SOME RECENT DEVELOPMENTS IN RAILWAY TELEPHONY

BY GREGORY BROWN

A paper presented at the Pacific Coast meeting of the American Institute of Electrical Engineers, Los Angeles, April 26, 1911.

The standard means of communication on railroads for despatching and blocking trains and transmitting messages for the past 60 years has been the telegraph. Although the telephone obviously possessed some advantages over the telegraph for railroad work, the fact that the railroads had been using the telegraph for such a long period and with such reliable results, made them loath to adopt a new and to them untried arrangement. About four years ago, however, a combination of circumstances arose which strongly focused the minds of railway officials upon the feasibility of the telephone to replace the telegraph for railroad work. The most important circumstance causing this result was the enactment of a federal law limiting the working hours of an operator transmitting or receiving orders affecting train movements, to nine hours. In addition to this, there had been a growing difficulty among the railroad companies in securing a sufficient number of competent operators to take care of the natural increase in business. It was also felt that the efficiency of the railroad telegraph operators had been steadily decreasing for some time, this state of affairs probably being brought about by the attitude of the Telegraphers' Organization toward student operators.

It was estimated that it would be necessary to employ about 15,000 more operators on the railroads throughout the country when the federal nine-hour law went into effect and this large increased expense, together with the difficulty of obtaining good operators, caused the railway officials carefully to investigate the possibilities of the telephone in place of the telegraph, for handling train movements and message work.

Up to this time the use of the telephone by the railroad companies had been somewhat limited. It had, however, been in use for a number of years for the transaction at terminals and division points of miscellaneous business between departments and throughout the yards, and also in some cases for the handling of trains in the immediate vicinity of the terminal. In addition to the above, many of the roads have been using the composite telephone in some of their divisions, to assist in the handling of trains and for general railroad business. There have also been two or three instances where the telephone has been in use for a number of years for despatching of trains. As early as 1883 this means of handling traffic was used on the New Orleans and Northeastern Railroad, ordinary magneto telephones being used, together with code ringing. The telephone circuit was about 100 miles in length and consisted of one iron wire, and orders were issued for the handling of four regular trains a day, together with numerous work trains.

The Lake Erie, Alliance & Wheeling Railroad has been operating a line of single track road for a distance of about 100 miles by telephone exclusively for a number of years, with equipment not to be compared with that now available for this service.

The first telephone train wire using improved equipment was installed in October, 1907 by the New York Central between Albany and Fonda, New York, a distance of 40 miles. Shortly after this the Burlington installed a circuit on a double track section and later several circuits on single track divisions. The success attained with these installations conclusively proved that the telephone could be used to advantage for railroad work, and since that time the railroads have been rapidly equipping their divisions with the telephone.

The object of this paper is to outline the requirements to be met in railroad telephone service and to describe briefly the circuits and apparatus developed to meet these requirements.

During the long use of the telegraph by the railroads they have built up an efficient organization for handling trains by this method, and have thoroughly standardized in the method of doing this business. In order to determine the requirements to be met by the telephone, if it is to take the place of the telegraph throughout a railroad division, it will be necessary to examine the methods used and the results obtained by the use of the telegraph.

There are three main classes of service on every division which are performed by the telegraph.

1. Train despatching.
2. Message service.

3. Block wire service.

The train despatching circuit, or train wire, as it is generally termed, extends along one division and is used exclusively by the despatcher located at the division point for issuing orders regarding train movements to, and receiving train reports from operators along the line. The average length of division is about 130 miles (209 km.), which is divided into a number of sections or blocks, averaging about 20 to 25, there being located at the beginning of each block an operator controlling that block. The length of division and number of operators, however, vary greatly, some divisions being over 250 miles (402 km.) long and having between 50 and 60 operators on the line.

The despatcher has supreme control of each division, in so far as train movements are concerned, and he handles the business somewhat as follows: Each division has its printed schedule of trains, which contains the time of passing all stations and towers, also time and place of meeting for all regular trains, both passenger and freight. In addition to the regularly scheduled trains, there are more or less extra trains to take care of the varying volume of business, and also there are delays which invariably occur, particularly in freight service, due to condition of motive power, time of loading cars, weather, etc.

The above conditions constantly disarrange the schedule and as it is the despatcher's duty to keep traffic moving with the minimum delay, giving preference to the proper classes of trains, such as mail, passenger and perishable freight, it will be readily understood that he is at all times confronted with a complicated problem, the proper handling of which requires great judgment and foresight.

Each of the operators at the block stations has complete control, under the direction of the despatcher, of his block section. It is his duty to report to the despatcher the time of arrival and departure of trains, and also to transmit a large amount of miscellaneous information concerning the cause of train delays, nature and extent of accidents, hot boxes, broken gears, length of time required to repair, track condition and various other items which are factors that the despatcher must take into consideration in planning his train movements.

The bulk of the despatcher's outgoing business consists in giving train orders to one or more of the operators who, in turn, transmit the orders to the proper train crews. A large proportion of the orders are transmitted simultaneously to several operators. The despatcher calls the operators interested and when they are all prepared, he transmits the message, and they each in turn repeat it back, in order that the despatcher may know that his order is properly understood. In addition to the transmission of an order to a group of operators, it will be remembered that the sounders in all the other offices are repeating the same order. This permits every operator on the line, if he so desires, to hear the orders being given and to keep in touch with traffic conditions.

It will easily be seen that it is of the utmost importance that no interruption occur in train wire service, as the despatcher's inability to communicate with the operators would practically result in tying up the traffic of the division. In order to provide for interruptions in service which might occur, due to line troubles, it is customary to loop all the telegraph wires on the line through telegraph peg switchboards located in most of the towers. By this arrangement it is possible, should any portion of the train wire get in trouble, for the operators in the affected district to cut out the defective section of wire and connect in its place a portion of any other telegraph line on the division. This, of course, would interrupt the service on the line which was used for patching, but the importance of maintaining the train wire is so great that any other available wire is used for patching until the defective portion of the train wire can be repaired.

The above describes in a general way the manner in which the telegraph is used in train despatching. We can now specify the requirements which are being met by the telegraph for this service and which the telephone must meet in order to successfully compete. These requirements are:

1. Ability to signal any one of 50 or more stations on a 250 mile (402-km.) line and ability to signal despatcher from any of the stations.

2. Arrangements whereby any number of stations can simultaneously listen in.

3. Means for quickly testing and patching any portion of the circuit which gets into trouble.

In addition to the above requirements, the telephone owing to its greater flexibility can be arranged to permit of other operating advantages not possible with the use of the telegraph. Among these are the following:

a. Provision whereby officials who are not telegraph operators, but who are directly interested in the movement of traffic, as for instance, train masters, yard masters, division superintendents, etc., can listen on the wire and keep in touch with traffic conditions.

b. Arrangements permitting the signaling of stations without interrupting conversation. This feature results in saving a considerable amount of time.

c. Automatic notification to the dispatcher that the station he is calling is receiving the signal.

SIGNALING

The first requirement is the ability to signal any one of 50 or more stations on a 250 mile (402-km.) line.

The problem involved here is selective signaling on a long and very heavily loaded line, and is an extreme condition which has not been met with in commercial practice. When consideration is also given to the degree of reliability required for this service, it will be seen that the development of special apparatus was necessary. The instrument used for this purpose is called a selector and is installed at the substation and so designed that the despatcher at will can cause any selector to operate and close a contact, thereby signaling that station by ringing a bell or causing a signal to be displayed. There are three general types of selectors which have been developed for this purpose, operating on three different principles:

1. Instruments responding only to a certain number and sequence of long and short current impulses or long and short intervals between impulses. In this case the only instrument on the line that would function properly and close its contact would be the one which was adjusted to respond to the particular code arrangement

of impulses which were being impressed on the line.

2. Instruments arranged to be started simultaneously by the despatcher and to operate independently but in synchronism with each other by means of local energy at the station. The despatcher's sending device being so arranged that at a predetermined instant one impulse is sent out on the line which at this instant is provided with a path through one selector contact only, the other selectors either having passed their contacts or not having reached them.

3. Instruments of the so-called step-by-step type which are stepped around in synchronism by a succession of impulses from the despatcher's office, the number of impulses sent determining the station called.

What is known as the Gill selector is an instrument of the first or code impulse type. This device has been used for a number of years to selectively signal telegraph offices, and for this service it is connected in series with the back contact of the telegraph relay and battery. When the proper code is sent over the line, the selector will function and ring the bell, but by using ordinary Morse characters it is practically impossible to reproduce the code and falsely call. As this selector had been pretty well tried out for telegraph service, it was but natural that it should be one of the first used with the telephone. Fig. 1 shows a view of this instrument with the glass cover removed. It consists essentially of a ratchet wheel, an electromagnet whose armature is arranged to step the wheel forward, a retaining pawl to retain the teeth stepped and a mechanical time element whose function it is to permit the retaining pawl to assume either one of two positions, according to the length of the impulse of current.

The time element is seen at the right of the instrument and consists of a metal wheel fastened to a small diameter shaft so arranged that it can roll down an inclined rod.

The fact that it is the small diameter shaft of the comparatively large wheel, that rolls down the incline causes the descent to take an appreciable time. When the stepping arm is in its upper position it prevents the wheel from descending, but when it moves to the lower position due to current, the wheel starts to roll and will reach its lower limiting position provided the current impulse is of long enough duration. If, however, the impulse is short, the stepping arm will return to its upper position due to the retractile spring, and prevent the wheel from descending its full distance. It will thus be seen that a long impulse permits the time element to function while a short impulse does not.

Fig. 2 shows a diagrammatic view of the ratchet wheel and retaining pawl. The time element wheel, through a system of levers, is so arranged that it permits the retaining pawl to fall in the ratchet teeth to one half their depth if it is in its upper position and to the full depth if it is in its lower position.

The teeth of the ratchet wheels on the selectors are all cut differently, some are perfect ratchet teeth, some have a diagonal slot sawed in their lower half, while others have the top half of the tooth diagonally cut away. Fastened to the pawl is a semi-circular piece which falls behind the teeth and holds the wheel from returning to normal when the stepping pawl is in its up position, preparatory to making another step. If, however, the lower or upper half of a tooth, against which the piece rests, is diagonally cut away, it will push the pawl to one side and the wheel will return to normal position under the influence of its retractile spring.

In order that the retaining pawl hold each tooth stepped of a given selector, its position with relation to the face of the teeth must be such that at no time does it rest against a portion of a tooth face that has been diagonally cut away. This condition is brought about only in the case of a selector which is being operated by its proper sequence of long and short impulses, and this is the only selector that will close its contact and signal its station.

Fig. 3 shows a despatcher's sending key cabinet with the cover removed. There is a key for each selector and each key consists of a train of gears, whose speed of rotation is controlled by an escapement, and when operated a specially cut code wheel makes one revolution sending out on the line a certain code of impulses.

Fig. 4 shows a schematic diagram of the first type of way-station circuit that was used with this selector. The closure of the contact of the line relay puts local battery current through the selector and steps it around. When the selector contact is made, local current flows through the right-hand spool of the polarized relay closing its contacts and ringing the vibrating bell.

The lower relay contact closes the battery through the bell while the upper contact places a shunt on one side of the line around the line relay and through a one-tenth microfarad condenser and vibrating bell contact. This shunt through the vibrating contact introduces a tone on the line and is heard in the despatcher's receiver, thus notifying him that the station bell is being rung.

In the first installations of this type of apparatus the line circuit arrangement was as shown in Fig. 5. It was thought advisable to use a line relay at every station and operate the selectors and bells by local battery. In order that the sending impulses might not introduce enough noise in the receiver bridges to interfere with conversation while the despatcher was signaling and also to permit each line relay to receive the same amount of current, a grounded simplexing arrangement was used for signaling, the relays being placed in series with the line. Relays at alternate stations were connected in opposite sides of the line, so as to maintain balance as nearly as possible. With ordinary relays placed in series, the transmission loss would, of course, be very considerable. The relays used therefore on the first installations were of a sensitive type having an inductive winding of 20 ohms and a non-inductive shunt of 30 ohms. This was, in fact, a type of telephone supervisory relay, and from a transmission standpoint was the most efficient relay available. Although the transmission loss in the relay was reduced to a minimum, it was still appreciable especially on a long line with many stations and several receivers off the hook. In addition to this, the shunt winding of the relay made a very inefficient arrangement for operation, as, of course, the signaling current going through the non-inductive shunt represented a clear waste. Another objection to this circuit that was found in practice was noise introduced from the grounds and unbalance, as it is almost impossible to balance the line with series relays. Also the effect of lightning on the series arrangement was found to be rather disastrous. The troubles experienced with this circuit finally led to the development of a new circuit, as shown in Fig. 6. In this arrangement there are no grounds on the line and no line relays used. The selectors are wound to 4,500 ohms resistance and placed directly across the line. In series with the selectors is placed the proper amount of tapering resistance, so that the amount of signaling current through each bridge will be the same.

The answer back is obtained by including, in series with the selector contact bell and battery, a secondary winding on the spools of the selector. As the bell vibrates it induces current in the selector windings which produces a tone in the despatcher's receiver. With this circuit arrangement the normal current for the operation of the selectors is ten milliamperes. The current, however, can fall considerably below this without affecting the operation of the selectors. The retardation coils and condensers at the despatcher's end of the line are used to cut down the peak of the current wave to such a point that the noise in the receivers while the signal is being sent is not enough to interfere with conversation. In this circuit it is necessary to introduce a condenser in series with the receivers across the line in order that the signaling current may not be shunted through the talking bridges.

The second type of selector which has been extensively used, that is, selectors maintained in synchronism by local energy at the substation, is what is known as the Wray-Cummings selector. Fig. 7 shows the despatcher's master sending outfit and Fig. 8 shows the substation selector. The master selector consists of a standard clock-work mechanism, to the second hand of which is attached a contact arm. In the path of this contact there are thirty insulated segments which are arranged so that any one of them can close battery current through a relay when the contact arm engages with this particular segment. The despatcher depresses any of the locking push buttons shown at the right of the figure and then operates the key mechanism shown on the door. This mechanism is merely a retardation device arranged so that when operated a contact is made for a length of time sufficient to operate the relays which start the master and all the station clocks. The substation selector is similar to the despatcher's clock mechanism except that each station is equipped with but one contact arranged to engage with the revolving arm. These contacts at the various stations are adjusted at different angular displacements from the normal position of the contact arm. When the despatcher has started all the clocks simultaneously, it is evident that the contact arm on the master selector will have reached, say its tenth point at the same instant that the tenth selector has reached its point. At this instant there are no other selectors which are on their contact point and due to the fact that the tenth point on the despatcher's clock is connected by means of a locked push button to cause current to flow on the line, the signaling mechanism at the desired station will be operated. Fig. 9 shows the circuit arrangement at the despatcher's office and at the way-station. When properly adjusted this selector has given satisfactory service. It, however, requires one minute to call the thirtieth station.

The third class, or step-by-step selector, is represented in Fig. 10 which shows the Western Electric selector. This device is probably the simplest and quickest so far used for this purpose and consists of two electromagnets connected in series and mounted in a brass frame. Each magnet is equipped with two spools, the cores of one of the magnets being covered with copper sleeves to produce slow action. Fig. 11 shows the schematic diagram of the lever movements. Upon the fast-acting lever is mounted a stepping pawl A designed to engage with a ratchet wheel to which is fastened a platinum pointed arm. Mounted on the framework is a retaining pawl B designed to retain the teeth as they are stepped. Attached to the slow-acting armature are two fingers designed to engage with the two pawls in such a way that when in the normal position of the slow acting armature, the two pawls will be held out of engagement with the wheel, while in the operated position the fingers will permit the pawls to engage with the wheel. This selector is operated by first placing on the line an impulse of current which operates both magnets. There is then placed on the line a succession of short impulses, which cause the stepping magnet to oscillate back and forth and step the wheel around the desired number of steps. The speed with which these impulses are placed upon the line, however, does not permit of the slow-acting magnet releasing. When the desired number of steps are taken, the contact is made and current is held on the line, thus ringing the bell.

As soon as current is removed from the line the slow-acting magnet releases, which raises the pawls and permits the wheel to fall back to normal position under the influence of its retractile spring. When a station is called, say for instance No. 10, all the selectors take ten steps and the selectors at the first nine stations will momentarily make their contacts as they step around; thus momentarily the local station battery circuit is closed at these stations. This, however, will not cause the bell to ring for the following reason: The selector operates at the rate of from 8 to 10 steps per second, and the arrangement of the contact spring C, Fig. 11, is such that it follows the movement of the stepping lever and during a stepping cycle makes contact with the contact arm in but a small percentage of the one-tenth of a second necessary to take a step. This action is of such momentary duration that there is no danger of a false signal being given. It will be noted that the contact arm of the wheel in its normal position rests against an insulated contact or stop piece. On the other side of this stop piece is fastened a platinum contact which will engage with the contact arm when the wheel has gone around to its limiting position. This stop piece is angularly adjustable and permits easy adjustment of any selector for any station. It is sometimes necessary, as will be explained later, to produce a simultaneous signal at all the stations and that is the function of the contact on the stop piece, it being only necessary to send out the proper number of impulses on the line which will cause all the selectors to engage with this contact.

Fig. 12 shows the local battery way-station circuit used with this selector. There are two 40-ohm retardation coils placed on either side of the selector as a protection against lightning. The selector is wound to 3,750 ohms and is connected with the proper taper resistance to produce equal current in all the bridges. When a station is called, contact A is made, which closes the local battery through the vibrating bell. The bell is also equipped with a front contact which makes and breaks a 10,000 ohm resistance across the line and gives the despatcher an answer back.

This selector is also arranged to ring a bell by means of the battery located at the despatcher's office, thus eliminating the local battery at the substation. Fig. 13 shows the apparatus so arranged. When using central battery to ring the bell it is necessary, of course, to have it high wound. In this case, its resistance if 1100 ohms and a taper resistance is used in series to produce the same current through the bell wherever it may be located on the line. It was found that if the taper resistance used for the selector was also used for the bell, the drop in voltage due to the combined current passing through the resistance was great enough to reduce the current to an objectionable extent. Separate taper resistances are, therefore, used on the bell circuit. Fig. 14 shows the despatcher's sending key, one being used for each station. These keys are mounted by means of a latch in a suitable cabinet and can be individually and quickly removed without disturbing electrical connections. They consist of a train of gears whose speed is controlled by an improved silent governor. The contact wheels are the same in all keys of a given type but are adjusted for each station by moving the segments so as to uncover the proper number of teeth for the station desired.

This feature makes the keys universal and as the selectors are easily adjustable to any station, they are also universal, and a spare selector and key kept on hand can be arranged quickly to replace any selector or key which may become defective.

Fig. 15 shows the despatcher's and line circuit. The contacts of the sending keys are all arranged in parallel so that the operation of any one will cause the sending relay to operate and place main battery current on the line. Capacity and resistances are placed around the contacts to reduce the sparking. The noise of sending is reduced by leading the battery current through three retardation coils and placing six-microfarad condensers across the line. It was found that if on a despatching wire the line should from any cause break, leaving but few selectors on the line, the current through the selector bridges would rise to such a point, due to the fact that the total voltage was still used, that the selector stepping armature would stay in its forward position when stepping impulses were sent on the line instead of oscillating and stepping the wheel. This was a serious objection as, in case of an accident of this kind, the despatcher would be unable to call the stations between him and the break. It was found that this sticking occurred more or less in all types of selector operated by impulse from the despatcher's office. The fault was overcome to a certain extent with the Western Electric selector by designing the magnetic circuit of the selector so that under normal current it would be fairly near saturation, excessive current not increasing the pull of the armature very much. This remedied the objection somewhat, but upon further investigation, it was found that with excessive current going to the line, the six-microfarad condensers, used for quieting the circuit at the despatcher's office, becoming more highly charged under this extreme condition, tended to hold the selectors up during intervals between stepping, due to their discharge over the line and through the bridges. In order to counteract this effect, the sending relay was equipped with an extra contact A so constructed that the closure of the battery contact B caused the opening of A, and the instant that contact B broke, contact A made. In series with contact A across the line was placed a 250 ohm resistance. This arrangement provides a comparatively low resistance path for the discharge of the condensers and prevents their discharging to any great extent throughout the line and holding the selectors up.

In addition to the three types of selectors described, there are polarized types of selectors which I believe have been used to a small extent. This type of selector generally employs current of one polarity for stepping and of the opposite polarity for ringing. The objection which has been brought forth against polarized apparatus has been that it is necessary to maintain the line poled in one direction all the time, as a reversal of the line wires will cause all the selectors beyond this point to fail. The liability of reversing lines due to line repairs, patching, etc., seems to be great enough to raise a serious objection to polarized apparatus.

The foregoing description covers in general the means used by the despatcher for signaling the various stations. The tower operator, when he wants to communicate with the despatcher, listens in to learn whether the line is busy, and if it is not, he merely says "despatcher" in the transmitter. The despatcher wears a head receiver and central office type of chest transmitter and is on the line all the time.

The second requirement which must be met by the telephone as used on a train wire are means whereby any number of stations can simultaneously listen in.

As we will have to refer to transmission values it might be well at this point to explain the units used.

In giving a value to a certain quality and volume of transmission it is said to equal a certain number of miles of cable. This means that the number of miles stated is such that when standard instruments are used for this distance over No. 19 gauge telephone cable of 0.06 microfarads capacity per mile, the value of transmission will be the same. It is considered that the commercial limit of good transmission is 30 cable-miles. This value can be equated in terms of any other kind of circuit. One mile-cable loss is equivalent to the loss sustained in 16 miles (25.7 km.) of No. 9 B. & S. copper and as this is the standard size of wire used on despatching circuits, it will be seen that the line may be 480 miles (772 km.) long before the so-called commercial limit is reached. This is considerably longer than any of the circuits in use, there being but few over 250 miles (402 km.) in length. There is, therefore, a surplus of transmission available which can be taken advantage of in arranging circuits to permit several operators to listen in simultaneously. The loss occasioned by the selector bridges is almost negligible, the impedance to talking frequencies of the W. E. selector being about 90,000 ohms. This value is such, that the loss sustained when forty selectors are across the line is only one mile of cable.

The first form of substation talking circuit used on train wires was the standard local battery circuit, which is schematically shown in Fig. 16. It will be seen that during conversation, the condenser, receiver and secondary of the induction coil are in series. The resistance of the secondary of the coil used was 20 ohms, and of the receiver 70 ohms, a two-microfarad condenser being used in series. The total impedance of this bridge to talking current is approximately 600 ohms, about 300 ohms of which are active for receiving purposes. It is obvious that when a number of these sets are bridged across the line at once, the joint impedance of the parallel paths is very low and the transmission correspondingly difficult between widely separated stations.

The first step towards overcoming this difficulty was to raise the impedance of the talking bridge by the use of a different induction coil, wound with a low primary and a high impedance secondary. This bettered matters somewhat as the higher resistance bridges produced a more even distribution of the talking current from the despatcher's office, and would give better outgoing transmission from the substations. Although the despatcher's voice currents were undoubtedly better distributed among the bridges with this arrangement, still, due to the fact that the bulk of the impedance in the bridges was in the secondary of the coil, the receiver having a resistance of but 70 ohms, the transmission gain was very slight.

The next obvious step would be to maintain the high impedance in the talking bridge but put as much of this impedance as possible in the receiver. If this were done, however, the high impedance receiver in series with the secondary of the induction coil would reduce the outgoing transmission from the substation to an objectionable extent. It was then determined that the best results, both for receiving and transmitting, would be obtained by installing a switching arrangement at the substation so that when the switch was in one position the circuit was in the best possible condition for receiving and when in the other position was in the best possible condition for transmitting. The circuit developed is shown in Fig. 17, the circuit to the left representing the despatcher's station and to the right the way station.

It will be noted that a non-locking push button is located at the way station and in its normal position the bridge across the line consists merely of a 700 ohm receiver and a one-microfarad condenser. The impedance of this receiver is about 2500 ohms and as the total impedance of the bridge is all in the receiver it is all effective for receiving purposes.

When the operator wishes to talk he depresses the push button or in some cases a foot switch which closes his local transmitter battery circuit and also connects the secondary of his induction coil to the line. The voice currents generated in the secondary have a path directly across the line in series with the condenser and also a shunt path through the retardation coil and receiver in series. This retardation coil is of about 6,000 ohms impedance and is placed in series with the receiver in the manner shown, in order that the despatcher may break in if it is necessary for him to interrupt an operator while talking. The impedance values are such that the amount of side tone is just sufficient for the operator to distinguish the despatcher's voice if he interrupts and he will release his button in order to clearly understand what the despatcher is saying. The outgoing transmission of this circuit is, therefore, the best possible consistent with the fact that we must arrange to permit the despatcher to interrupt the operator's conversation when necessary.

The induction coil used in the way-station and also the transmitter are especially designed for railway work. The transmitter button is of medium resistance and while not taking excessive battery current still varies the current through a large range and gives good volume and articulation with three cells of battery.

When the receiver is off the hook, this circuit reduces the transmission by about one mile of cable, for stations beyond, that are receiving from the despatcher. 130 miles (209 km.) No. 9 copper being the average length of despatcher's line, the line transmission loss at 16 miles (25.7 km.) of wire to one mile (1.6 km.) of cable, will be eight miles (12.8 km.) of cable, leaving an equivalent in transmission of 22 miles of cable that can be used in the bridges before we reach 30-mile (48-km.) transmission for the last station. Thus it will be seen that on a line of this kind 22 operators can be listening in and good transmission can be maintained. It is practically never necessary that this number be on the line, 15 being a liberal estimate of the number of receivers that will be off the hook at one time. If, however, emergencies should arise making it necessary for 25 or 30 operators to listen in, transmission will be sufficiently good for the transaction of business, even though it is beyond the 30-mile limit.

The requirements of the despatcher's circuit are somewhat different from those at the towers. He must be on the line all the time and the transmission and receiving of his set must be as good as possible, without resorting to the use of a push button for talking and listening, as his time is too fully occupied to permit him to use this device.

The circuit is shown at the left of the figure. A 70-ohm receiver is used in series with the secondary of the same type of induction coil, as is used at the substations, and a one-microfarad condenser in series. The impedance of this bridge is about 650 ohms and it being the lowest on the line, the receiving will be good. This value also permits good transmitting. The switch shown in the figure is of the locking type and opens the battery circuit when the set is not in use. Another form of the substation circuit developed for the way-station is shown in Fig. 18. This arrangement is somewhat similar to the one previously described and contains a push button to operate when talking. Under normal conditions, that is, when the push button contacts are open, the path of incoming voice currents is through the adjustable retardation coil, 70-ohm receiver, secondary of the induction coil and condenser. The impedance of this retardation coil is adjustable by means of a sliding core and the various stations are adjusted with reference to their distance from the despatcher's office, the furthest station on the line having the least impedance. When the button is depressed for talking the transmitter battery is closed and a retardation coil is placed in shunt around the adjustable coil and receiver. This cuts down the impedance of the bridge for outgoing voice currents and still permits of enough side tone so that the despatcher can break in on the conversation. The impedance of the bridge under these conditions, however, is considerably higher than in the previous circuit described and for this reason it is advisable to use more local battery current, as many as eight cells being sometimes used for this purpose. This, of course, is somewhat objectionable in that it tends to decrease the life of the transmitter. The impedance of the receiving bridge with the core all in the adjustable retardation coil, is about 4,300 ohms, and all out is 1,200 ohms. A bridge of 4,300 ohms is equivalent to 0.6 mile-cable loss and 1200 ohms to 1.8 mile loss, or an average of 1.2 mile loss for each station on this circuit.

PATCHING

In order to facilitate testing and maintain service on the train wire in the case of line trouble, it is customary to loop the various lines on the pole into every station or every few stations, through patching boxes. A typical box is shown in Fig. 19 and its circuit arrangement in Fig. 20. The wires entering the tower are connected to the jacks at the left, the connection passing through the cutoff contact to the jack at the right and from thence back on the pole line. Two locking keys are provided, arranged so that the selector and telephone set are normally connected to the train wires but by operating the key they are connected to two pairs of cords. When a train wire gets into trouble, the operator can cut off the line beyond his station by inserting any plug in either one of the train wire jacks. This operates the cutoff contact and opens the line. When the trouble is located between any two towers, the operator at the tower nearer to the despatcher throws his key, placing a plug of one pair in the incoming train wire and the other plug of this pair into the wire which he is going to use for patching. He also places one plug of the other pair in the other side of the incoming wire, placing its mate in the other side of the outgoing wire. This will connect the incoming train wires to the outgoing pair of wires to be used for patching. The operator on the other side of the break, plugs in in such a way that the patching wire is again connected onto the train wire. The patching box is equipped with a grounding jack so that any line can be grounded for test.

The foregoing describes in a general way the manner in which the telephone has been adapted for use on train wires. The second class of service in which the telephone is replacing the telegraph is on message wires.

MESSAGE WIRES

A telegraph message wire extends throughout a division and is generally cut in to all the offices on the division. It is used for the transaction of miscellaneous railway business between division and intermediate points. It is also used in a great many cases for sending commercial telegraph messages, when the railroad and telegraph companies employ joint operators. In addition to the above uses, the message wire is usually used for sending time to the various towers. It is extremely important that the clocks at the offices along the line be correct, as even a comparatively slight difference in the indicated time between the despatchers' and substation offices may cause serious results to follow. In order that the accuracy of the various clocks may be regularly checked at a certain time each day, and on some roads twice a day, a certain number and arrangement of dots are sent out on the telegraph line in such a way that they indicate to the various operators the exact time, thus permitting the operators to properly set their clocks, if such action is necessary. From the above it will be seen that the requirements which the telephone must meet for this class of service are:

1. To selectively signal on a line whose characteristics are in general the same as a train wire, but that the selective signaling should be capable of being performed by any operator on the line. In other words, selective signaling arranged for intercommunicating work.

2. The ability to simultaneously signal all the operators so that time may be given.

The telephone has been in use for message work on a number of wires in which all the calling is done by one operator, thereby differing somewhat from telegraph operation. Circuits, however, have recently been developed for inter-communicating work which give satisfactory service. Probably the one having the widest margin of operation was developed in connection with the step-by-step selector and is shown in Fig. 21.

The condensers and retardation coils at the despatcher's end, for reducing the noise of sending, are arranged practically as in the standard train wire circuit. Each substation is equipped with a sending key, so connected that its operation will place impulses on the line from ground through the center of the resistance, over both sides of the line, through the point A, thence through the battery and sending relay to ground. The operation of this relay places current impulses metallically on the line and operates the selectors at the various stations, the selector used being the standard type used on train wires. Modifications of this circuit arrangement are in use for this purpose but the difficulty that has heretofore been encountered has been that with a grounded relay, the line leaks are liable to be sufficient to either operate the relay or hold it in its operated position. The glass insulators on a pole line along the right of way of a railway are constantly subjected to the smoke and soot from the locomotives. This almost invariably causes the insulators to become permanently coated with soot and when wet weather sets in, the leaks to ground on railroad lines probably average considerably higher than is found to be the case in commercial practice. The circuit shown was designed to neutralize as much as possible the effects of line leakage in so far as it affected operation. It will be noted that when any station is sending, current flows from ground of that station over the upper line wire as shown in the figure, to a normally closed contact of the relay, through this contact to the point A on the lower line wire, and then through battery and relay to ground. The contact arrangement is such that the making of the normally open contact breaks the normally closed. This cuts off the current from the upper line wire and doubles the resistance for grounded current, thereby, cutting the current through the relay in half. The relay being in its operated position, this current is sufficient to hold it. As the first effect of line leaks would be to hold the ground relay closed when it was operated, the arrangement shown largely overcomes this tendency. The taper resistances used in connection with the keys at the substation are arranged so as to give the grounded relay the same current from any substation. The curves shown in Fig. 22 show the margins of operation of this system for various lengths of line and operating voltages. For an average line of 130 miles (209 km.) and 160 volts, the line leaks can be as low as 125,000 ohms per mile, without interfering with operation. This is equivalent to about 960 ohms ground leak, which is a value that would seldom be met with in practice.

The manner of sending out time is as follows: Referring to Fig. 12, which is the local substation circuit of the Western Electric selector, it will be noted that when the selector closes the lower contact, the local battery current goes through the bell winding but in its path is not included the vibrating contact. This will cause the bell to become single stroke in action.

Referring to Fig. 11 which shows the selector, the platinum contact on the stop piece will be made simultaneously on all the selectors when a sufficient number of impulses have been placed on the line. When time is to be sent, the Wire Chief at the division point operates a special key which steps all the selectors around to their time contact point and holds current on the line. The circuit at the division point is so arranged that the contact of the telegraph relay receiving time makes and breaks the current on the message wire. The interval of no current on the line is so short that the slow acting member of the selector does not fall back, but the time contact is made and broken, which taps the bell, and reproduces the signals which were formerly heard on the sounder.

This is the method used to send time when local battery bells are used. If the same manner of tapping the bells were employed in circuits where way-station bells are rung by the despatcher's battery, the amount of current required to operate all the selectors and ring all the bells at once, would tend to cause such an excessive current flow that the amount of voltage drop on long lines would be such that satisfactory operation could not be obtained. Another arrangement, Fig. 23, was therefore developed for sending time on the central ringing systems. When time is to be sent on the line, the Wire Chief at the division point throws a switch which connects up the circuit as shown. The secondary of a repeating coil or transformer is connected across the line and the middle point of its primary connected to one side of the main battery, the other two ends of the primary winding being connected to the front and back contact of the telegraph relay, which operates in accordance with the time impulses being sent from the distant point.

Resistances are introduced in the leads from the relay contacts in order to limit the amount of current and condensers are used to reduce the sparking. It will be seen that as the relay operates, there will be generated in the secondary of the coil and sent out on the line an impulse or kick, alternating in character. There is placed in series with the selector at each of the substations an ordinary 1000-ohm polarized telephone bell. These bells are operated every time a secondary impulse is sent out. After time has been given and the Wire Chief has opened his switches, leaving the lines in normal condition, the first impulse sent out by the despatcher when he calls a station, may be of such polarity that it will cause some of the bells to tap. There will only be one tap heard, however, as the bells will remain in the position to which they have moved. This circuit arrangement obviates any danger of stepping the selectors up which might be the case where the contacts of the time repeating relay connected directly on the line. The fact that the polarized bells at the substations are unbiased and will not be affected by reversal of line wires, is another advantage of this system.

Up to the present time, most of the railroads are still giving time over the telegraph as there are but few instances of divisions where there are no longer telegraph instruments in the towers. There are, however, divisions on some roads in which the telephone has replaced the telegraph entirely, and on these divisions, time is being given over the telephone circuit.

In addition to the use of the telephone for train despatching and message work, it has also come into very extensive use for block wire service

BLOCK WIRES

The length of a block wire ranges from one-half mile (0.8 km.) to six or eight miles (9.6 or 12.8 km.) and the service required of the telephone for blocking purposes is merely to maintain communication between two block towers. There are no new features required of the telephone for this work A great many of the roads are using the existing telegraph wire between blocks for a grounded telephone circuit. This will, of course, introduce some noise in the telephone, but the line being short, this is not generally objected to. If a satisfactory loud-speaking receiver could be produced, it would undoubtedly be very generally used for blocking purposes. If this instrument were used, no signaling device would be necessary, as by simply throwing a key and talking into this transmitter, an operator can call the adjacent tower. This arrangement would also have the advantage of permitting the operator to be handling his levers or doing other work, and still receive the message. Loud speakers have recently been developed and are now being experimentally tried out on a division of one of the roads. The results so far obtained indicate that it will be advantageous to use these instruments for blocking service.

It is very often the case that besides the block wire, there are one or two short party lines reaching from the tower to siding telephones, residences of employees, etc. The hand generator and code signaling is in general use for signaling between blocks and on these party lines. In order to relieve the load of the operator somewhat, an interrupter has been developed, and is arranged so that code ringing can be performed by means of a push button. Fig. 24 shows a schematic diagram of this interrupter. A very efficient type of transformer is used in this instrument, and with six dry cells in the primary circuit, twenty 2,500-ohm bells can be rung on a 500-ohm line.

In addition to the service performed by the telephone on railroads, as has been described in this paper, it has facilitated railroad business in several other ways. Telephones are used very extensively at sidings. These telephones are generally connected with the despatcher's wire and train crews can immediately get in touch with the despatcher, and a great amount of time can be saved. There has been put on the market a semaphore type of signal in the base of which is mounted a telephone and selector equipment. In case the despatcher wants to stop a train and call the conductor to the telephone, he can do so by operating the selector which throws the signal.

Portable telephones have also come into pretty general use. On some roads, every train carries a portable telephone and a line pole. The line pole is jointed for convenience in carrying and can be quickly assembled for use. It is equipped with two metallic hooks at its upper end which the conductor can connect with the despatcher's wires on the pole line and thereby get into communication with him.

Although the telephone has been in use on railroad divisions for less than four years, it has proven to have a great many advantages over the telegraph which the railroads were quick to appreciate, and at the present time, there are about 37,000 miles (59,545 km.) of road equipped with the telephone, and there have been no instances so far in which accident of any kind can be traced to the use of the telephone for railroad work.

DISCUSSION ON "SOME RECENT DEVELOPMENTS IN RAILWAY TELEPHONY,"
LOS ANGELES, CAL., APRIL 27, 1911.

Kempster B. Miller: The matter of railway train dispatching, discussed by Mr. Brown in his paper, is one of great importance, not only to telephone men, but to railway people and the public at large. There is an impressive mileage of railroads, important railroads, that are now being operated by telephone rather than by the telegraph, and this fact is surprising to those who have not watched and been in close touch with the development of this branch of telephony.

An interesting thing in the discussion of the power transmission papers, day before yesterday, was that some companies had seen fit to build a separate pole line for the telephone circuit, distinct from the power transmission line. That is not because it is impossible to put telephone wires on transmission poles and get fairly good service, but in order to effect an extra precaution to insure telephone transmission at the time it is most needed. In many cases that is not done— I should say in the great majority of cases. Now, if the power transmission companies are, for added security, willing to build a separate pole line for telephone circuits when they already have a high grade line, the question naturally arises in my mind in regard to this telephone railway train dispatching, is it wise for the railroads to load up the talking circuit with the selective ringing apparatus? I see no reason for even suggesting the building of another pole line in the case of railway circuits; but it does seem to me that in many cases the building of a separate copper circuit, or iron if the conditions warrant iron, for operating the selective bells would be warranted. This separate circuit for the operation of the selective bells on the dispatching system, would prevent loading down, with ringing apparatus, a circuit already overloaded with a multiplicity of bridged talking circuits. I understand that some railroads are doing it but that many others have refused to spend the necessary amount of money. In view of the extreme importance, particularly from the standpoint of the safety of the public, I think this phase of the subject worth discussion.

L. B. Cramer: I have not much to say in regard to this paper, as the experience that I have had with the system is not of very long duration, because the line was not entirely completed when I left to come here; but I have a few questions to ask Mr. Brown.

One thing that I do not entirely agree with Mr. Brown in is his statement that the "arrangements permitting the signaling of stations without interrupting conversation results in a saving of a considerable amount of time."

So far as my observation has been concerned, that seems to be more of a salesman's talking point than a reality in operation. Perhaps you might be able to talk while the man is signaling, but once he is finished and the man at the other end has an opportunity to say, "What was that?" and then all of it has to be repeated. Perhaps I have not had enough experience or perhaps our line is not in proper tune to take care of this, but at present that seems to be one thing that does not work out as it is supposed to -- that is, the way the company represented the apparatus said it would work.

I have also noticed, in regard to the ringing of the bell at the station called, the sending keys are made of such a size, that if they were made a little larger they would not make a cabinet of extremely large dimensions and the amount of space that can be given to them would then be enough to produce a ring long enough to call the operator. I notice our dispatcher often calls a second and even a third time. In case of substations, where the bell is mounted on a booth, there being some noise in the machines, we have an auxiliary bell that makes plenty of noise and the substations are the stations from which we get the best responses.

In regard to the switches, which have one position for receiving and one for transmitting I have already thought of making some changes in the apparatus because in stations where we have a set that is mounted on a desk, about the second or third day after the telephone is in operation the agents get a ruler or a stick and plug the button. This, perhaps, could be made a subject of discipline and, taken care of in that way, and you could get the result which you are supposed to get by being able to hear better by leaving the button in normal position and only press the button in when you are talking. The agent and operator will do these things and when there is a train coming, or anyone whom they think will see it, they will take the plug out; but ordinarily, they will leave it plugged up so when they want to O. S. a train, they will not have to work the plug.

Another thing that I would like to as Mr. Brown is in regard to the retardation coils. We made some tests on another railway where their telephone circuit is carried on the same poles as the 33,000-volt transmission system. We made tests of two different companys' apparatus. In the type of apparatus which the author describes I notice they used three retardation coils. On that particular test the man had about 80 miles of telephone line and he was unable to produce results to any great extent, while another company's representative with apparatus similar to this one, but on which he used only one retardation coil, he was able to handle his calling without any trouble and the transmission seemed to be first class. Now, whether there was something in the atmospheric conditions at the time when these different tests were made, or whether it was just a case of some operator's interfering -- that is one thing that some of the telegraph operators will try to do. If they know you are trying out a telephone which will do away with their job as telegraph operator, they will resort to almost any means to put the telephone out of commission. We have no trouble in using the telephone in connection with the telegraph, where the telephone is used mostly for handling messages pertaining to freight shipments and dispatching power.

Ralph Bennett: This system was offered to me about two years ago, for use in connection with the transmission line telephone. We did not adopt it. There were a number of questions that came up that the manufacturers could not answer. We have on our telephone line a pressure of about 2,000 volts to the ground, and 600 micro-amperes unbalanced current flow. The line is noisy. When we had trouble on the line we would have additional voltages. The manufacturer could not state how we could repair his sets with the men we had. He could not state definitely his apparatus would satisfactorily select in the presence of those large currents under heavy pressure in this transmission line. I would ask Mr. Brown whether these things could not be handled as the securing of a telephone which will call and select stations for transmission line work is very important.

Ralph W. Pope: Mr. Chairman, there does not seem to be anyone here to take up the telegraph operators' view of the situation.

Now it has been my experience in my fifty years of knowledge of the Morse telegraph, that the people who do not understand it and work it don't appreciate what a beautiful and simple method it is of transmitting communications. It may be of a little bit of interest -- add a personal touch -- if I tell you that years ago, having some fifty pages of what would now be fifty pages of typewriting, to copy, and several manifold copies to be made, that Mr. Edison, my brother, one other operator and myself took turns in sending and then copying down from the sounder. We did that because it is an easier way to copy it from the sounder than by looking from one page to another. You simply write and the words go in your ear and go out of your pen or pencil onto the paper and that becomes so automatic that in the course of receiving a long press report, as we did during the Civil War, the operator was obliged to take a bunch of carbon paper and change the sheets at the bottom of each page so as to pick up the work when a new batch of sheets were ready, and this involved keeping behind about fifteen words, behind the sounder, and it took all of the next page to catch up with the sender. I am giving you this as an instance of what the telegraph system really is. Now, we take the way station of a railroad and the operator always has to look out for baggage and various things around the place and wherever he is in that room, no matter whether he is called or not, he knows what is going on over the wire. Of course, if he is called, he is obliged to answer. As an instance of what an operator can pick up in that way, I went down from Great Barrington, to Sheffield, expecting to ride back on the passenger train. It was bulletined on the telegraph board "No Report". I thought I could get to Great Barrington for dinner but I could not find out whether I could and I sat there waiting to get my lunch, growing hungrier all the time. Meanwhile I heard a message going over the line that the train had been delayed, and that they would meet at Canam somewhere below, and so on; and I figured out it would be an hour and forty minutes before the train would be along. So I went to the operator and said, "How late is your train going to be?" He says, "I don't know; I have had no report of it." I said to him, "According to the information I received, they are going to meet at Canam and it will be about an hour and forty minutes wait, and I thought I would have time to go out and get my lunch." Well, he said, "you are a pretty good guesser."

Perhaps what we may call that particular qualification of the telegraph would not appeal to the railroad management, that a man outside could find out how the trains were running. The point I am endeavoring to make in this is, that the Morse system is available to that man wherever he may be walking around the place. He has not got to go and answer a call and put a telephone up to his ear and drop everything else; but he takes that incidentally with his other work. That is simply one of the features of the Morse system that appeals to the railroad telegraph man. You must remember also that a great many of the men who are in active management are practical Morse operators, have grown up with the system, and know what it can do. This question has been discussed before several conventions of the Railway Telegraph Superintendents, and the probabilities are that I shall have occasion to discuss it at their next convention in June. So you will see that there is another side to the question. Here you have a railroad force developed from telegraph operators who are familiar with a system of this kind, and it is the simplest and best thing that appeals to us in carrying on this work.

Were a sounder there, I can receive a message sitting here, and I don't have to hold anything to my ear at all. I simply sit down and write from it, and where a man has grown up with it and is familiar with it, he never can get over that love and appreciation of the simplicity of the Morse telegraph system as known to the one who has practiced it, although it is now thirty years since I have done so.

K. B. Miller: I can add my little personal touch there, although a much less skillful operator than Mr. Pope was, and having no right to claim to be an old timer, that it is much easier for me, or would have been in days gone by, to have written down matter taken from a sounder than to get it by telephone. Mr. Pope's remarks suggest a distinct need in railway train dispatching. Some way may be evolved of relieving the despatcher, who is a rather important man, from wearing a harness -- I refer to the head telephone. They don't like to do it. The loud speaking receiver has been proposed and tried out rather carefully, and so far as I know has failed. One very ingenious way has been proposed and tried, but has not met with good results owing to poor articulation. It is to use at the despatcher's station a telephone repeater so that the feeble incoming currents could be magnified to produce loud talk in the receiver, and thus relieve the despatcher of the necessity of listening to a receiver held to his ear. This produced plenty of noise but it is articulate speech rather than noise that railway train despatching needs.

C. F. Elwell: In glancing over the paper, I was struck by the last paragraph, "Although the telephone has been in use on railroad divisions for less than four years, it has proven to have a great many advantages over the telegraph." I only intrude on your time to tell you the little experience I have had with the thing 10 years ago in Australia. I went out there to put in block signal systems, and they were already then using the telephone for all of their work. They had a system there in circuits of about 100 miles, just a parallel system magneto and code of signals for ringing. The signals were usually Morse letters, dots and dashes, and they seemed to have very good satisfaction with the phone. They had no telegraph instruments in the office at all. In the matter of calling up, we found lots of times that at certain stations it was almost needless to call.

All we had to do was to take the phone off and say, "Are you there?" Those men used to sit with the receiver glued to their ears so they could know all that was going on between all the stations. I just mention this in passing to show you that the matter is a good deal older in other countries. I don't know how old it is there, but I know this was in 1901 -- ten years ago.

Ralph W. Pope: I might add to my remarks, that the conditions which I spoke of in regard to the railroad service have changed very much within my recollection. When I entered the service, the station agents knew nothing about the telegraph, so in order to have telegraph facilities, the railroad was obliged to have an operator in addition to the agent, so that today we have this different state of affairs where the telegraph operator has grown up to be the agent, and the agent therefore is not necessarily obliged to have an operator at his station, on his staff. This means nothing in large stations where they have several employees, because there is enough work to keep the operator busy; but in small stations it simply means that one man, by his knowledge of telegraphy, his knowledge of railroad work, can be the whole thing.

S. G. McMeen: Some gentleman asked the author the question whether systems of this kind could be used on telephone lines associated with transmission lines? If Mr. Lisberger is present, he can speak of a system of this kind which is in service with a transmission line and distributing system, all within one system, but which has in it all the elements which would result in a long transmission. He could give practical information on a selector line. As to the thought, the author may criticize my asking the question, in this particular case in which Mr. Lisberger is familiar, as it connects stations which he operates, the only difference between a long transmission line and his case, is in the line. It is not in the apparatus or in the operation of the apparatus. Therefore, the problem becomes this: If with the system he has he had a longer line and a greater exposure, he would have a practical answer to the question which has been answered. Now, if the lines were longer and had a greater exposure, what new difficulties would be introduced? Only these: that the greater exposure might make that line noisy if it were not well balanced. That is to say, the only features which might make it unsuccessful in that case would be line features. And if we can build a telephone line which will be quiet during reasonable perfection of the telegraph line which it accompanies, then we can have good service over it. Such lines as that are operating every day successfully. So far as the telephone line and telegraph line are in normal condition, then successful operation ensues. There is nothing in the selective apparatus or in the special features of the dispatching circuit which would cause that line to be less easily perfected and operated than a telephone bridging apparatus. Therefore I would like to hear Mr. Lisberger speak of this line as to its automatic and rapid selection, which represents everything that is of a new character as to which the gentleman asked.

Ralph W. Pope: I wish to express my appreciation especially of this telephone session. Perhaps the Institute has been criticized more severely by some of its members upon this telephone question than any other branch of electrical engineering, as to why it was not giving more attention to the telephone. As you know, that means, why have we not had more telephone papers? I think that this question has been answered -- that for the first time we have had Mr. McMeen as an active member of the Telephony and Telegraphy Committee on the Pacific Coast where both great systems of telephony are in operation. We have had Col. Reber as chairman of that committee and he has taken a great deal of interest in this subject and has added to it a great deal by reason of his great familiarity with it due to the position he holds in the Signal Department of the Government.

I must admit I was surprised at the number and quality of this group of telephone papers. I think that great credit is due to Mr. McMeen for his activity in getting them together. I wish to say further that we have had telephone papers before but they never have been discussed so thoroughly by people who were familiar with the various systems in use. This meeting, suggested by Mr. McMeen, for this year, to my mind marks an epoch in the development of the Institute's treatment of telephone engineering. It will be up to us, wherever we may meet hereafter, to endeavor to attain this standard.

J. A. Lighthipe: I have been out of the telephone work a long time but I feel like our beloved Secretary, Mr. Pope, no matter how long he is away from the old original Morse, he still loves it. It is the same way with me in the telephone work. I still love it and try to follow it.

In the old days of the telephone, when it first started, the best receiver we had was what we called a crown receiver. It had six magnets screwed on the back of a handle, and was found to be wonderfully improved by dropping off five and using one. Then the only carbon buttons that were used in the country -- we must give Mr. Edison the credit of being the first man who really used carbon buttons on his transmitter -- were made in a small shack in the rear of the laboratory at Menlo Park. Mr. Edison could not use commercial lamp black for making the buttons so he made it by smoking kerosene lamps. He had about fifty of these lamps with a V cut out of the center of the wick to make it smoke, and kept the chimneys turning around until they were full of lampblack which was scraped out later.

The smoking process was attended to by an old Irishman who was possessed of great skill in picking up a lamp when it was on fire and throwing it out of the open door. The old transmitter was made of two brass buttons the faces of which were covered with platinum, and a carbon button pressed in between them. At that time it completely revolutionized the telephone business. It was the first time we could talk any distance at all and it really opened the commercial field for telephone work.

Mr. Edison, at that time, was quite deaf. Today he is even more so. It is very hard to talk to him. He could hardly hear the old Bell telephone; even with the carbon transmitter. It was hard work for him to understand what was said at the other end. He therefore tried to invent, or did invent a loud speaking telephone. Very few of you have ever seen one, although they are very simple to make. They consist of a chalk cylinder made by pressing precipitated chalk and afterward turning it down to one inch in diameter. Upon the surface of the cylinder rested a small stylus tipped with palladium. The end of the stylus was fastened to the center of a mica diaphragm. This cylinder was continually rotating and when the telephone was properly adjusted the sound coming out of the receiver was considerably louder than that going into the transmitter; you almost invariably had to pull your ear away when you were talking into it. I don't know that the principle of that telephone has ever been thoroughly understood. When a current passes through the stylus to the cylinder, the tension is released. In turning the cylinder the diaphragm was continually pulled in one direction. As the different waves passed through the chalk the stylus would slip so that the mica diaphragm in the receiver would practically duplicate the motion of the diaphragm in the transmitter. This telephone lasted only a few months. I don't think it was ever introduced in this country. They tried to put it in use in London, but today it is simply laid aside as one of our curiosities.

When the Blake transmitter came out, it was the starting point of all our telephones. It was adjusted so beautifully that you could stand off five or six inches from the transmitter, whereas before you had to talk right up close. The old Blake transmitter probably has done more good towards the universal adoption of the telephone system than any one thing.

In closing I will simply state that I am very very glad to meet the engineers of the telephone convention here. I have followed up, as far as I could, in my crude way, what wonderful improvements they have made. Mr. McMeen was kind enough to show me the first automatic machine I ever saw. That was at Fourth and Market Streets in San Francisco right after the fire. I was simply astonished at the magnificent mechanism of that machine. It was almost human in its hunting up a free trunk, selecting the number, either getting the subscriber or answering back that it was busy. I had no idea up to that time what a wonderful development had been made.

S. J. Lisberger: The telephone system which we have in use in San Francisco is not in any wise connected with a long distance transmission system. The system of the San Francisco Gas & Electric Co. is that used by most companies in city distribution work, namely, a main generating station with a number of substations. In San Francisco we have nine substations and one generating station. We were confronted with the problem of quick despatching between substations in times of trouble. Our ordinary system of telephone communication is a central board in our main office building on Sutter Street, from which point lines radiate to stations and substations. There is always an operator at this main switchboard, day and night. It was therefore necessary if an operator at substation B wanted to get into communication with substation C, to get into communication with the main office first. If we lost a bank of transformers, or a small section of line came down, or in the event of serious trouble to a substation, such as we had after the San Francisco fire, there would be so many calls coming into the main board, that the operator could not give time and attention to the substation calls, and very often we found that if one substation could only get into communication with another substation the trouble could be very quickly remedied, whereas we were often delayed five or ten minutes. The solution of the problem was to get quick communication between substations. The system we finally adopted was worked out for us by Mr. McMeen and was an automatic system. We had objections to an intercommunicating system of our own due to the fact that it must be attached to our poles or in our conduits and that was open to the objection that if we had trouble it was entirely possible to lose our entire communicating system. The wire system, belongs entirely to the Home Telephone Company; is carried on their own lines, in their own conduit systems, and is entirely independent of the system we have in operation; all that is necessary for one station to get another is merely to turn the selector switch to the required numbers -- it takes three different movements to call; the system starts with 721 and runs to 730. I have shown to several of our visitors the time it takes to call a station, which is about 9 seconds.

It is very often necessary for one station to talk to three stations, or four stations at a time and we have what we call a master switch and one station can get every other station on the line by working that mechanism. Mr. McMeen went further to help us in the problem, (but we did not take his further suggestion, not because we did not want it, but because we could not afford it) wherein he offered to give us a signal board which would show, by means of lights when we were calling a series of stations, whether they answered or not. If station C called stations B, E and F, under our present system, station C would ring first station B, then station E and then station F. All the stations have orders to wait on the line until someone talks. Mr. McMeen designed an indicating board that would quickly indicate who was on the line, would show when B was on the line and next E was on the line and next F was on the line. That was very nice but involved some financial difficulties that we did not care to meet. Otherwise, in all matters, it is most satisfactory to us.

S. G. McMeen: I might say that although Mr. Lisberger spoke of this as automatic, it is not an adaptation of the automatic station equipment. It is an adaptation of the railway dispatching apparatus. The devices used are not telephone exchange selectors, but railway telephone selectors, although instead of working the telegraph key, the operator works it with a round, automatic station dial. This is merely used as an interruptor for the calling impulses.

Gregory Brown: Mr. Miller brought up the question of separate signalling circuits. There is one type of selector, so far as I know, that uses three wires -- one for signalling and two for talking. That has not been very extensively used. When you consider the impedance of the selectors across the line, it hardly seems necessary to consider that line very heavily loaded as far as transmission is concerned. For that reason, I do not believe it would be necessary to have a separate signalling wire. Selectors are also being experimented with now that have an impedance of something over 600,000 ohms. These selectors contain advantages due to that high resistance, and if they are used, it certainly would not be necessary from a transmission standpoint to have an extra signalling wire.

Mr. Cramer seems to have had quite a few troubles. The first he mentions is that he does not find it feasible to signal and talk at the same time. I have been around pretty nearly all over the country on the various roads, and this is a complaint that is practically new to me. In some cases I have found this to occur, but on investigation we generally find that there is some trouble with the despatchers apparatus. One of the troubles that occurs perhaps more than any other and causes these results is the breaking down of the condensers at the dispatcher's office. These would not round off a sending wave to such a great extent.

The length of ring has been criticized -- the length of ring at the station. I have gotten around that, where they want a longer ring, by installing a strap key at the dispatcher's office. This key is wired in a parallel with the automatic keys, and if the dispatcher, for any reason wants the bell in the station he is calling to ring longer than would ordinarily be the case, he turns the calling key of that station, and when he hears the answer back he merely presses down the strap key. There are various other modifications of selector arrangements which permit the bell to ring in the substation until the substation operator presses a button. In fact, most any kind of service can be given, according to what the particular railroad wants, but, as a general thing, most of them are satisfied with a certain length ring, about a second and a half, uniformly in all stations.

Another trouble that was experienced was that the agent sticks a toothpick or something in the push button and holds it down. The obvious plan to pursue there is to fire the agent; and this has been done in a great many cases, especially when the telephone was first used on railroads. As has been mentioned by several of the speakers, the operators bucked a good deal at the introduction of the telephone, their idea being that they probably were going to have their salaries reduced, or some of them would lose their jobs. It is not the policy of large railroads to put men out of employment except in very extreme cases, and if the introduction of the telephone permits offices to be closed, or forces to be reduced at certain points the men as a rule are taken care of in some other position.

A test on a 33,000-volt line was mentioned in which the apparatus of two manufacturers was used. It seems to me that the telephone apparatus used in this test is at least very similar among manufacturers, that is, the large manufacturers, and that it hardly could be a question of quality of apparatus to show up in the way that was indicated; that is, according to the statement that was made, I gather that one of them failed completely, and the other one gave good satisfaction. It seems to me there must have been another factor that entered into those two tests that caused that great difference, because the transmitters and coils, and so on, are very nearly similar insofar as their excellence is concerned.

Mr. Bennett spoke of calling and selecting on transmission lines. Mr. McMeen answered this question about the only way it can be answered, I guess, and that is with proper transpositions of your line if you get a quiet telephone line you can do anything with it in the way of talking and selecting.

Mr. Pope brought up the point in favor of the telegraph in that you could hear the telegraph when you were at some distance away from the instrument, whereas in the telephone you have to have the instrument up to your ear. About two months ago I conducted a trial installation down on one of the Pennsylvania lines, using a new type of loud speaking receiver. Criticism has been made of the telephone when used on a railroad division that it was all right for every purpose except blocking, and that for this purpose it was not as quick as the telegraph, and this criticism seemed to be more or less justified. The reason that this criticism was made was that in telephone blocking it is necessary for the operator to ring up another operator and then go through the motions of putting the receiver on his head and talking with him, whereas with the telegraph he merely ticks off what he wants to say and it is done. And that was the reason for the development or the experiments with loud speakers of various kinds and the attempt to develop a good one.

There has been considerable work done on this, and although it has been comparatively easy to get up a loud speaker for blocking -- one that was plenty loud enough -- still the articulation was not what it should be. This blocking service represents an ideal condition for loud speakers, because the lines are extremely short and are not loaded, and you can take full advantage of all the energy coming out of the transmitter. This installation was put in in three or four of the towers, and was left in for about ten days. During that time it was used exclusively by the operators for blocking trains, and in fact, they much preferred to use these speakers because the work was easier for them. They were then taken out merely to put them in in a better shape the next time as far as mounting is concerned, making it more convenient for use, and also to employ a busy test by means of a buzzer that had not been taken care of in the first installation. It is intended to use or experiment with this same type of receiver for dispatcher's use, and there will shortly be some trials in that field.

Mr. Elwell spoke of a train dispatching line being in use in Australia in 1902, I think it was. In the first part of my paper I mention two or three instances of the early installation of telephones on a train wire. All these installations used code ringing, and for that reason they were not very successful. There was too much of a load on the dispatcher. I think the first one used in this country was in 1883, which is probably before the one mentioned by Mr. Elwell.

I think there is no doubt that the telephone has proven its case on the railroad and I mention in the paper quite a few advantages of the telephone over the telegraph and I can probably mention quite a few more, and anybody who thinks of the matter can easily see that there is no question but what the telephone does have advantages over the telegraph. Mr. Miller, I believe, raised the point about the distinctness with which the intelligence could be transmitted over the telephone -- that is, where train orders, important orders regarding train service in which human life is risked -- the distinctness with which they could be heard. Now, in sending out orders, the various railroads have standardized, in their telegraph methods, and they have also adopted practically the same scheme when they shifted over to the telephone. In sending out an order the despatcher rings the various operators and they will come in and then he states a certain number, 31 or 23, or whatever it is, which indicates the type of order he is to give and he starts to give his order and as he gives his order he writes it down himself so as not to give the order faster than the operator can take it down. As the dispatcher writes the order when he comes to the name of a town or any figures whatever, engine numbers or anything similar, or the time, besides speaking it in the ordinary manner, he spells it out. After he has completed giving the order the operators in their turn repeat this back to him and as each operator repeats it back to him the despatcher underlines the word repeated, so if there are three operators repeating the record of the order would be in the despatcher's book -- it would have three underlines under each word which was repeated, which would supposedly prove it had been repeated by three operators.

line was described in a paper read before the Seattle Section of the A.I.E.E., December 19, 1908, published in the Proceedings, and in the Journal of Electricity, April 24, 1909. This paper covers only the four years 1907, 1908, 1909 and 1910.

Modern Methods in Train Dispatching
Electrical Communication Vol. III #1
July, 1924

AIEE	1921	Vol. XL, Pg. #396
AIEE	1914	Vol. XXXLLL, Part #1, Pg. #340
AIEE	1911	Vol. XXX, Part #2, Pg. #1006

TRAIN DISPATCHING FIGURES

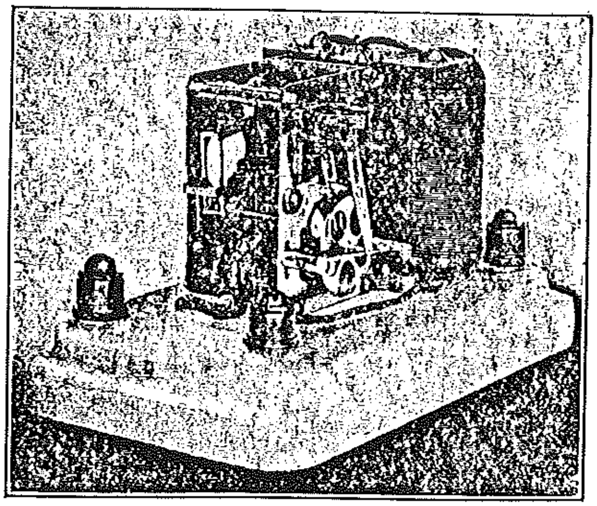

Fig. 1.—Gill selector

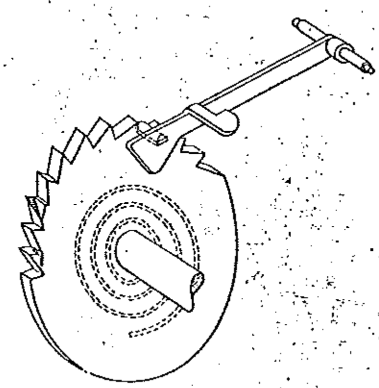

Fig. 2.—Gill selector ratchet wheel

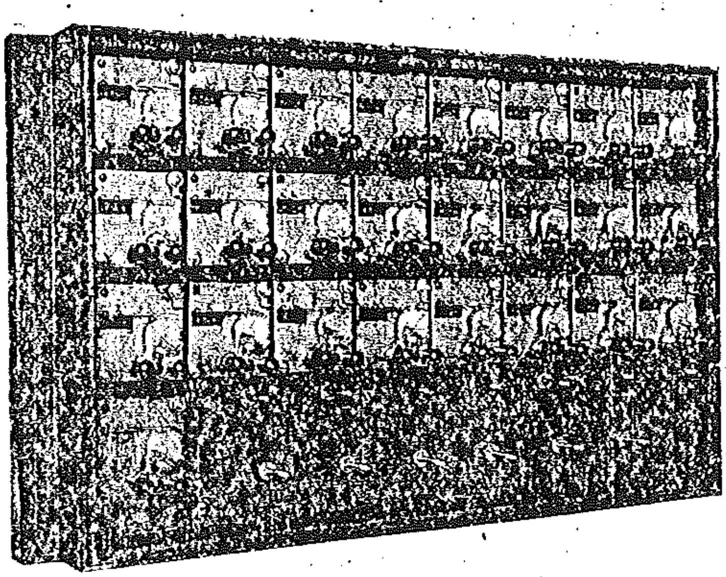

Fig. 3.—Sending keys

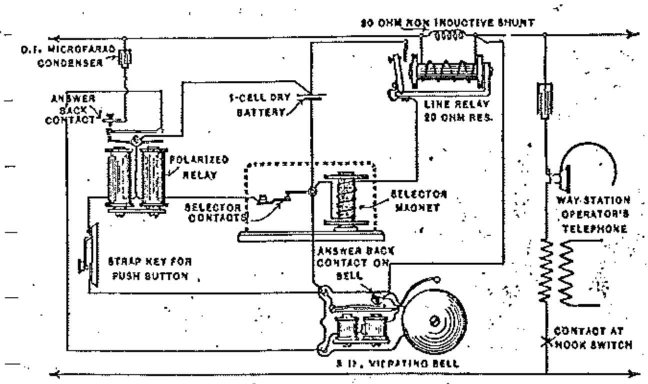

Fig. 4.—Sub-station circuit

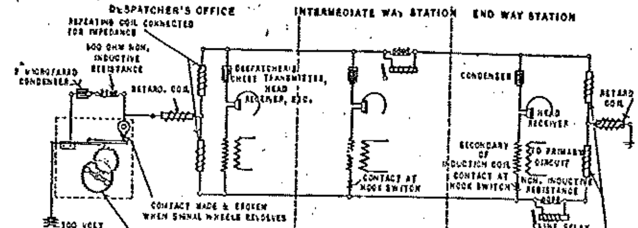

Fig. 5.—Line circuit

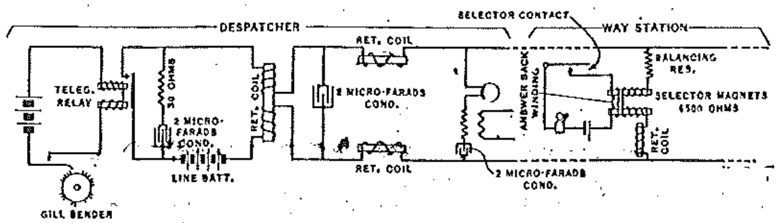

Fig. 6.—New line circuit

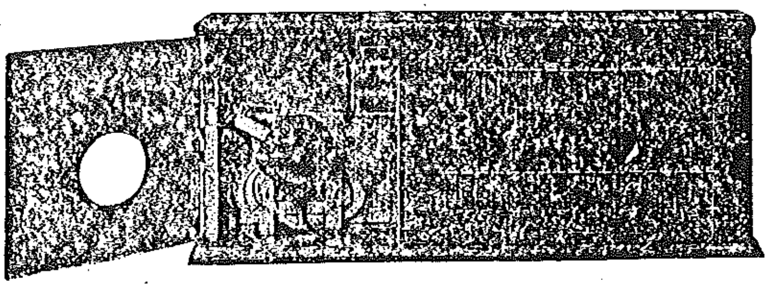

Fig. 7.—Wray-Cummings despatchers keys

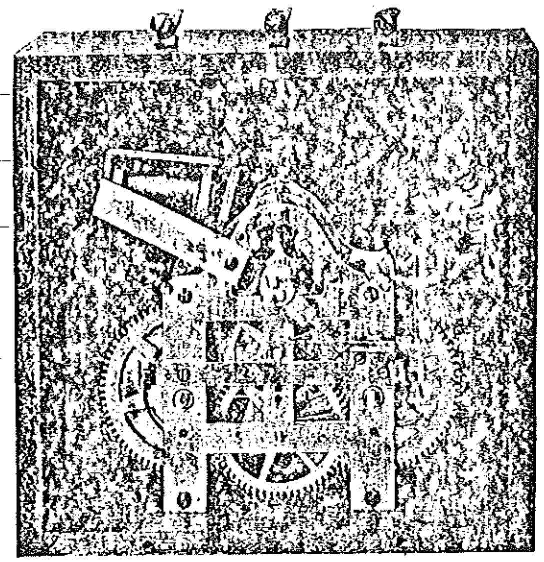

Fig. 8.—Wray-Cummings selector

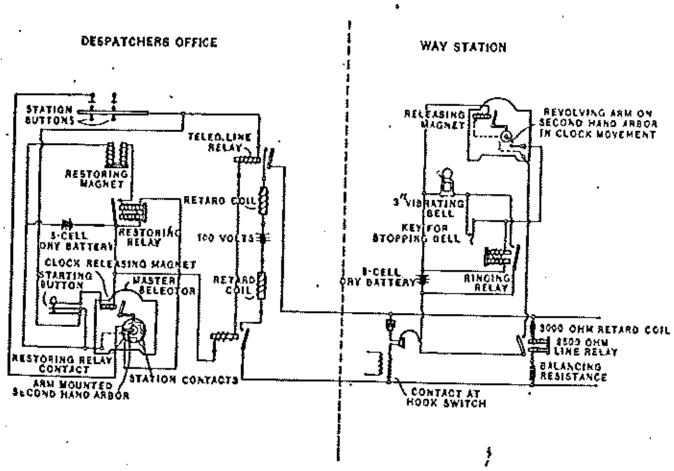

Fig. 9.—Wray-Cummings circuit

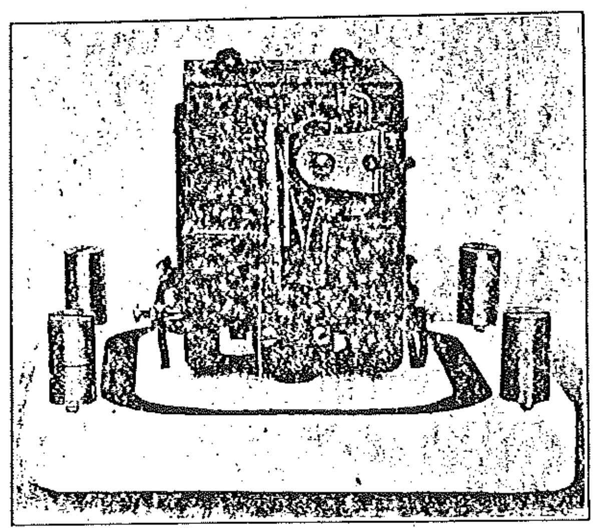

Fig. 10.—Western Electric selector

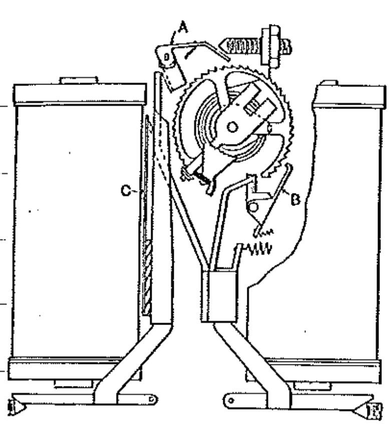

Fig. 11.—Lever movements of W. E. selector

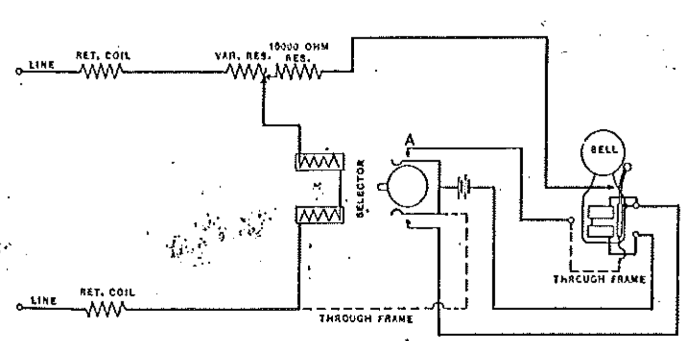

Fig. 12.—W. E. substation circuit (local battery)

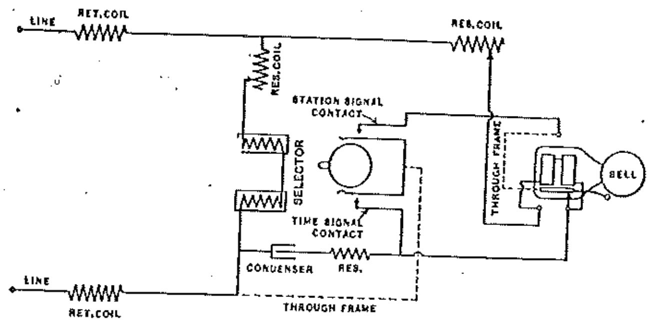

FIG. 13.—W. E. Substation circuit (central ring)

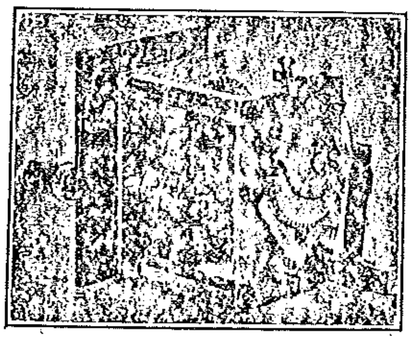

FIG. 14.—W. E. sending key

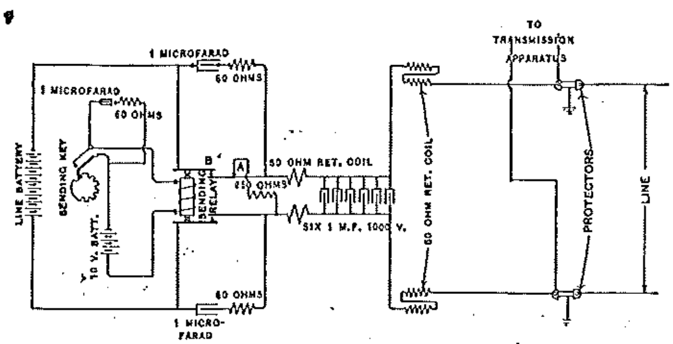

FIG. 15.—W. E. despatchers and line circuit

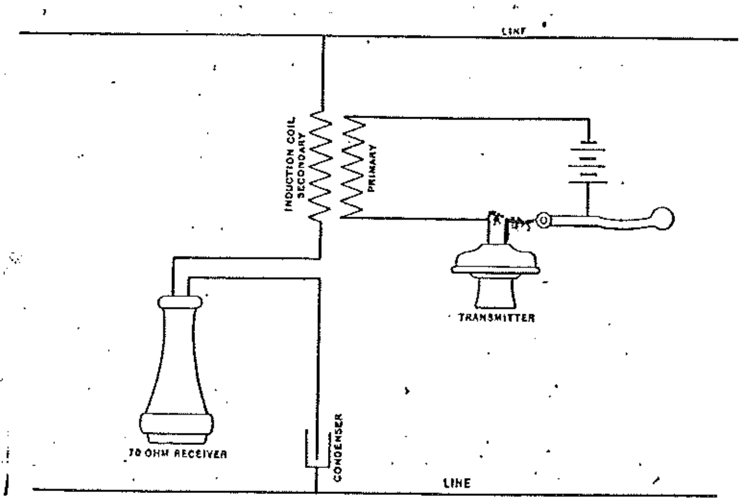

FIG. 16.—Local battery telephone circuit

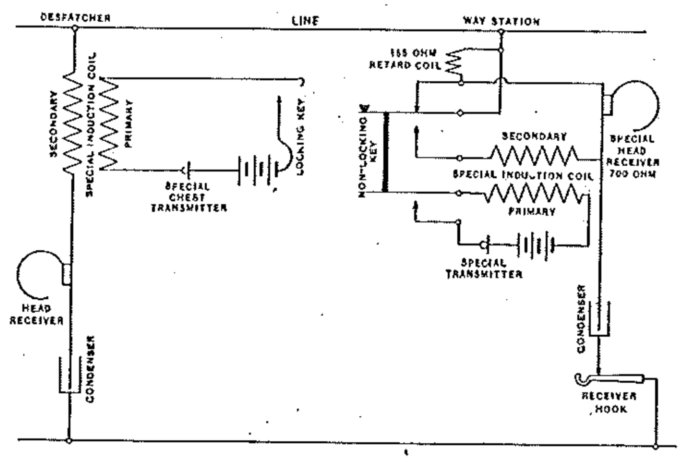

FIG. 17.—W. E. Train despatching way station circuit

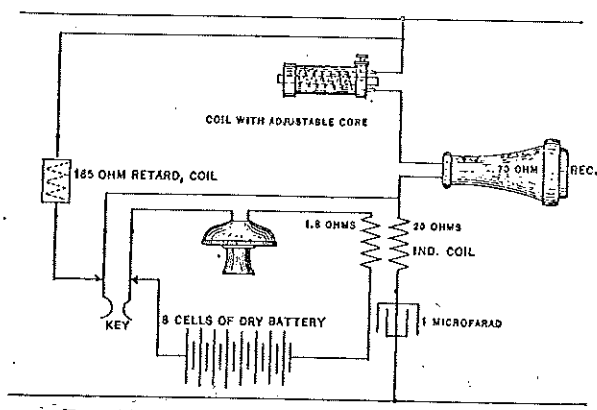

FIG. 18.—Adjustable coil way station circuit

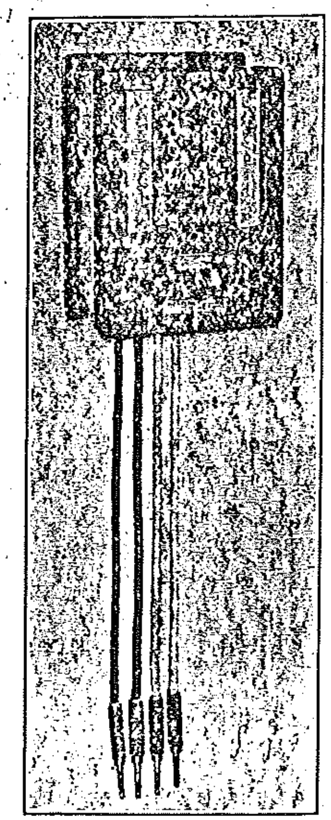

FIG. 19.—Patching box

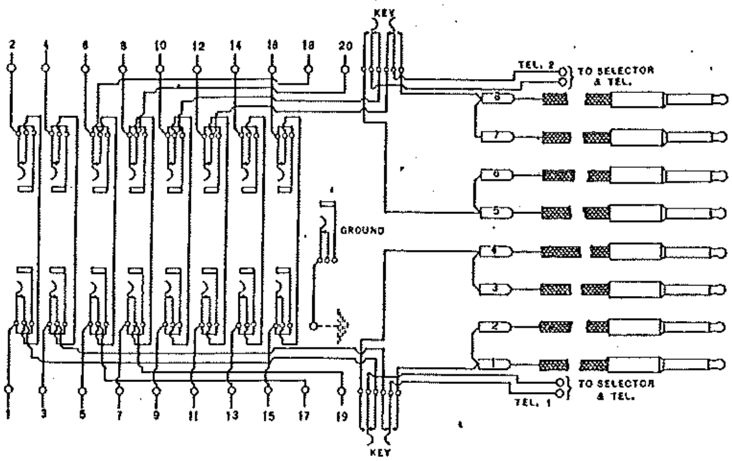

FIG. 20.—Patching box circuit

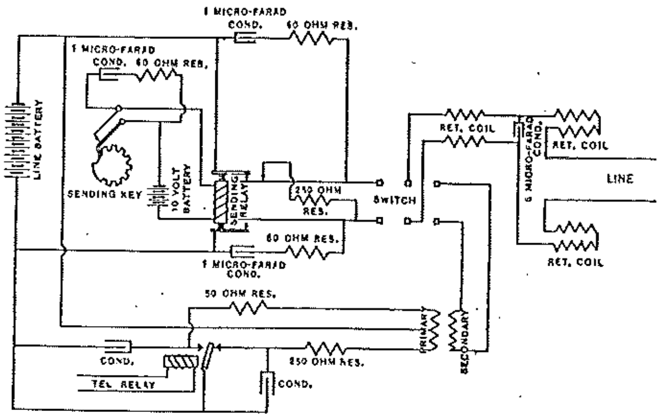

FIG. 23.—Time sending circuit

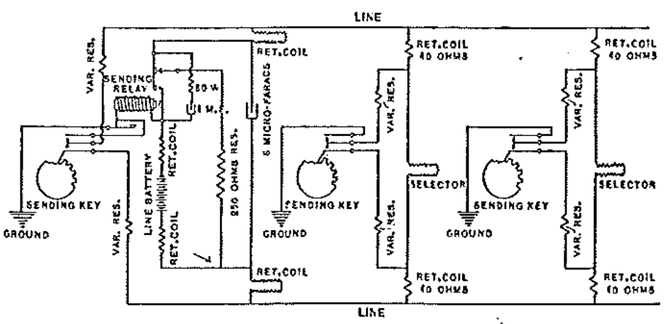

FIG. 21.—Western Electric Intercommunicating circuit

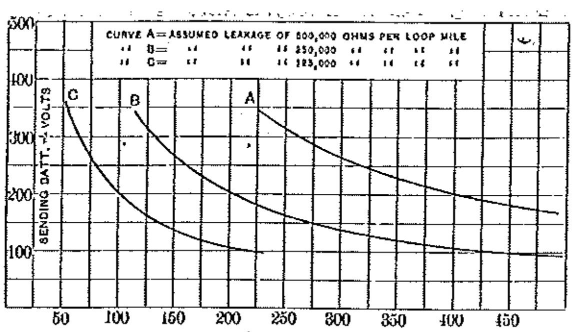

Fig. 22.—Intercommunicating system. Curves show relation between line voltage and length of line. System can be operated over assuming a definite leakage per loop mile (with no readjustment of sending relay).

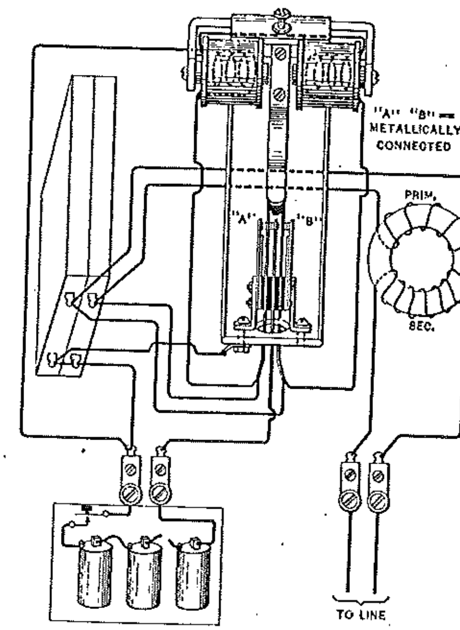

FIG. 4.—Substation circuit