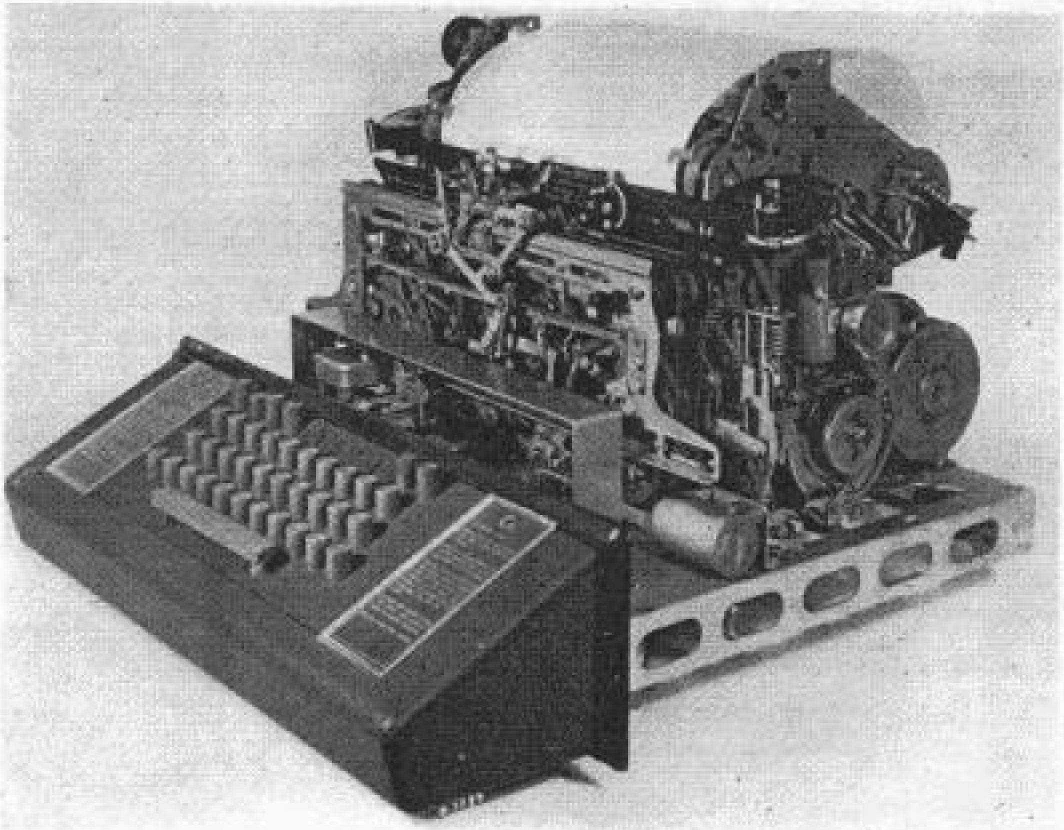


Figure 10. Teletype's Model 28 teleprinter removed from console

The shoe lever then pivots clockwise about lug A on its upper end, and as lug B on the lever moves clockwise an extension spring pulls the two shoes inward away from the inner surface of the clutch driving drum. When the clutch throw-out lever is momentarily disengaged from lug C on the shoe lever, the shoe lever spring pulls the shoe lever in a counterclockwise direction (see Figure 12B). As lug B moves counterclockwise it pushes the point D on the primary shoe against the inner surface of the drum, which is rotating continuously in a counter-clockwise direction. As the drum rotates, it drives the primary shoe downward until the lower end of the shoe makes contact with the drum at point E.

The friction between the shoe and the drum at these two points causes the primary shoe to rotate with the drum and push against the secondary shoe at F. This shoe is then pushed against the drum at G and the revolving drum moves the shoe upward until it again makes contact with the drum at H. The secondary shoe then drives the lug on the adjusting disc, which in turn drives the driven disc. The clutch sleeve bearing rotates with the driven disc so that the load may be coupled to either of these two members. The motions

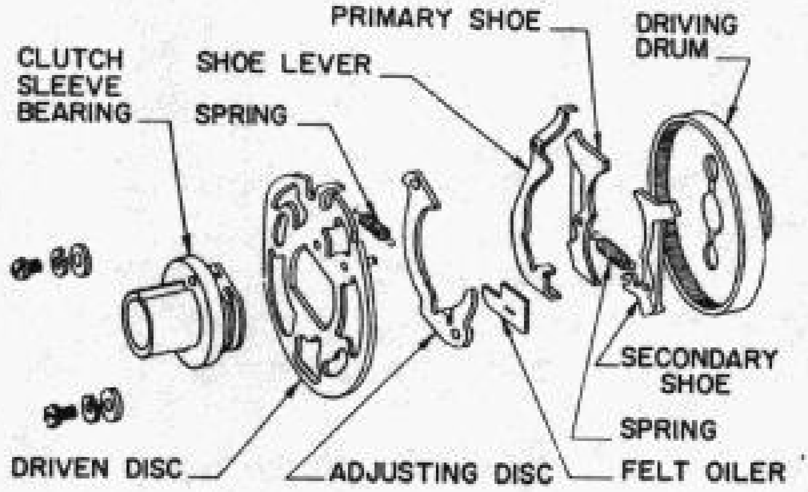


Figure 11. Exploded view of Teletype clutch

involved in engaging and disengaging the clutch are very small; for example, lug C on the shoe lever moves approximately 0.065 inch from the engaged to the fully disengaged position. This produces a very fast take-up, on the order of two degrees. The forces applied to the driven shoes are multipled at each of the points of contact with the drum so that the force applied at H (Figure 12B) is very large.

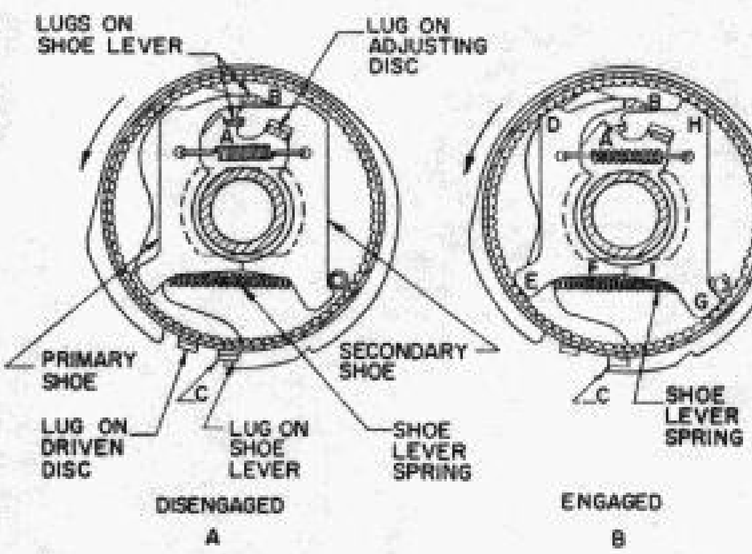


Figure 12. Teletype clutch assembly

Seven clutches are used on the Model 28 teleprinter. Two of these have three sets of lugs on the shoe lever and the driven disc, so that these clutches turn only one-third of a revolution when they are momentarily released. One of the clutches has two sets of lugs and makes one-half a revolution when momentarily released. The functions of the various clutches will be described later.

The new clutch has many advantages over the conventional felt friction clutches used in most teleprinters. In these felt clutches the torque, take-up time and slippage vary greatly with the condition of the felts and particularly with the type and amount of lubricant present. Also, when a felt clutch is performing no work, as when a teleprinter is idling, the load on the motor is not materially reduced and slippage is 100 percent. Such a clutch is naturally costly to maintain. The new Teletype Model 28 clutch has been designed to eliminate these undesirable features. The lubrication interval necessary for satisfactory operation of the clutch has been greatly extended. The torque, take-up time, and slippage are not dependent upon the lubricant present. Since the clutch is fully disengaged in the stopped position, there is very little load on the motor when the teleprinter is idling and there is very little wear on the clutch parts.

Keyboard

The spacing of the key tops on the Model 28 teleprinter conforms to the spacing on a standard American-made typewriter; that is, the left-to-right spacing between adjacent keys in any row is one-eighth of an inch less than the spacing on our present teleprinters, but the spacing between the rows of keys is the same as on our teleprinters. This change in spacing is of some advantage when a teleprinter is used in a customer's office where a stenographer usually sends telegrams on a tie-line teleprinter as a part of her regular duties, but it is not particularly advantageous for use in Western Union offices where operators are accustomed to our standard teleprinter keyboards.

When a key is depressed a latch is tripped to permit the five code bars and a clutch trip bar to be pulled to the right by springs. The code bars are coded by means of notches so that the code bars representing spacing pulses in the character selected are blocked by the depressed key lever, but the other code bars move to the right until they come to rest against a

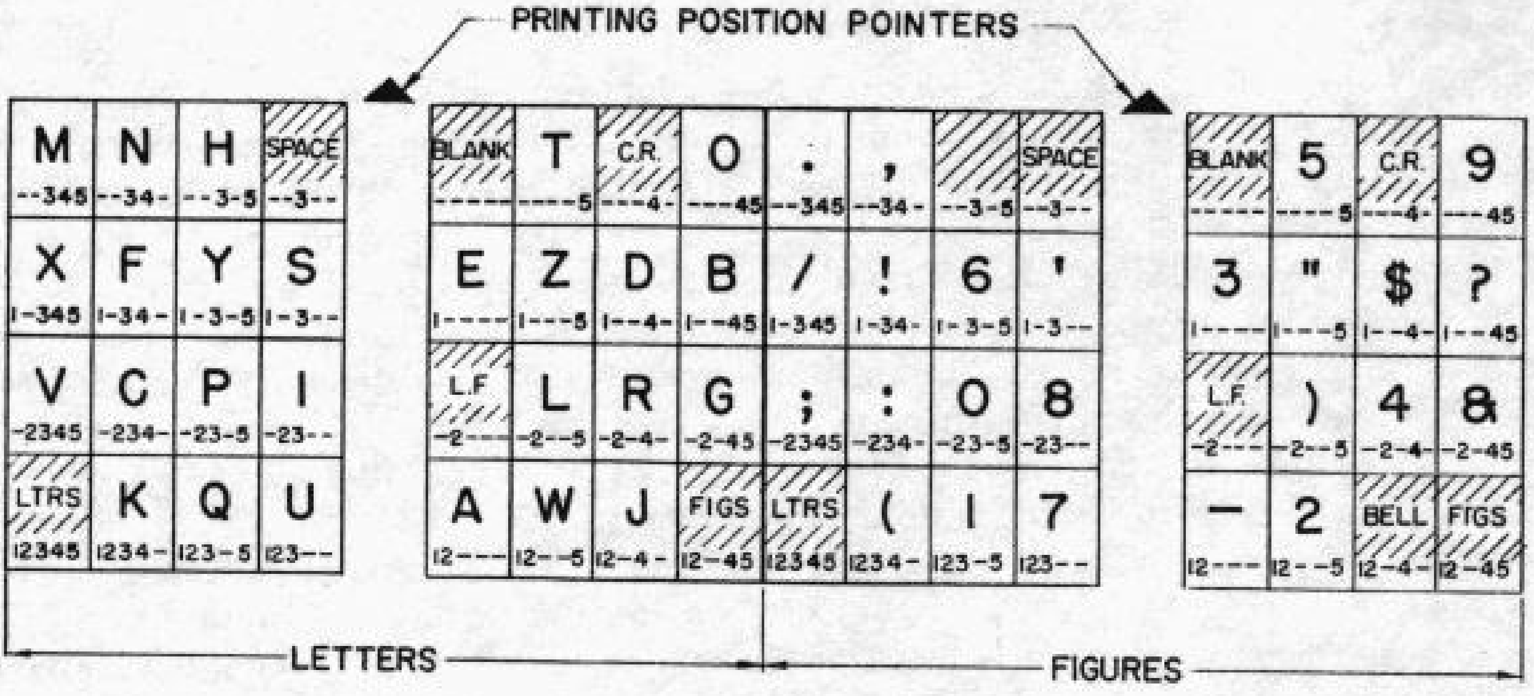


Figure 13. Model 28 type box code chart

stop. Transfer levers associated with the code bars transfer the selection set up on the code bars to a signal generator mechanism which transmits the signal train for the selected character. The code bars are then reset by means of a cam and bail. Use of this permissive selection of the code bars, instead of positioning them directly from the key lever, reduces the variation in the forces required to depress keys corresponding to different characters and results in a more even touch.

The keyboard is equipped with a lock key which, when depressed, locks the keys to prevent accidentally depressing a key; a keyboard unlock key; a break key which opens the line circuit when held down; a repeat key which permits any character to be transmitted repeatedly; a local line feed key; and a local carriage-return key. Optional features available include keyboard locking upon reception of two consecutive "blank" signals, and a motor-stop relay which may be controlled by an upper case H, M, or "blank" combination or from a time delay mechanism which will turn off the motor when no signals have been received for approximately two minutes.

Type Box and Type Box Carriage

In the Model 28 typing unit, the type pallets are mounted in a small rectangular type box approximately ½ inch thick, 1 inch wide, and 2 inches long. The total weight of this type box and its associated carriage is approximately eight ounces, about one-tenth as much as the type-carriage assembly used on Teletype's Model 15 teleprinter, yet it performs the same function as the old carriage assembly. This weight reduction permits the carriage to return from the right to the left margin within the time of two characters, even when the teleprinter is operating at 100 words per minute.

The type pallets in the left half of the type box are letters and those in the right half are figures. When the type box is in position to print letters, a printing position pointer in the center of the top of the letters half of the box is just below the position in which the next character will be printed. When a figures-shift signal is received by the typing unit, the type box shifts to the left so that the figures half of the type box is in the printing position and a printing position pointer in the figures half of the type box is then just below the printing position.

Each half of the type box consists of eight vertical rows of type pallets, four on each side of the printing position pointer, and four horizontal rows of type pallets. The character to be printed is selected by moving the type box vertically and horizontally to move the type pallet into the printing position.

The arrangement of the characters in the type box, with the code combination for each character, is shown in Figure 13. The actual type box may be seen in its rest position in Figure 10. The four possible combinations of the first and second pulses are used to determine which of the four horizontal rows of type will be selected. The third pulse determines whether the type box will shift to the right or to the left from its rest position, and the fourth and fifth pulses determine how far it will shift from its rest position. As shown in Figure 13, each of the four horizontal rows has a different combination of the first and second pulses. Each character to the left of the printing position pointer has a marking third pulse and each character to the right of the pointer has a spacing third pulse. Also, the combinations of the fourth and fifth pulses are different for each of the four possible vertical rows on either side of the center position.

After the type box has been positioned, a spring-operated print hammer which moves with the type box is unlatched and allowed to drive the selected type pallet against the ribbon and paper to print the character. The print hammer is then reset to its latched position and the type box is returned to its rest position. When the signal for a nonprinting function is received, the type box is positioned in the usual manner and the print hammer is operated; however, dummy type pallets which do not print are placed in each of the nonprinting positions, so that no impression is made on the paper. A spacing suppression mechanism prevents the type box and carriage from spacing when a nonprinting function is selected.

Several advantages are gained by use of the type box, in addition to the obvious advantages due to its light weight. One of the most important of these advantages is the ease with which the entire type box can be removed and replaced. For example, a standard communications type box can be removed and a weather-symbol type box installed in its place in a matter of seconds without using tools. Each character is mounted on a separate type pallet, so that it is not possible to print part of a letter and part of its associated upper case character at the same time. Since the type box shifts to change from letters to figures, the platen remains stationary except during a line feed, thus reducing paper creep when multicopy paper is used and also eliminating the shock produced by shifting a heavy platen assembly from the letters to the figures position. Type alignment is controlled in manufacture and it is never necessary to solder type pallets in position with a soldering fixture to obtain accurate alignment, as it is on a typebar teleprinter. When it is necessary to replace a defective part, the entire type box can be replaced by a spare while repairs are being made, without removing the teleprinter from service.

Receiving Selector Mechanism

The principle of operation of the selector mechanism is illustrated in Figures 14 and 15. A selector cam assembly, consisting essentially of a marking and spacing lock lever cam and five selector cams, is released and allowed to start rotating when a start pulse is received by the selector magnets. In the stop position of the cam shaft, the marking and spacing lock levers are on the long high part of the locking cam and the upper ends of

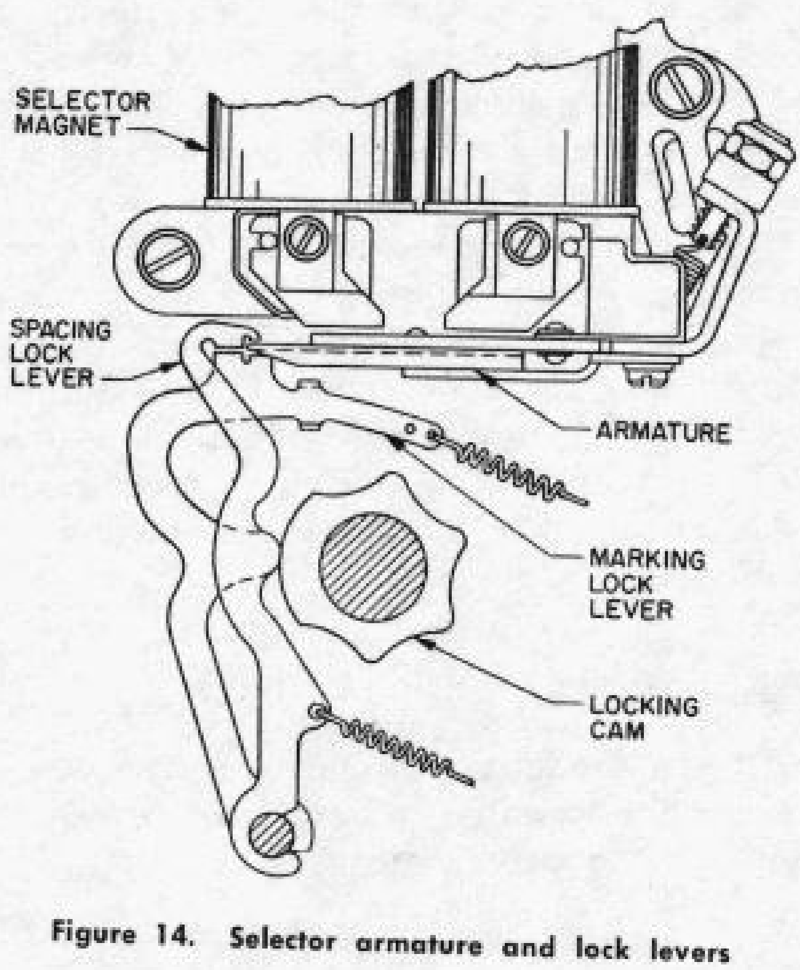


Figure 14. Selector armature and lock levers

the two lock levers are held in their left-hand positions, as shown in Figure 14, so that the selector armature is free to move from the marking to the spacing position. As the selector cam shaft rotates from the stop position, the two lock levers ride to the first low part of the locking cam. If the selector armature is in the spacing position at this time, the marking lock lever will be blocked from following the cam by the left end of the armature, but the spacing lock lever will follow the cam and the upper end of this lever will lock the armature in the spacing position.

Conversely, if the armature is in the marking position as the two lock levers ride to the low part of the cam, the spacing lock lever will be blocked from following the cam, but the marking lock lever will ride to the low part of the cam and the lever will rotate clockwise about its lower end. The upper end of the marking lock lever will then move beneath the armature and lock the armature in its marking position. As the cam shaft continues to rotate, the two lock levers ride again to a high part of the cam and the armature is momentarily unlatched so that it is free to move. Thus, the armature

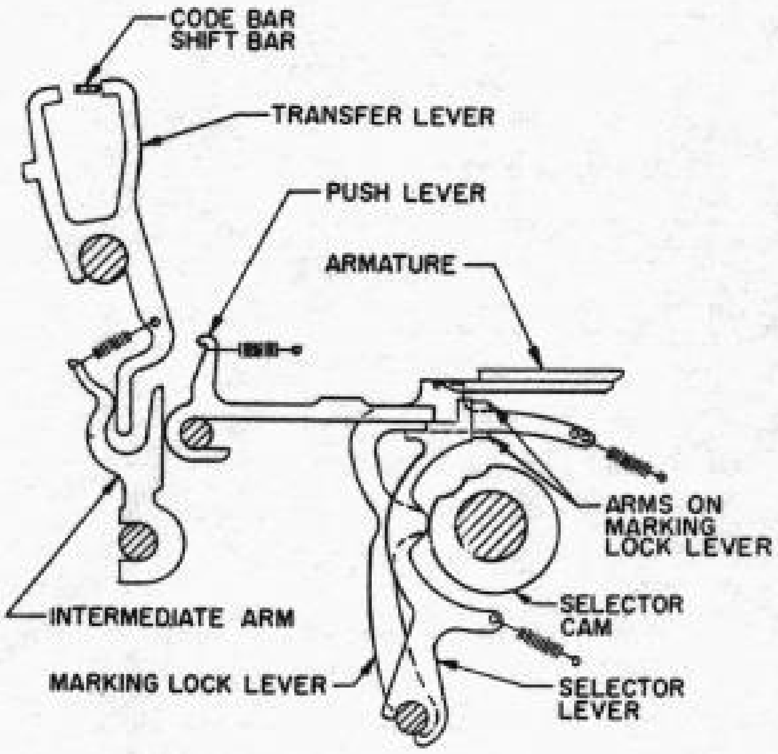


Figure 15. Model 28 selector mechanism

is unlocked at the time of each signal transition so that the armature is free to respond to the incoming signals, then one of the two lock levers locks the armature in its selected position until just before the next signal transition is due to occur.

There are five depressions cut into the flutter-type locking cam. Also, there are five selector cams and each of these selector cams has a depression corresponding to one of the five depressions on the locking cam. (See Figure 15.) As the selector cam rotates, the marking and spacing lock levers move to the low part of the first depression on the locking cam and at the same time the No. 1 selector lever moves into the depression in the No. 1 selector cam, unless the marking lock lever is blocked from following its cam by the end of the armature. If the marking lock lever is blocked from following its cam, an arm on the upper end of the marking lock lever will block the selector lever from following its cam; but if the armature is in the marking position, the No. 1 selector lever will be allowed to follow its cam and the upper end of the lever will rotate clockwise far enough to allow the right end of the No. 1 push lever to drop down into the step on the upper end of the selector lever. As the cam sleeve continues to rotate, the high part of the selector cam rotates the selector lever counterclockwise and the push lever is pushed to the left. The push lever then rotates the No. 1 intermediate arm counterclockwise, and the spring which connects this arm with the No. 1 transfer lever rotates the transfer lever clockwise. The left arm at the upper end of the transfer lever then moves the end of the code bar shift bar to the right, or marking, position. The code bar shift bar is pivoted in a slot in its asso-

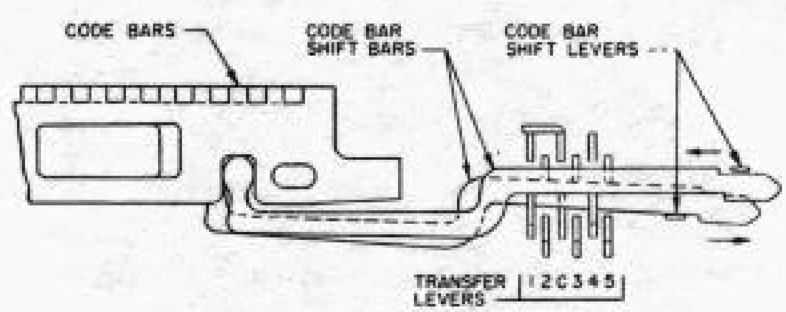


Figure 16. Code bar positioning mechanism

ciated code bar. (See Figure 16.) Of course, if the selector armature is in the spacing position and the marking lock lever is prevented from following its cam, the push lever will not drop into the step on the selector lever and the intermediate arm will not be rotated by the push lever. The code bar shift bar will then remain in the spacing position.

In addition to the five regular transfer levers, there is a sixth or common transfer lever which is not associated with an intermediate arm, push lever, and selector lever. This transfer lever has an extension which passes behind the Nos. 1 and 2 transfer levers (Figure 16), so that if either the No. 1 or the No. 2 transfer lever moves to the marking position, the common transfer lever will also move to the marking position.

Type Box Positioning Mechanism

Shortly after the five selector levers have operated in sequence and set up the received code combination on the code bar shift bars, a shift lever link is driven upward by a code bar positioning clutch and associated mechanism. As the shift lever link rises (Figure 17), the two code bar shift levers and the associated shift bars.

The Nos. 1 and 2 code bars and the common code bar have projections on their right ends which extend beyond the code bar guide. (See Figures 16 and 18.) In addition, there is a suppression code bar, marked "SUP" in Figure 18, which extends beyond the code bar guide. When the No. 1, 2 or the common code bar is in the spacing position, the projection on the bar will be in the path of point "a" on the vertical positioning levers (see Figure 19). When one of these code bars is in the marking position, it will be moved to the left far enough so that the projection on the code bar will not be in the path of the vertical positioning levers. The projection on the suppression code bar, however, is always in the path of the vertical positioning levers.

Shortly after the code bars have been positioned, a type box clutch and associated mechanism drives a driving lever (Figure 19) upward. This lever has attached to it an assembly consisting of the

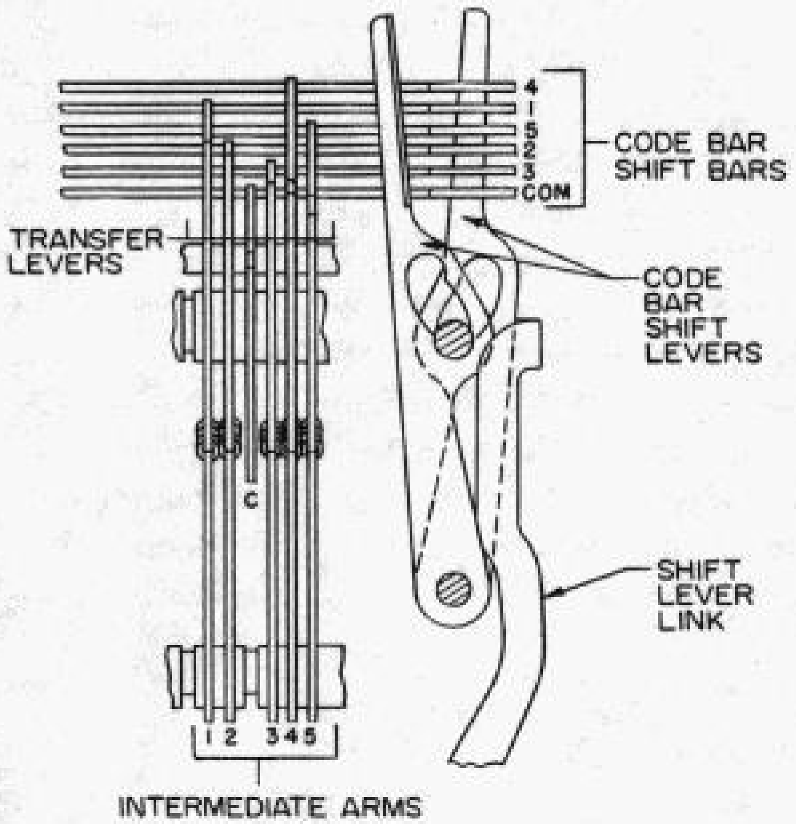


Figure 17. Code bar shift mechanism

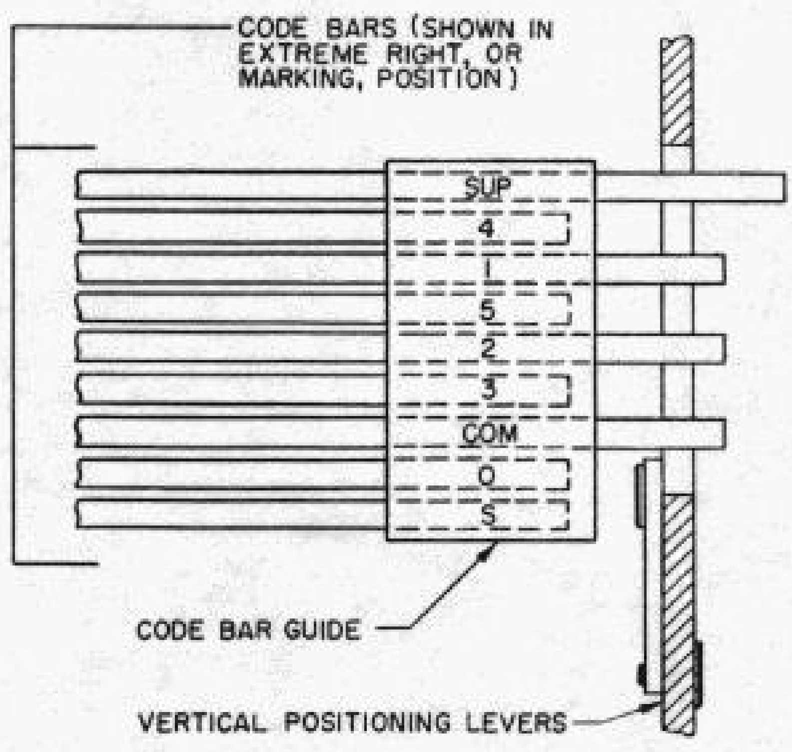


Figure 18. Code bar arrangement

bar shift levers engage notches on the code bar shift bars and position them to the right or left (Figure 16) depending on whether the shift bars are in the spacing or marking position. The code bars are thus positioned by the code bar shift bars to the right (spacing) or left (marking) position by the scissors action of the code

three vertical positioning levers. The type box carriage track is fastened to the upper of these three levers, as shown in Figure 19, so that the carriage track and type box move upward as the vertical positioning levers are driven upward. (There are actually two driving levers and two sets of vertical positioning levers, one on each side of the typing box, but only the right-hand set is shown.) As these levers move upward, point "a" on the middle lever strikes the projection on the lowest code bar which is in the spacing position. This causes the lever to rotate about its pivot "b," and the lower end of the middle lever rotates counterclockwise so that the knee joint buckles at the pivot "c." As the driving lever continues to rise, the two lower levers continue to buckle and the upper lever stops its upward travel. A latch (not shown) momentarily locks the upper lever in its uppermost position until after the selected character has been printed. Thus, the combination of the first and second pulses received by the teleprinter determines which of the four horizontal rows of type will be brought into position to print. The reason for the irregular vertical arrangement of the code bars, as shown in Figure 18, now becomes apparent. The spacing between the four code bars which determine the vertical position of the type box must correspond to the vertical spacing between horizontal rows of type, and for this reason the code bars cannot be placed in numerical order.

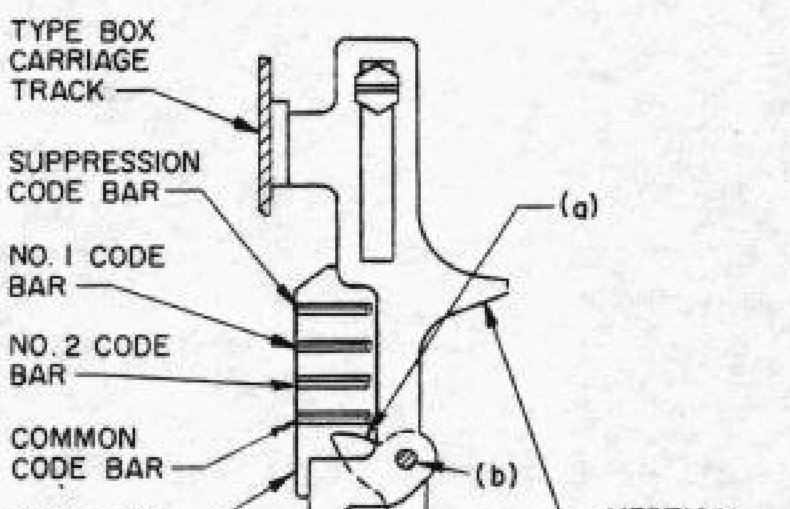


Figure 19. Vertical positioning mechanism

The position of the No. 3 code bar determines in which direction the type box will be shifted by determining which of two horizontal positioning drive links will be allowed to position the type box. When the No. 3 code bar is in the marking position, for example, a knee link which drives the type box to the left is buckled and another knee link which drives the type box to the right is allowed to operate and move the type box to the right. When the No. 3 code bar is in the spacing position, the knee link which drives the type box to the right is buckled and the other knee link is allowed to drive the type box to the left.

The combination of the fourth and fifth pulses received by the teleprinter determines how far the type box will shift from its rest position. The mechanism which accomplishes this operates on the same principle as the vertical positioning mechanism; that is, the Nos. 4 and 5 code bars both operate bell cranks which in turn operate horizontal stop slides. A common horizontal stop slide equipped with two stopping surfaces is operated by either of the other two slides so that four stop positions are obtained to correspond to the four possible combinations of the fourth and fifth pulses. These four stop positions determine at what point a horizontal positioning knee linkage will be buckled.

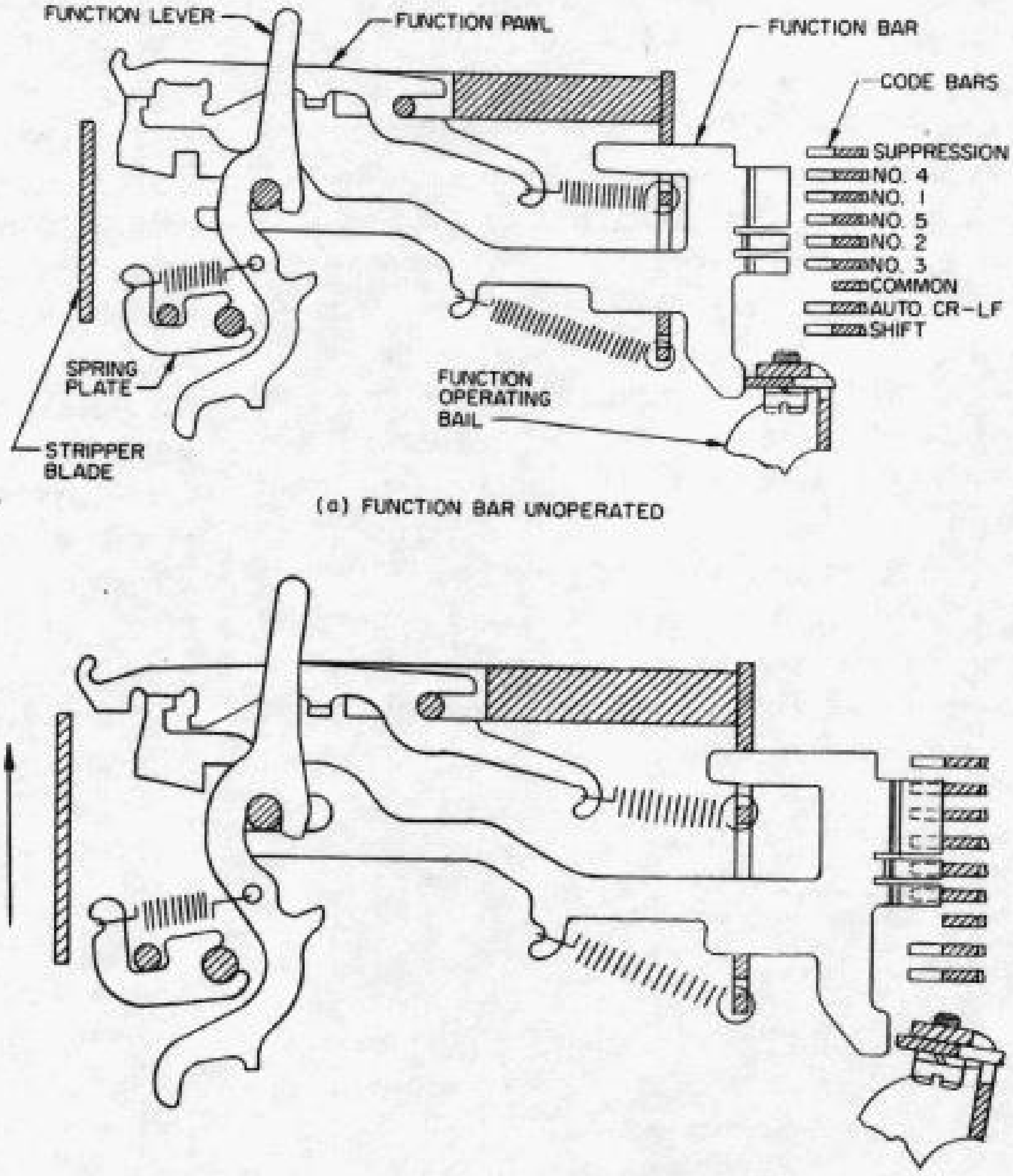
Two code bars not previously identified are shown in Figure 18. The code bar marked "O" is part of the automatic carriage return and line feed linkage and the one marked "S" is the letters-figures shift bar, the position of which determines which half of the type box will be in the printing position.

Function Box

One of the most interesting features of the Model 28 teleprinter is the function box, commonly called a "stunt" box. This function box is located behind the code bars and extends across the entire width of the typing unit. Each of the code bars is notched at the rear in an identical pattern. These notches in the code bars are used in conjunction with function bars in the stunt box to select a function. Each function bar (see Figures 20 and 21) has a series of tines on the front end which are bent to the right or left to correspond to the code combination for the character represented by the function bar. When the combination for which a function bar is coded is set up on the code bars, there will be a notch in each code bar opposite each of the tines on the function bar. (See Figure 21.) As the function operating bail, Figure 20 (a), rotates clockwise, the function bars are moved toward the code bars by their springs. Unselected function bars will be blocked by a projection on at least one code bar (Figure 21), but a selected function bar will continue to move to the right until the tines come to rest against the bottoms of the notches in the code bars. Thus, when a function bar is selected, it moves far enough to the right to permit its associated function pawl to drop down over the upper left end of the bar, as shown in Figure 20 (b).

As the function operating bail rotates counterclockwise back to its rest position, the selected function bar and the upper end of the function pawl which is in engagement with it are both moved to the left. A projection on the selected pawl engages the upper end of its associated function lever and rotates the lever about its pivot. The motion of this lever is used to initiate the desired function. The movement of the lower end of the lever is used to perform mechanical functions through appropriate mechanisms associated with the various function levers. A projection on the lower end of nonprinting function levers causes spacing to be suppressed when a nonprinting function is selected. The upper end of the function levers may be used to operate contacts for switching or to actuate other functions. Shortly after the function bar and its latched-up pawl return to the rest position, a stripper bail blade rises and moves the left end of the function pawl upward, unlatching the pawl and allowing the pawl and lever to return to their unselected positions.

There are 42 slots in the stunt box, each of which will accommodate a function bar and its associated mechanism. Approximately 10 of these positions are required for such common functions as line feed, carriage return, figures shift and letters shift. The remaining positions are available for other purposes. Since the function bars are coded (rather than the code bars), a function bar coded for any desired character, either upper or lower case, can be placed in any vacant slot in the function box. A function bar may be coded to respond to both upper and lower case by removing the tine opposite the



(b) FUNCTION BAR OPERATED

Figure 20. Function selecting mechanism

shift code bar. When changes must be made in the teleprinter functions, the necessary changes are made in the stunt box. For example, if it is necessary to change a typing unit from bell on "J" to

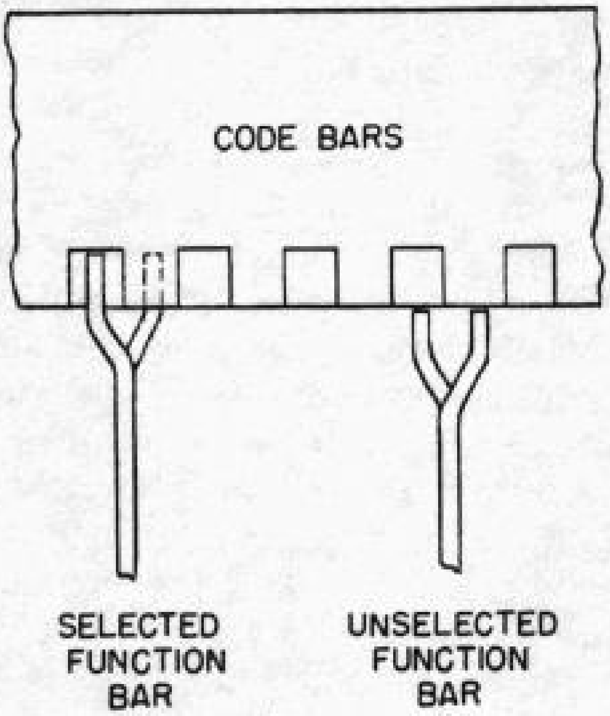


Figure 21. Function selection

bell on "S" operation, it is necessary only to remove the stunt box and change the function bar which operates the bell contacts.

The stunt box is a remarkably versatile mechanism which can be used to accomplish a large number of useful tasks. By means of special function levers and latches it is possible to obtain sequential selection of a function. For example, suppose that it is desired to operate a set of contacts upon receipt of a three-character code sequence such as "figures," "blank," "letters," when and only when this combination is received in this exact order. Special function mechanisms for these three functions are then installed in the stunt box. When a "figures" combination is received, the "figures" function mechanism operates and conditions the "blank" function mechanism for operation; that is, figuratively speaking, operation of the "figures" function mechanism opens a gate to permit the "blank" to operate. If the next character is anything but a "blank" the gate will be closed, but if the next character is a "blank," the "blank" mechanism will operate and condition the "letters" to operate. If the third character is a "letters," the "letters" function mechanism will be permitted to operate and the "letters" function lever will then operate the contacts. Interposing another character between the "blank" and the "letters" characters will, of course, close the gate to the "letters" function mechanism. A character sequence of 2, 3, 4 or more, in any desired order, may be used.

A total of 32 sets of contacts can be mounted on the stunt box. Any pair of contacts can be either normally open or normally closed. A break-before-make or a make-before-break transfer can be obtained by using two sets of function bar mechanisms and two pairs of associated contacts. These contacts can be operated by a single character or by a sequence of characters. The contacts can either be operated and returned to normal during the character cycle or they can be locked in either the closed or the open position. When a pair of contacts is locked in the operated position, they can be unlocked and returned to their normal position by a single character or by a sequence of characters.

Miscellaneous Features

The stunt box can be used as a way-station selector by using an accessory set of parts to suppress printing.

Of the seven clutches used on the Model 28 teleprinter, one is used to drive the keyboard and the other six are used to perform various functions on the typing unit. One of these six drives the selector clutch; one furnishes power to operate the code bar positioning mechanism; one operates the function mechanism; one drives the spacing mechanism; one furnishes power to position the type box; and one provides power for the line feed function.

Because of the type of clutch used, an overload release mechanism is employed on the driving gear. This release is mechanical and is adjusted to disengage at a predetermined load in the event that the teleprinter mechanism should become jammed for any reason.

Felt oilers are used liberally throughout the teleprinter to lubricate the moving parts and to dampen the oscillations of extension springs. These oilers and the type of clutch used permit the teleprinter to operate for long periods without lubrication. The Teletype Corporation recommends that when the unit is operated at 100 words per minute the teleprinter should be lubricated after every 1500 hours of operation or every six months, whichever occurs first. Laboratory tests conducted by Western Union indicate that this recommended lubrication interval is not overly optimistic.

In addition to the keyboard and typing unit, a complete Model 28 teleprinter includes a console and an electrical service unit. The console includes the copy holder, a fluorescent copy light, and space for mounting auxiliary equipment. When the teleprinter is operating in its console the operating noise is very low, even when the teleprinter is geared for 100 words per minute. The electrical service unit, which is mounted in the console directly behind the teleprinter, is equipped with a line shunt relay which shunts the line when the motor is turned off. Thus, the motor may be turned off and the typing unit removed from the console without opening the line. The service unit also provides a convenient means of adding standard electrical accessories such as a line relay, a motor control relay and a rectifier for supplying line current.

Conclusion

Both the Kleinschmidt and the Model 28 teleprinters which have been described are compact, light-weight units designed primarily for high-speed operation. The Kleinschmidt teleprinter is a rugged but simple machine, easy to maintain and easy to learn to maintain. The Teletype Model 28 is probably the most versatile teleprinter ever designed, but this versatility has been achieved at some sacrifice in simplicity. Because of its relative complexity, it is a comparatively difficult machine to learn, but once the principles of operation have been mastered, it is very easy to maintain, and long trouble-free periods of operation can be obtained.

References

1. Teletypewriter Redesigned for Speed, Quiet Operation, *Machine Design*, November 1953.
2. A New Teletypewriter, W. J. ZENNER, *Bell Laboratories Record*, June 1953.
3. A Step Forward in Printing Telegraphy, A. S. BENJAMIN and W. J. ZENNER, *Communications and Electronics*, March 1954; *Wire and Radio Communications*, September 1954.

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Power Failure Protection

I. T. BARTLETT, Jr.

CLOSELY associated with continuous improvement in speed and reliability of Western Union's telegraph and cable service, is a necessity to seek improvements in the reliability of primary power and power distribution systems. Increasing emphasis has been placed on the provision of alternate power distribution feeders for telegraph equipment so that feeder failure due to circuit faults will not cause prolonged outages of power. Through this alternate feeder arrangement, power interruptions within building distribution systems are kept at a minimum merely by quickly transferring from one feeder to another by means of transfer switches located in the proximity of the loads served. Insofar as practicable, the feeders are located at some distance from one another so that failure due, for example, to a fire in a power riser shaft, will not endanger the alternate route.

Although the commercial power companies have an enviable record of good service, it is still necessary to provide emergency or stand-by electric plants to maintain the continuity of power in the event of a service failure due to floods, hurricanes or other such disaster conditions. The ultimate possibility of bombing attacks must also be taken into consideration. There have always been emergency plants at the more important telegraph offices to protect the power service, and some engine installations of 20 or 25 years ago, while not of as advanced design as those of today, are still affording excellent protection.

Before the extensive improvement of the high-speed diesel engine shortly before and during World War II, permanently installed emergency power units were usually driven by gasoline engines. Today, however, the reduced hazard of diesel fuel storage compared to gasoline storage; the ability of the modern diesel engine to start and come up to operating speed within as little as five seconds, and to respond quickly to applications or changes of load; their heavy construction and improved ease of maintenance, make them more desirable except for telegraph offices located in lightly populated areas. Furthermore, the increased production of diesels for transportation and industrial applications has reduced their cost to the point where it is economically feasible to use them in place of gasoline engines, except for the smaller emergency power units of less than 15 to 20 kilowatts capacity, in which sizes the diesel is still more expensive than the gasoline engine unit.

In all major reperforator offices as well as in other important telegraph centers throughout the country, a program has been carried out to augment the modern power distribution systems by the installation of diesel-driven emergency power units to serve essential building power loads and partial lighting, as well as telegraph equipment loads, in the event of failure of the commercial power service. At the smaller tributary offices, where telegraph circuits are concentrated from surrounding areas, a possible prolonged power failure is protected against by the use of portable trailer-mounted emergency plants which are strategically located throughout the country.[1] When required, these units can be towed by a passenger car or truck to the office where the power interruption has occurred and connected to the building distribution system in a short time.

Manual Power Unit Control

Emergency power units may be manually controlled where trained personnel is available as in the reperforator center at Cincinnati (see Figure 1), or automatically controlled as in the case of the plant recently installed at the Richmond reperforator office. At most reperforator centers it has been found desirable to install two a-c units of a size available in quantity

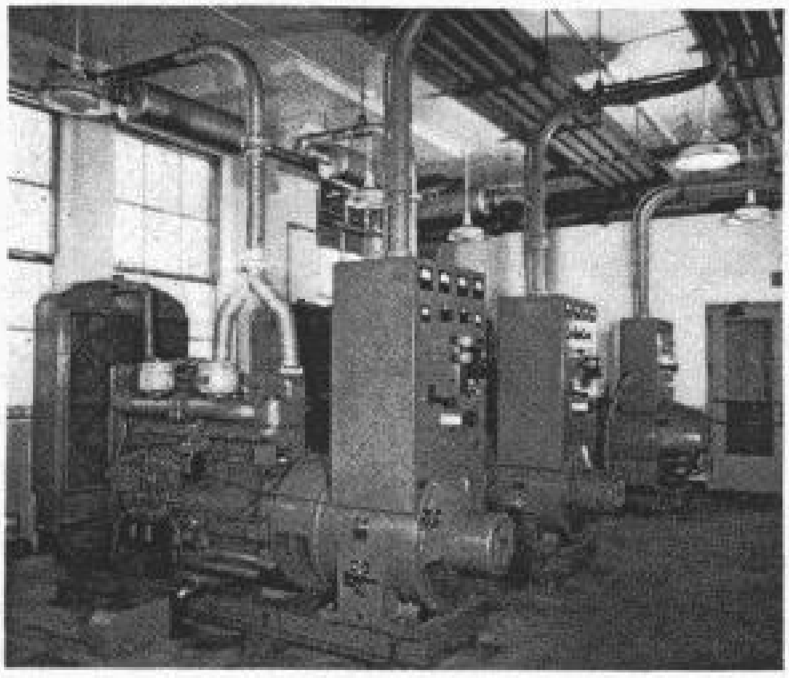


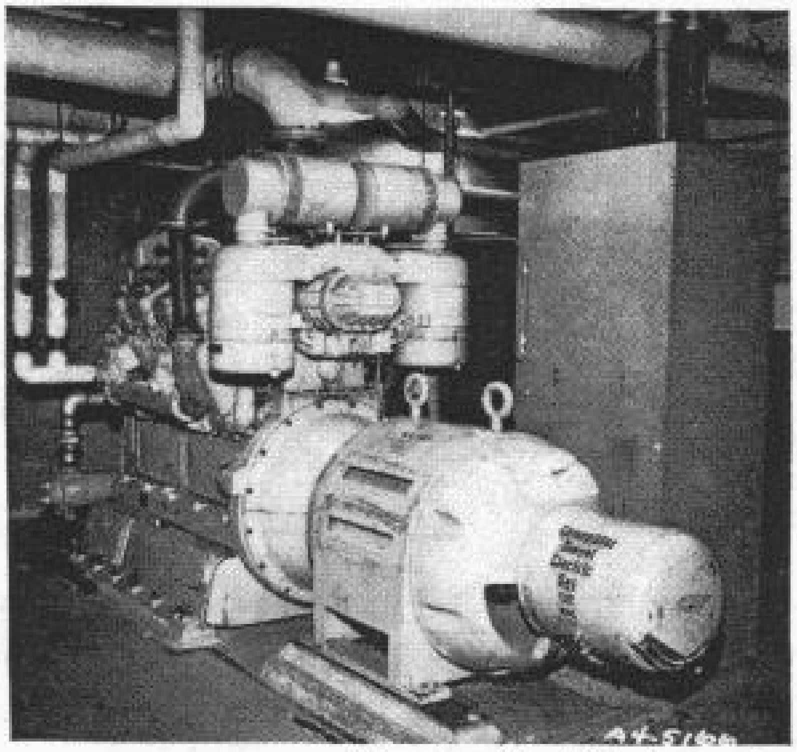
Figure 1. Emergency power plant installation, Western Union central office, Cincinnati, Ohio

production, rather than a single large unit of equivalent total capacity. In addition, d-c emergency units have been installed at some of the larger offices to provide d-c power requirements directly in an emergency without running the motor-generator sets, and also to serve as additional protection against possible failure of one of the motor-generators. Personnel properly trained to start and operate the emergency engines and transfer the power loads to the generators in a reasonably short time must of course be available. Since this may be difficult to arrange for, more and more emphasis is being placed on automatic control in order to protect the service most effectively.

The recently completed emergency power plant at the main office in Chicago is the largest stand-by diesel installation in the Western Union system. The plant consists of a 150-kw d-c and a 208-kw a-c unit, as shown in Figure 2, with provision for a second 208-kw unit should the increase in power usage necessitate this addition in the future.

The new d-c unit, which covers a floor area of only 110 square feet, was installed as a replacement for two 75-kw semi-diesel type units, originally installed in 1918, which required 550 square feet. Through improved design, the use of higher strength materials, higher rotational speeds, improved electrical installation and new generator cooling methods, the space requirement has been reduced to one-fifth that required 35 years ago.

Fuel for the emergency plant is stored in a 1000-gallon tank beneath the floor, representing a four days' supply. Fuel is pumped from this main storage tank to a "day tank" of 50 gallons capacity from which pumps on the engines take their suction. Cooling is accomplished by the use of heat exchangers mounted adjacent to the engines. The supply of cooling water may be obtained either from the city water supply or, during emergencies of short duration, from the large building water tanks.



(Courtesy Caterpillar Tractor Co.)

Figure 2. Chicago, Ill.—208-kw diesel generator set

Cranking of these comparatively large engines (250 and 300 hp) is by means of air motors instead of the usual electric motors, thus eliminating the possibility of failure to start due to a low or dead battery when emergency conditions prevail. Two large air receivers are automatically kept at full pressure by means of air-pressure controls for two separate air-compressor units, and either of the two engines can be started from either of the two tanks. In order to make the starting system as nearly foolproof as possible, two additional features have been provided. A third tank, also kept at full pressure and normally isolated from the others to insure that this last reserve is not lost, has been installed and may be used to supply air to the cranking motor on either engine.

The other feature consists of a small gasoline engine that may be employed, in case all air reserves are used, to pump up the third tank within 20 or 30 minutes, after which further efforts to start the diesels can be made.

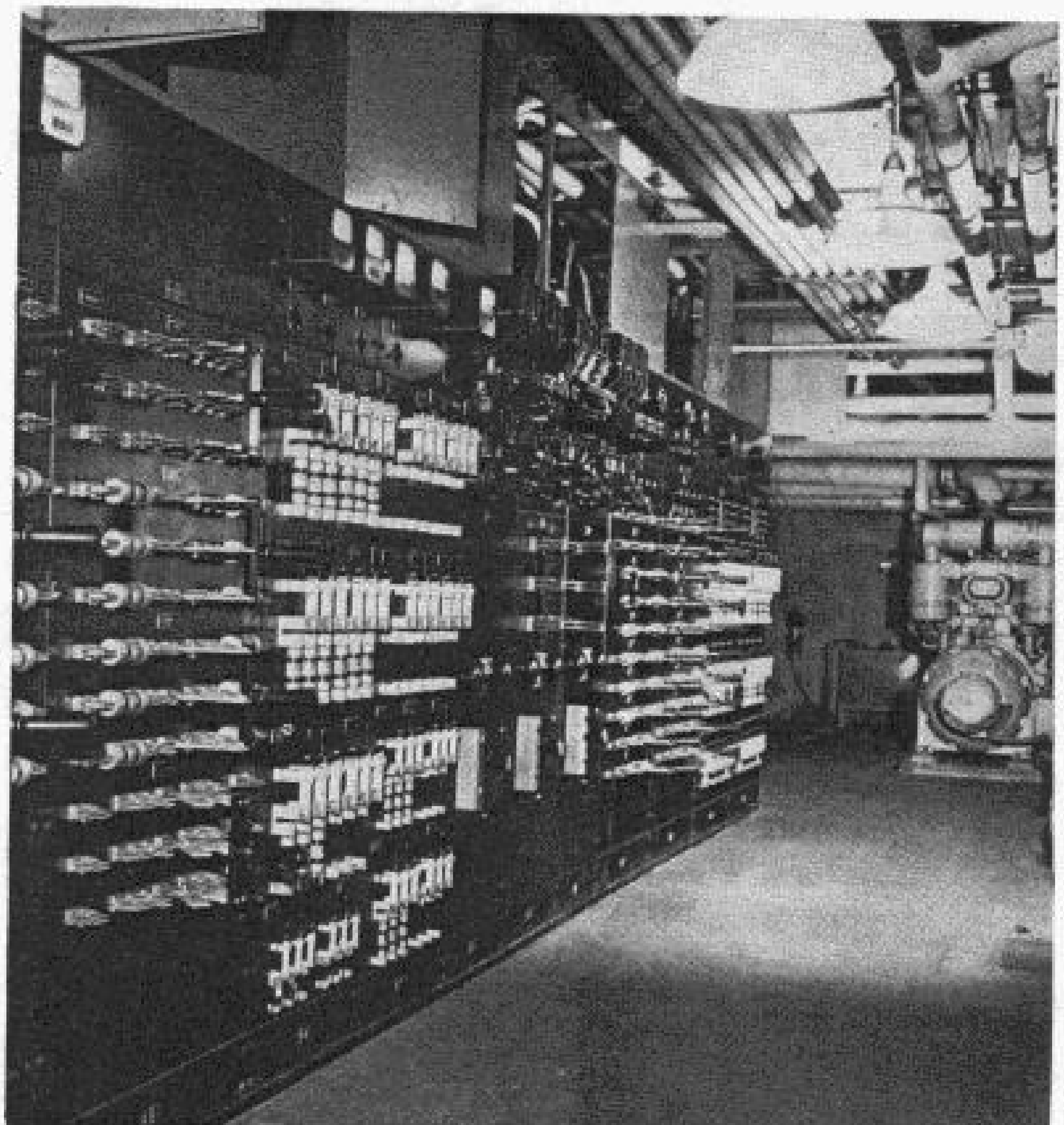
Each of the generator units is provided with a control station mounted adjacent to the generator. From this location, the operator has full sight of the main power distribution switchboards so that he may anticipate required adjustments to the engine speed and voltage by observing load transfers at the switchboard. The operator at the switchboard likewise has full view of the engines (see Figure 3) so that load transfers will not be made before the emergency unit operator has had time to start the unit and bring it up to proper speed for operation under load. After the load transfer has been completed, an operator need only occasionally check the power units for proper operation. Generator speed and voltage are kept within close limits, by automatic controls.

Automatic Power Unit Control

Automatically controlled stand-by power units can be installed at moderate sized offices to great advantage. First, these offices do not have large concentrations of through circuits handled by reperforator equipment; carrier circuits can usually be kept in operation through the automatic engine starting and load transfer operations, and manual equipment will not usually be adversely affected. Secondly, maintenance personnel with an understanding of the starting of the engine and operation of electrical transfer controls is not generally available, and the operating force responsible for operation of the unit have many other duties which necessarily keep them well occupied during a failure of the power supply.

In order to provide completely automatic protection, several requirements must be met: the fuel should be supplied to the engine in such a way that a positive pressure is maintained on the engine fuel transfer pump in order to assure quick starting; the engine cooling system must be self-operative, that is, radiator air exhaust or heat exchanger water supply must be automatically controlled, and provisions must be made for electrical transfer and engine control.

An example of the fully automatic power unit may be seen in Figure 4, which shows the installation in the new modern Western Union office at Birmingham, Alabama. A small fuel tank is installed adjacent to the unit, above the engine fuel transfer pump, equipped with a liquid level controlled automatic pump. This pump assures a minimum of one gallon fuel supply in the tank at all times and



(Courtesy Caterpillar Tractor Co.)

Figure 3. Partial view of telegraph a-c and d-c distribution switchboards—Chicago, Ill. (a-c emergency unit in background)

thus maintains the required positive pressure fuel supply. The engine is cooled with a radiator, and in order to exhaust air from the room a pusher type fan blows air through the radiator and via an exhaust duct to an automatic operating louver, which opens to the outside of the building. Another automatic louver is provided to supply fresh air to the engine room when the unit is running.

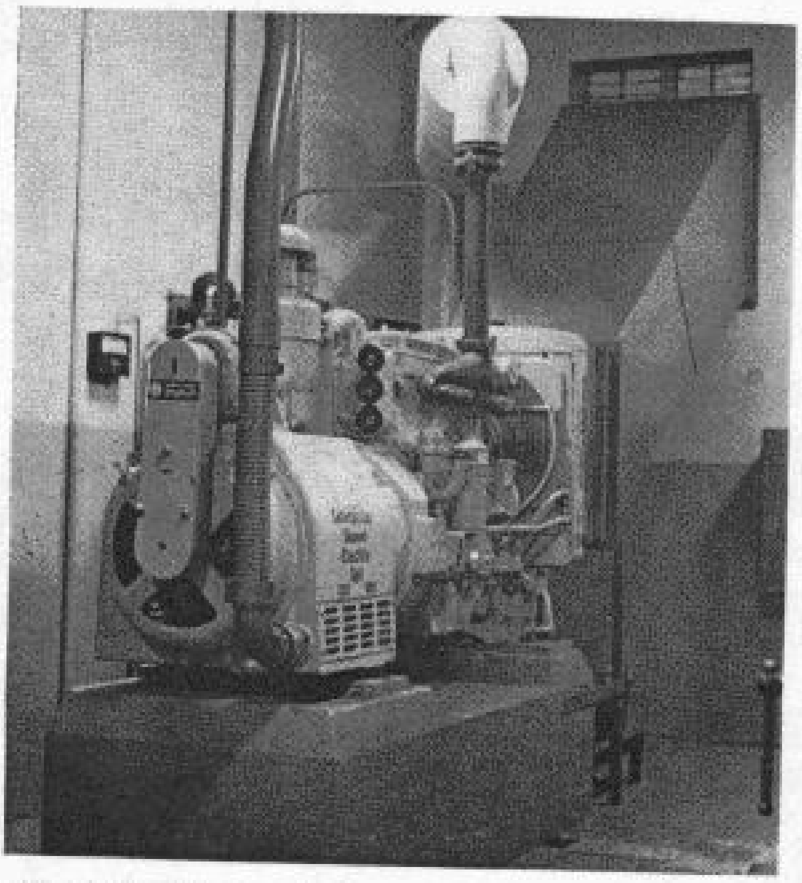


Figure 4. Western Union central office, Birmingham, Ala.—40-kw automatic emergency power unit

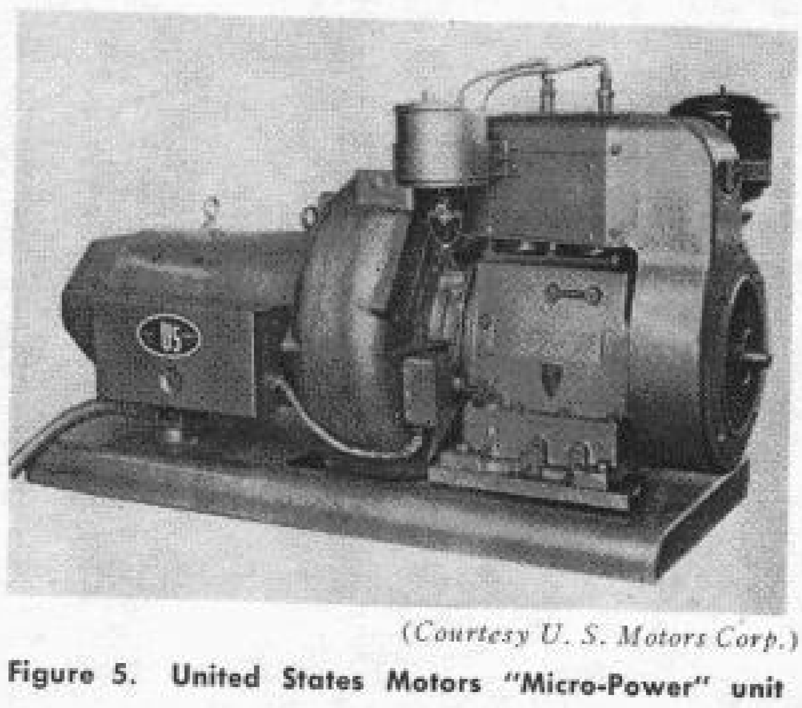
Completely automatic controls are installed in conjunction with the unit, which function to start the engine should the regular power source drop to 70 percent of normal voltage, and shut down the engine if the oil pressure drops or water temperature rises above a safe operating level. Automatic line transfer controls switch the telegraph and lighting loads from the regular commercial service to the emergency unit when the generator voltage reaches normal. Return of the load to the normal power, however, is manually controlled, so that the transfer will not be made before the commercial voltage becomes stable.

The complete operation of the load transfer to the engine is achieved in a maximum of approximately 10 seconds but is usually accomplished in less time. The length of time depends largely on how warm the engine is and, therefore, how quickly it will start. In colder climates where the engine is not installed in a heated building space, such aids as thermostatically controlled coolant heaters and lubricating oil heaters would be required to assure quick starting of the diesel engine.

Other examples of automatic engine generator installations are those at microwave relay towers, where a supplementary battery-operated vibrator reserve is provided to furnish power during the engine starting interval so no interruption in the voltage supply will occur. This type of installation is limited in size because of the capacity of vibrator units commercially available.

Microwave stations may be protected during periods of engine overhaul by a trailer-mounted portable power unit similar to that previously described in the TECHNICAL REVIEW.[1] These units, which were specially designed for the purpose, may be rolled up to a relay tower and connected to the automatic starting controls with flexible cable, thereby permitting necessary routine repairs or even complete disassembly of the unit regularly installed at the station without sacrificing the fully automatic, unattended operation control features normally available.

Trailer-mounted power units are used throughout the country to protect smaller offices where no stand-by power unit is regularly installed. The portable units have been so successful that additional



(Courtesy U. S. Motors Corp.)

Figure 5. United States Motors "Micro-Power" unit

units are being purchased to cover more thoroughly areas where adverse travel conditions prevail and long distances must be covered from the regular storage points, resulting in expensive outage time.

A leading producer of engine-generators has recently developed a new type of stand-by power unit shown in Figure 5. This three-unit motor-alternator-engine set, which supplies uninterrupted a-c power, was originally designed to meet the communications industry's need for such a unit to be used as a microwave power supply. Due to the nature of operation of this type of equipment, and the fact that microwave towers are usually remotely located and unattended, a power system was necessary that would automatically transfer to engine drive without a loss of voltage or frequency. Ingenious use of a flywheel to maintain alternator speed during engine starting, and a magnetic clutch to couple the engine to the alternator, permits the engine to be cranked and started by the flywheel inertia so quickly in the event of failure of the commercial power that only a very minor dip in frequency and voltage output of the alternator occurs during the starting period. Thereafter the engine almost immediately restores normal frequency and voltage and maintains the drive until the commercial power is restored. The regular a-c motor drive then takes over, the magnetic clutch is disengaged and the gasoline engine shuts down. Necessity for heavy investment in a storage battery reserve, with associated maintenance and replacement costs, is eliminated.

One of these units is to be installed for field trial at the Woodbridge relay tower of the Telegraph Company and if results of this trial are satisfactory, similar installations are planned for ocean cable stations where a continuous supply of alternating current is required for the submerged repeater power supplies.[3]

As the use of electrical energy continues to increase, the need for stand-by electric plants continues to grow. Engine-generator unit manufacturers are making new advances in the types and sizes of stand-by units as well as control equipment to meet this growing need, and as better units become available Western Union will be able to adopt them for continued improvement of the speed and reliability of telegraph service.

References

1. Mobile Emergency Power, I. T. BARTLETT, Jr., and H. M. WARD, *Western Union Technical Review*, Vol. 7, No. 1, January 1953.
2. Power Supplies for Microwave Relay Systems, H. M. WARD, *Western Union Technical Review*, Vol. 3, No. 4, October 1949.
3. A Stabilized Power Supply for Use with Submerged Ocean Cable Repeaters, A. ATHERTON, *Western Union Technical Review*, Vol. 7, No. 2, April 1953.

I. T. Bartlett, Jr., was graduated from the University of Rochester in 1945 with a B.S. in Mechanical Engineering. After serving in the U. S. Navy, he joined the Central Office Engineer's division of Western Union in 1946. As a power engineer on the staff of the Director of Installation, he was engaged in the design of power and emergency engine plant installations for new reperforator offices, and was responsible for a major portion of the Minneapolis power and the Chicago emergency diesel power installations. Mr. Bartlett, whose paramount interest has been with internal combustion engines and their application, rather than communications, is now employed by the United States Motors Corporation.