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PARTY LINES.

BY KEMPSTER B. MILLER, M.E.

Probably no branch of telephone work has offered more advantages to the inventor and designer and consequently received a greater share of ingenious application than the party-line problem.

A party line, or *many party line*, as it should undoubtedly have been called, is a line having more than two stations upon it. This definition probably needs a little explanation, as a line running from a central office to two stations only is a party line in every sense of the word, and we must therefore and very properly count the central office as a station, thus making three in all. The term party line is used in distinction from *private line*, which may be defined as a line connecting a central office with one subscriber only, or one subscriber with one other only.

Party lines may be divided into two general classes:

(1) Those where a code of audible signals is employed to enable the various parties to distinguish their calls from those of others.

(2) Those where a system of selective signaling is employed so that any one party may be called up without disturbing any of the others.

The first of these classes may be divided into two general sub-classes, according to the connection of the instruments on the line, as follows:

(a) Those on which the instruments are connected in series in the line circuit.

(b) Those on which instruments are connected in multiple in the line circuit.

The second or selective signaling class of lines may be divided into three sub-classes, according to the method of selective signaling used, as follows:

(*a*) Those employing step by step movements to complete the desired circuit.

(*b*) Those using the harmonic system of selecting — that is, those using currents of various frequencies for actuating the different signals.

(*c*) Those using currents of different strengths or different polarities or both, for operating the different signals.

The nonselective systems will be discussed first, and for dealing with this very familiar subject at as great a length as I shall, I offer two reasons, the first of which is that the party line is the first plan usually adopted in communities where but a few subscribers exist, and in such communities it is but seldom that a man is found with the requisite knowledge for distinguishing between a series or a multiple connection of telephones. I have good reason to know that a large majority of the installers of party lines have, to say the least, the vaguest notions as to the principles involved and as a result frequently connect up series instruments in multiple, or what is worse, multiple instruments in series, or what is still worse, if possible, to indiscriminately mix the two kinds of instruments on one circuit. My second reason is that any set of articles would be far from complete without a fairly comprehensive treatment of the nonselective class of party lines, inasmuch as in this class are probably ninety-five per cent of all the party lines of this country.

Probably the first party line ever constructed connected the instruments in the line circuit in series; there are records, however, in the very early days of telephony, of their connection in multiple.

In the series party line the usual form of wiring is used and is substantially that shown in Fig. 1. In this the switch lever L cuts out the talking apparatus, consisting of the transmitter T, induction coil I, receiver R and battery B, and completes the circuit through the calling generator G, and polarized bell P, while the lever is down, and accomplishes the reverse connections when the lever is relieved from the weight of the receiver. Instruments of this kind are connected *directly in* the line circuit, that is, the line wire is cut and the two terminals so formed are connected to the two binding posts 1 and 2. In other words, the line circuit enters one binding post of the instrument, passes through the circuits of the instrument and out at the other binding post and to the next instrument, and so on through the entire circuit.

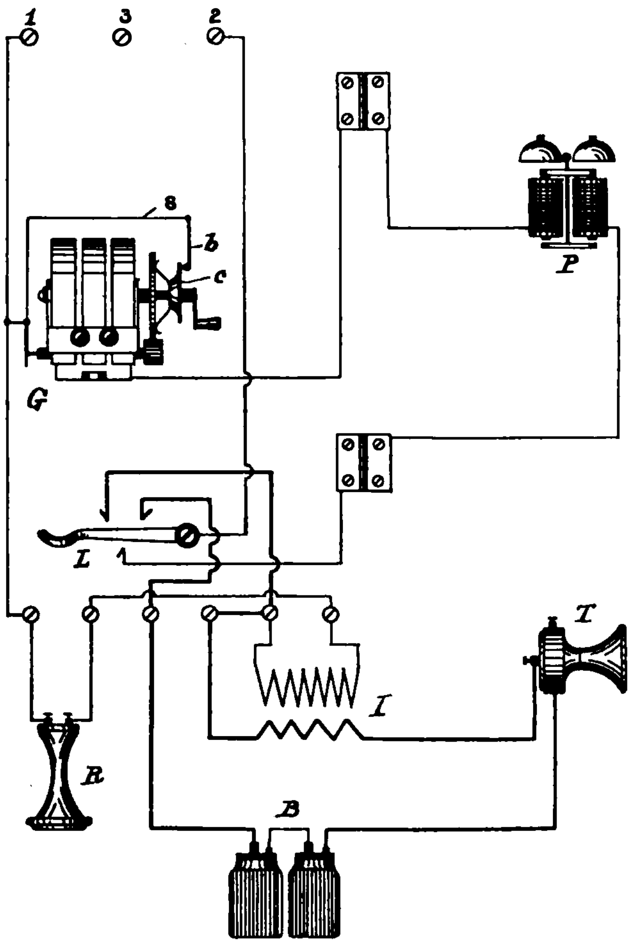


FIG. 1. CIRCUITS OF SERIES TELEPHONE.

A grounded line of four such instruments is shown in Fig. 2. This figure simply illustrates the method of connecting the telephones in the line wire, it being understood that all of the instruments are wired substantially in accordance with Fig. 1.

A little consideration will now show one of the chief disadvantages of the series line. The talking circuit of any two stations engaged in conversation must always pass through the bell magnets of all the other stations. As these magnets necessarily possess considerable impedance, this is a very serious objection, and when a great number of instruments are used the talking becomes very faint. For this reason it is customary to wind the bell magnets on instruments to be used on series lines to a low resistance, rather lower in fact than on the ordinary exchange instruments. Eighty ohms for each complete double magnet is a very good resistance, the winding being of No. 31 single silk-insulated copper wire.

It might be thought at first sight that the resistance of the armatures of the magneto generators would also be included in the circuit. This was true in the earliest forms of instruments, and proved a most serious objection. Now every good series instrument is provided with what is termed an automatic shunt, which provides that a path of practically no resistance shall always be closed about the generator armature, except at such times as the generator is being operated. Such a shunt is well shown in Fig. 1, where *s* is the shunt wire, normally connecting the armature spindle spring with the frame of the generator through the medium of the spring *b* and the contact disk *c*. This forms a short circuit

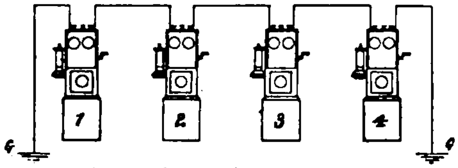


FIG. 2. SERIES GROUNDED LINE.

around the armature winding, as is readily seen. When, however, the generator crank is turned, the disk *c* is pressed out of engagement with the spring *b* by the wedging action of a pin on the shaft against the side of a spiral slot on the crank sleeve. Many other forms of automatic shunts have been devised, the one shown being typical.

The number of bells which can be rung on a series line is far in excess of the number that can be talked through. Thus fifty instruments would have a combined resistance of 4,000 ohms, and if we assume a very high line resistance of 3,000 ohms, we have a total resistance of only 7,000 ohms, which any good generator could easily ring through. Fifty instruments in series, however, or even half that number, without line resistance, give almost intolerable talking service.

Such a line as that shown in Fig. 2 would, moreover, be susceptible to all the inductive trouble to which the telephone is heir. This can, of course, be partly remedied by making the circuit a complete metallic one, and transposing the line at frequent intervals; but even this will not do away with the trouble altogether, as it is impossible to get a proper balance between the two sides of the circuit.

The generators for series instruments should be wound for producing a high electro-motive force, inasmuch as there is always a great amount of resistance to be overcome. A good type of generator is one wound with No. 35 single silk-covered wire to a resistance of 550 ohms. Such a generator, with proper mechanical construction and good permanent magnets, will easily ring through 15,000 ohms.

It is well to explain here what is meant by the terms "ten thousand ohm" or "twenty-five thousand ohm" generators. It means that the generator will ring its own bell through the resistance specified. The necessity for giving this definition may not be clear to some, but I have frequently been asked whether the "ten thousand ohms" refers to the *actual resistance* of the generator armature or the ringer magnets, or the *receiver* or *induction coil*.

The bridging or multiple system of party line working is now rapidly superseding the series system. Fig. 3 shows the method of attaching the telephones to a single or grounded line according to this plan.

The line wire *l* is continuous through all the stations, and each instrument is placed in a separate bridge wire *b* or tap to ground. If the circuit is to be metallic, the ends of the bridge wires *b*, which are shown connected with the ground, are connected instead with the second line wire.

The circuits of a bridging instrument

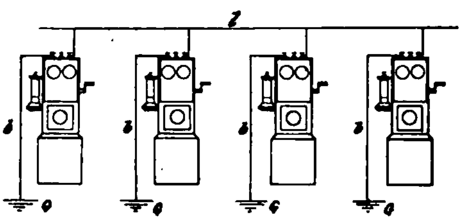


FIG. 3. BRIDGED GROUNDED LINE.

are shown in Fig. 4, and the line connections of an eleven station metallic circuit line in Fig. 5. This latter figure is a reproduction of a figure in the famous Carty patent alleged to control the art of bridging telephones.

In this system the call bells P at each station are *permanently* bridged across the two sides of the line, and are made of high *resistance* and *retardation*. The generator G at each station is in a separate bridge circuit, which is normally open, but closed when the generator is operated. The talking circuit of each instrument, containing the receiver R and secondary winding of the induction coil I, forms a third bridge circuit, which, like the generator circuit, is normally open.

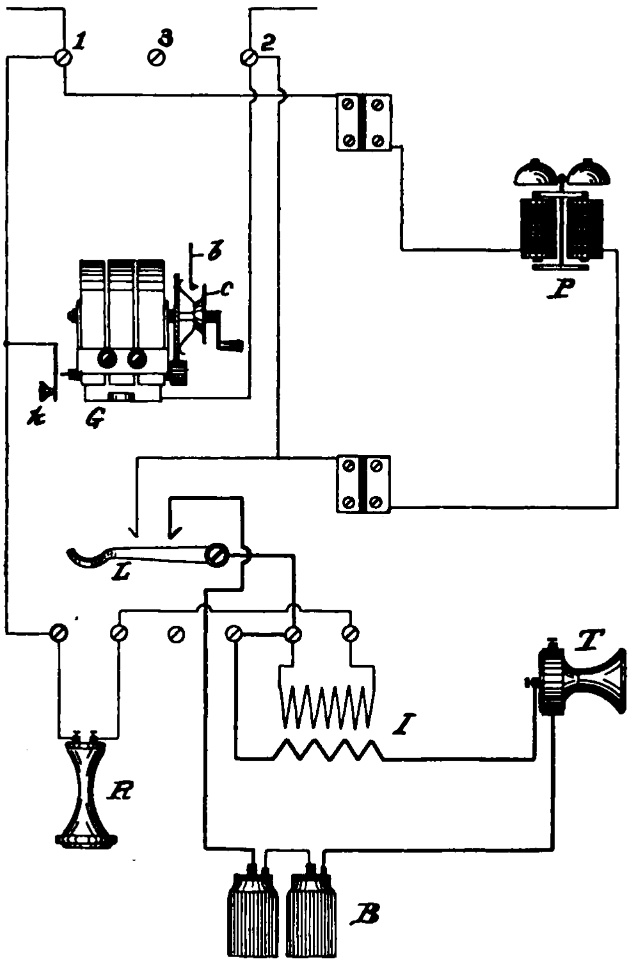


FIG. 4. CIRCUITS OF BRIDGING TELEPHONE.

The telephone circuit of each instrument is automatically closed when the receiver is removed from its hook for use, and this operation also closes the local circuit containing the primary of the induction coil I, the local battery B, and the transmitter T. In order that there shall not be an undue leakage of the voice currents through the permanently bridged call-bell circuits, the magnets of these call bells are wound to a high resistance (usually a thousand ohms) and are also constructed in such manner that they will have a high coefficient of self-induction. When a generator at any one station is operated, it is connected across the two sides of the line in parallel with all of the call-bell magnets on the line. Part of the currents in this generator will, therefore, pass through each of the call-bell magnets on the line, thus causing them all to operate if the amount of the current generated is sufficient to accomplish this result. The successful operation of this system depends on the fact that a coil possessing a high coefficient of self-induction will transmit with comparative ease alternating or pulsating currents of low frequency, while it will form a practical barrier to similar currents having a very high frequency. The currents generated by the calling generator at any station are of sufficiently low frequency to pass with comparative ease through the call-bell magnets arranged along the line, while the rapidly alternating voice currents impressed upon the line by the telephonic apparatus at any station will be compelled to pass over the main line to the receiving station without being materially weakened by leakage through the call-bell magnets. At the receiving station these voice currents will pass through the telephone receiver and secondary coil of the induction coil, these being connected across the line at that station by virtue of the receiver being off its hook. This path through the receiving instrument is of comparatively low resistance and retardation, and thus practically takes all of the current from the distant station.

The closing of the generator bridge upon the sending of a call may be accomplished manually, as with the key *k* in Figs. 4 and 5, or automatically, in much the same manner as that described for breaking the shunt around the generator in the series instrument. Thus, if the wire leading from binding post 2 in Fig. 4 were led to the spring *b* instead of to the frame of the generator, it is evident that the inward movement of the disk *c*, caused by turning the generator crank, would accomplish the same result as pressure on the key *k*, and with the advantage of not requiring the volition of the operator.

The high retardation of the ringer magnets is obtained by winding them to a high resistance with a comparatively coarse wire so as to obtain a large number of turns in the winding. The length of the cores is increased for the double purpose of getting more iron in the magnetic circuit, and therefore a higher retardation, and also for affording a greater amount of room for the winding. The Western Electric Company, I believe, wind their coils to a resistance of 1,000 ohms, using No. 33 single silk magnet wire. Many other companies use No. 38 wire and wind to a resistance of 1,200 or 1,600 ohms. This does not give such good results, however, as using the coarser wire and the lower resistance and long cores. Some companies wind, or once wound, their bridging bell magnets partly with German silver wire in order to make a high resistance at a low cost. They should learn, however, that resistance in itself is not the thing desired, but a great number of turns in the winding, which, of course, incidentally produces a high resistance.

The generators for bridging systems should be designed for quantity of current rather than high pressure, since they have to supply current to pieces of apparatus arranged in multiple. The fact that in some instances a high voltage also is needed must not be overlooked. On long iron lines, heavily loaded, sufficient *current* must be generated to ring all the bells in multiple and sufficient *voltage* to ring the bells at the farthest end of the line. In this case it becomes a question of watts, horse-power, or, more properly, man-power. The winding of the generator is, therefore, a question of vital importance and must vary to meet different requirements. A

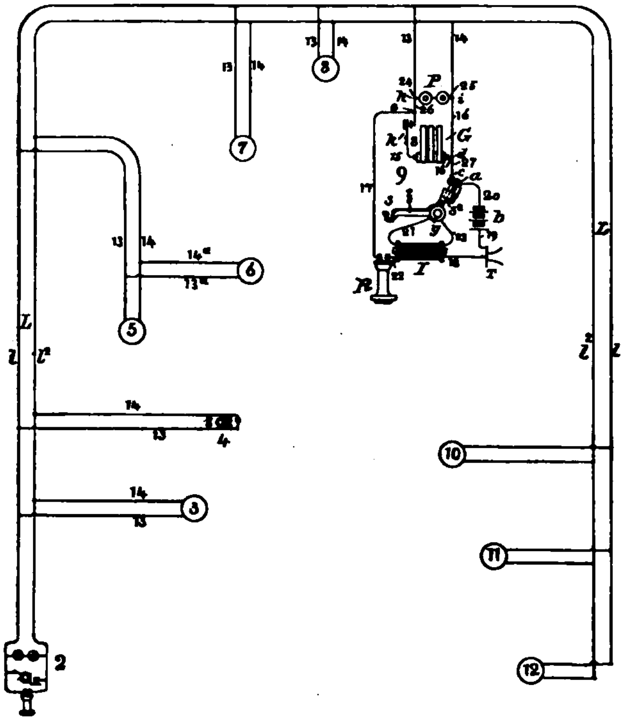


FIG. 5.

generator wound to 350 ohms with No. 33 wire makes a first-class one, however, for ordinary bridged lines where copper circuits are employed.

It is undoubtedly better on bridged circuits to use low wound induction coils, so that the voice currents coming along the line wire will find a much readier path through the talking circuit of the station receiving than through the call-bell bridges at the various stations. In many cases the use of 500, and even 1,000 ohm induction coils on bridged circuits renders the impedance of the talking circuits higher than that of the call-bell circuits, which is exactly what should be avoided.

The smart contractor who specifies 25,000 ohm generators and 750 ohm induction coils for instruments to be used on a bridged line would probably meet greater success in the field of politics than in that of telephony.

(To be continued.)

CENTRALIZING FORCES AND EQUIPMENT OF THE TELEPHONE EXCHANGE.

Much thought and study has been given by telephone engineers in recent years to the concentrating of as much of

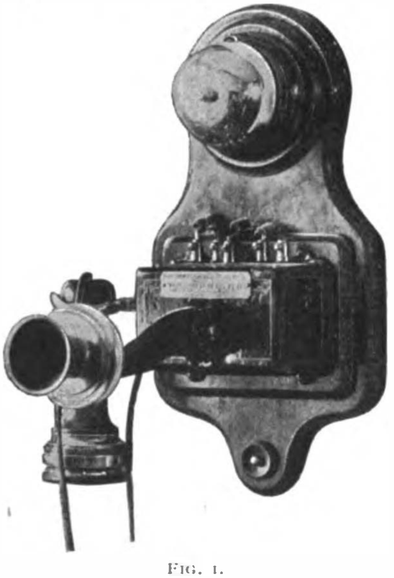


FIG. 1.

the equipment and source of energy of exchanges as is possible at the central office, not only on account of its greater convenience and desirability to subscribers, but also from an economical point of view.

A marvelous advance in this direction is shown in the "Central Energy System" recently put on the market by the Stromberg-Carlson Telephone Manufacturing Company, of Chicago. Fig. 1 shows a station instrument as used in exchanges where battery call can be employed. In this system the talking battery of the entire exchange, as well as batteries for calling the subscribers and for signaling central, are placed at the central office. The battery requirement

FIG. 2.

is about one-tenth of that necessary in the ordinary system.

In exchanges where generator power is required for calling subscribers, an instrument such as shown in Fig. 2 is used. This instrument is furnished with a ringer and bells, neatly mounted underneath the battery-box shelf, and it is provided with a battery box so that local

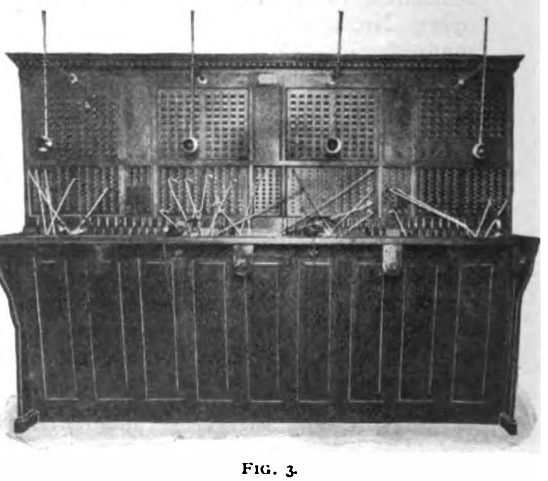


FIG. 3.

talking battery may be used if preferred.

The instrument, however, has no generator, which in the ordinary system

PARTY LINES.

II.—BY KEMPSTER B. MILLER, M.E.

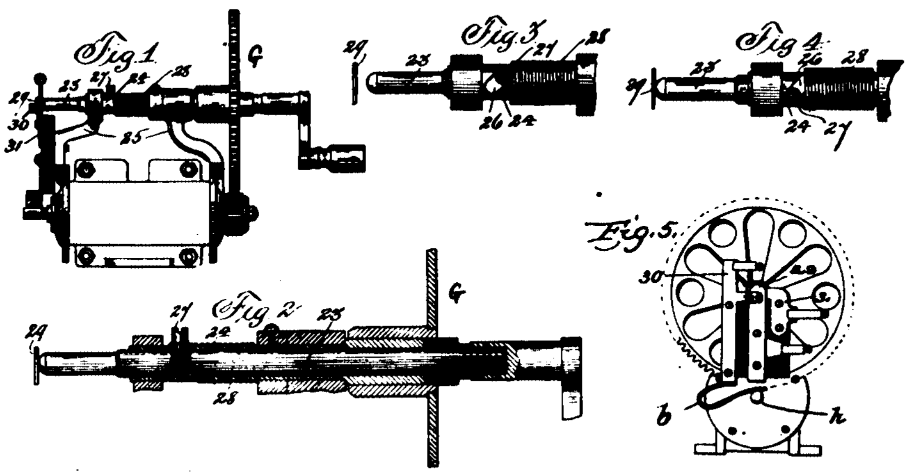
In connecting a party line with a switchboard a great deal of trouble is often caused by the use of an improperly wound annunciator coil. It should be borne in mind that the drop magnet really bears the same relation to the line as the ringer magnets, in the various telephones, and should therefore be connected in the same way. For a series party line the switchboard drop should be wound to about the same resistance as the ringer magnets. If the resistance is made higher, as is often done in the attempt to secure a more sensitive drop, the parties on the line will have much difficulty in talking to each other, because the drop is in series in the line; but if that line is connected with some other line, through the switchboard, this trouble will not exist, as the circuits should be so arranged as to cut out the drop upon the insertion of the plug.

In the bridging bell system the resistance of the switchboard drop should also be about the same as that of the ringer magnets, and it should possess a high coefficient of self-induction, so as to prevent the short-circuiting of the voice currents. Such a drop may be left permanently bridged across the line, to serve as a clearing-out drop when the subscribers are through talking. In small exchanges, operating party lines, it is customary for the operator at such a switchboard to distinguish between the calls for a connection with some other line, and those which are for parties on the same line, by means of the buzz caused by the vibration of the armature of the drop. It is, therefore, desirable to give the drop armature a rather wide adjustment, so that it will make enough noise to enable the operator to readily distinguish the signals.

On lines where a measured service rate is charged, much loss of revenue is often caused by surreptitious conversations, that is, by parties on the same line calling each other and carrying on their conversation without the knowledge of the switchboard operator, so that no means is afforded for properly charging the use of the line against them. Many arrangements of circuits and apparatus have been devised for obviating this difficulty. One of these, which is suitable only for bridging lines, is to provide at the central office a switchboard drop of extremely low resistance and so arranging it that it will be cut out upon the insertion of the plug. The low resistance path through this drop acts practically as a short circuit to all of the high resistance bells on the line, so that when any party rings, nearly all of the current from his generator passes through the switchboard drop, without actuating any of the bells. When the operator plugs in for conversation, or for the purpose of calling up some subscriber on that line, the low resistance drop is cut out, so that the line is no longer short-circuited. This method cannot be used on long lines, because the resistance of the drop, in addition to that of the line wire, proves high enough to shunt some of the current through the magnets of the bells at the distant end of the line, when parties at that end attempt to signal each other. While the drop would short-circuit the end of the line nearest the switchboard, the instruments at the farther end would not be appreciably affected, owing to the high resistance of the line wire between them and the board.

This method is not, on the whole, very satisfactory, and a better one is to arrange the magnetos at the subscribers' stations to generate a current *in one direction only*, instead of the usual alternating current, and to give the armatures of the bridged call bells at all of the stations a permanent set or tendency toward the pole which would be rendered stronger by currents in this direction. The switchboard drop, also bridged across the line, is of a nonpolarized type, so as to fall when actuated by currents in either direction. Thus, when any subscriber calls, the current will have no effect upon any of the ringer magnets of the other subscribers, because it tends only to pull the armatures closer to the poles toward which they are already attracted, but will cause the switchboard drop to fall in the ordinary manner. Thus, no subscriber can obtain a conversation with any other subscriber without the full knowledge of the operator. The switchboard generator is equipped for sending out currents, either of the opposite polarity from those generated by the subscriber's generators or of the ordinary alternating character, so that the operator may ring up the subscribers at will.

Mr. Frank B. Cook, of the Sterling Electric Company, has recently patented an apparatus for using in a system of this journaled in the brackets 25 mounted on the end plates of the machine. A pin, 27, fixed in the crank shaft 23 engages a diagonal slot 26, in the sleeve 24. This pin is held at one end of the slot by the spring 28, which is coiled around and fastened to the sleeve 24. When, however, the crank shaft is rotated, the pin 27 rides against the side of the slot 26, until it assumes the position shown in Fig. 3, after which the sleeve and gear turn with the shaft. This causes the crank shaft 23 to break contact with the spring 29; and also allows the spring 29 to break contact with the spring 30, with which it is in normal engagement, and to engage the spring 31. This breaks the shunt around the generator,



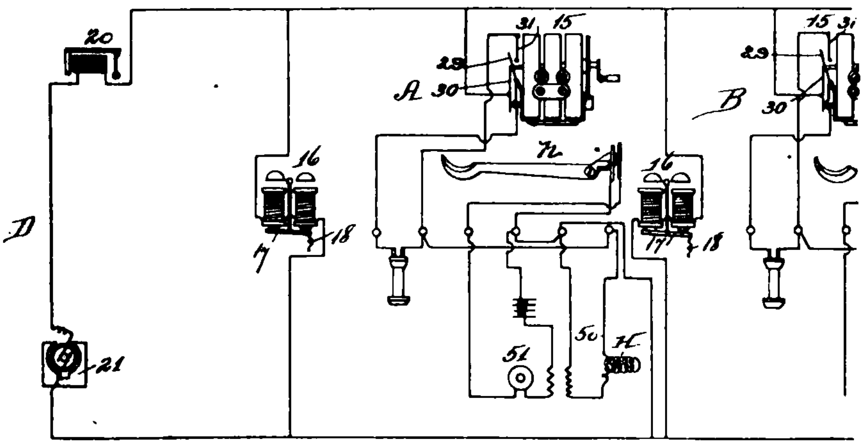
FIGS. 1, 2, 3, 4 and 5.—Details of Cook Generator.

kind. The principal feature of this invention is in the generator, the details of which are shown in figures 1, 2, 3, 4 and 5. The armature and pole pieces are arranged in the ordinary manner, but an insulating strip k, shown best in figure 5, is fastened to one side of the armature spindle, so that the spring brush b will make contact with the armature spindle during half of a revolution only. In this manner, every alternate wave of the generator will be "weeded out," so that the waves which are sent to line will be in one direction only. The shunt mechanism is operated by the crank shaft, which carries the large gear wheel. This shaft turns in a hollow sleeve 24, which is and cuts out the receiver from the calling circuit.

The peculiar arrangement of this mechanism has for its object the prevention of one subscriber ringing any other subscriber by turning his generator backwards, for it is obvious that a backward turn of the generator would send to line currents of the opposite polarity from those which were sent by turning the generator forward, and this would accomplish a result which might be desirable to the subscribers, if not to the managers of the exchange. A backward turn of the generator in this device will not break the shunt, and therefore will allow no currents to pass to line.

The circuit connections of an instrument are shown in Fig. 6, the switchboard generator being shown at 21, and the drop at 20. 16 are the high-wound bells bridged across two sides of the line at stations A and B. In another bridge circuit, at each station is included the generator which is normally shunted by the device described. The hook switch h serves only to open and close the local circuit containing the transmitter 51 and battery. The circuits through this bridge may be traced normally from the upper line wire to the spring 30, thence through spring 29 to the receiver, and through a resistance H, and the secondary of the induction coil to the other side of the line. This circuit is normally closed, and, were it not for the resistance H, would serve as a shunt which would greatly lower the efficiency of ringing of the bells 16. The resistance h is described as being differentially wound to a resistance of about 5,000 ohms.

Fig 6.



Circuits of Cook Bridging System.

In order to prevent the ringing through the receiver when the generator at any station is operated, the spring 29 automatically breaks contact with the spring 30, and at the same time makes contact with the spring 31, which leaves the receiver out of circuit entirely. It would seem that the use of the high-wound coil H which is permanently in series not only with the talking apparatus but also with the generator, would be a very serious drawback, but Mr. Cook says in his specification, "I am aware that to some this additional resistance in the talking circuit would appear very detrimental, but in practice it is impossible to detect with the telephone whether such a coil is in circuit or not." Of course the resistance, even though it be a non-inductive one in series with the generator, will always have a very decided effect; but inasmuch as the generators in this system are for the purpose of operating the switchboard drop, and not the various subscribers' bells, this defect can probably be overcome to a large extent.

This system is particularly interesting in view of recent developments, in connection with the bridging bell patent.

LOCK-OUT SYSTEMS.

A very interesting class of systems has within a comparatively recent time come into existence to secure a certain degree of secrecy in party line service. In the systems so far described, there is nothing to prevent one subscriber from taking his receiver off the hook and listening to whatever conversation other subscribers may be engaged in. Another object of the lock-out system is to prevent subscribers, desiring to use their instrument, from breaking in while the line is already busy, thus ringing in the ears of the parties who are using their telephones.

Mr. C. E. Scribner, of the Western Electric Company, has, as in nearly every other branch of telephony, been well to the front in this line. One of these systems, designed by Mr. Scribner, is shown in Fig. 7, which illustrates two subscribers' stations A and B connected by the line wires 5 and 6 of a metallic circuit with the switchboard at the central office C.

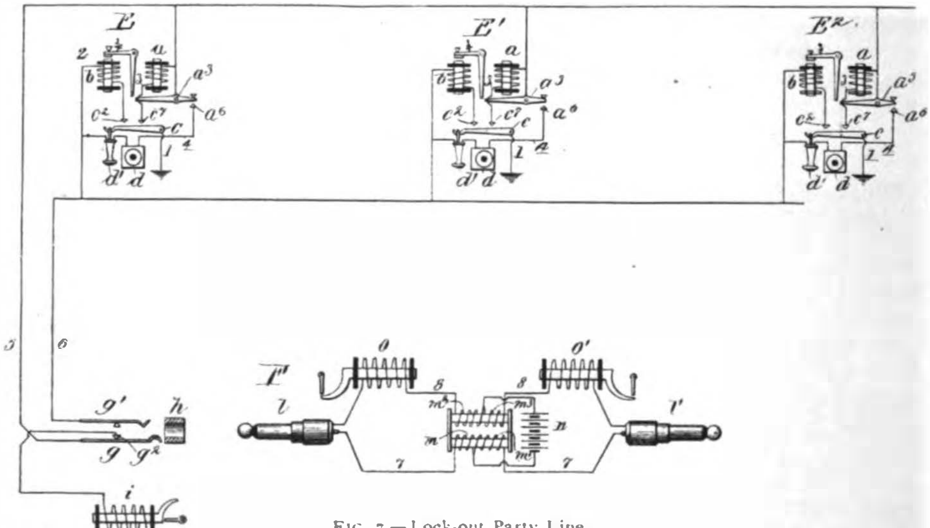
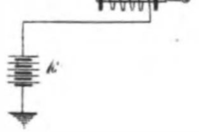



FIG. 7.—Lock-out Party Line.

The mechanism for operating the lock-out devices at each station on the party line is shown in Fig. 8. In this figure a magnet a, supported on a bracket a^1 is provided with an armature a^2, carried upon a lever a^3 pivoted as shown. The armature a^2 is normally pulled away from the core of the magnet a by the attraction of gravity, the magnet being mounted with its core vertical. The backward movement of the lever is limited by the stop a^5, and the forward movement by the contact anvil a^6, with which it makes contact when the armature is attracted.

Mounted alongside of the magnet a is a similar magnet b, having its armature b^1 mounted on the short arm b^2 of a bell-crank lever b^4. The armature is normally held away from the core of the magnet b by the spring b^5 which bears against the adjustment screw b^6. When the armature b^1 is attracted by its magnet, the long arm b^4, which normally rests against the back stop b^7, is pushed sidewise and into the path of the lever a^3, so as to prevent the upward movement of the latter.

The hook switch is of the Warner type, and the contacts are so adjusted that the spring c^2 makes contact with the lever at the point c^4 before the spring c^7 makes contact at the point c^6, when the receiver is removed from the outer end of the hook. The action of these springs is the same as in the ordinary receiver hook, being such that when the hook is depressed the spring c^7 breaks contact with c^6, resting on the hard rubber lug c^5, while the spring c^2 breaks contact with c^4 and rests on the hard rubber lug c^3.

Referring now to Fig. 7, and remembering that the various parts in the apparatus shown at the substations E, E^1 and E^2 bear the same reference letters as those in Fig. 8, the circuits may be traced as follows: The telephone switch hook C is permanently connected to ground by the wire 1. The wire 2, leading from line wire 6, includes the winding of the magnet b and terminates in the contact point c^2 which, it must be remembered, is the contact first made when the hook is raised. The wire 3 which branches from the main line wire 5 includes the winding of the magnet a, and terminates in the contact spring c^7. The wire 4 branches from the wire 2 and includes the receiver d^1 and the transmitter d, and terminates in the contact point a^6 with which the locking lever a^3 makes contact when attracted by the magnet a. The apparatus at all of the subscribers' stations on the line are connected in the same manner. The main line wires 5 and 6 terminate respectively in the springs g and g^1 of the spring jack. The spring normally rests on the anvil g^2 which forms the terminal of a wire leading through the self-restoring drop i and the battery k to ground.

The operator's circuit is shown at F, l and l^1, being respectively the answering and calling plugs of a pair. The tips of the plugs are connected together through the wire 7, while the sleeves are similarly connected through the wire 8; this latter wire including serially the clearing out or supervisory signals o and o^1. The conductors 7 and 8 each includes two helices, m, m^1 and m^2, m^3, respectively. The point between the coils m and m^1 is connected to one terminal of a battery n, while the opposite terminal of the battery is connected to the junction of the coils m^2 and m^3. The arrangement is such that the coils m and m^2 act inductively on the coils m^1 and m^3, and vice versa. When a plug is inserted into a jack, therefore, the battery n is bridged across the line, and thus supplies current directly for operating the telephone transmitters and receivers at the substations.

The apparatus is shown in its normal or idle condition; that is, with the plugs withdrawn from the jacks and with all of the subscribers' receivers resting upon their respective switch hooks. Suppose, now, that a subscriber at station E desires to be connected with some other subscriber; he removes his receiver from its hook, and the latter in rising makes contact first with the point c^2 and immediately thereafter with the point c^7. The making of the contact with the point c^2 produces no result on the magnet b, because there is no battery in circuit with the line wire 6 with which the wire 2 is connected. As soon, however, as the contact with c^7 is made, a current flows from the battery k through a coil of the drop i, thereby actuating the shutter; thence through the contact g^2 and spring g of wire 5; thence through the magnet a and wire 3 to contact c^7 and to ground, which forms the return circuit of the battery. This current, besides actuating the shutter at the central office, causes the lever a^3 to come in contact with the point a^6, thus completing the circuit between the two sides of the line through

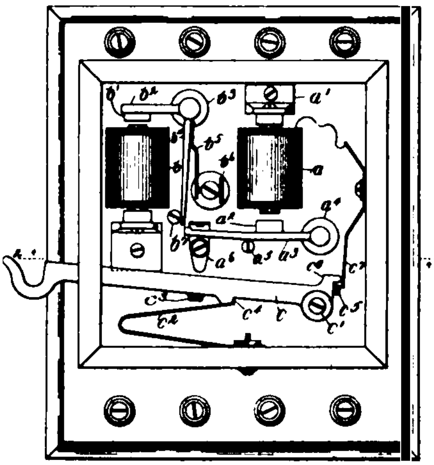


FIG. 8.—Scribner Lock-out Box.

the telephone apparatus proper. The lever a^3 is allowed to rise, for the reason that the magnet b has not actuated its armature to pull the lever b^4 into the path of the lever a^3.

The operator at the central station seeing the shutter fall, inserts the plug l into the spring jack, thus establishing connection with the line, and, at the same time, breaking the connection between the line wire 5 and the drop i. The operator's talking apparatus is not shown, but it is adapted to be bridged across the cord circuit 7 and 8 in a manner well understood. It will be noticed that no induction coil is used at the subscribers' stations, the current from battery n passing directly through the transmitter and receiver in series. This circuit may be traced as follows: Starting at the upper pole of the battery n the current passes through coil m^2, wire 8, annunciator o, sleeve of plug l, sleeve spring g of the jack, line wire 5, lever a^3 at the subscriber's station E, contact point a^6, wire 4, transmitter d, receiver d^1, line wire 6, tip spring g^1 at the central office, tip of the plug l, wire 7 and coil m to the other pole of the battery n.

The subscriber then communicates with the central office in the ordinary manner, and is there connected with some other subscriber in the exchange by means of the plug l^1. Suppose, now, that while the subscriber at E is using

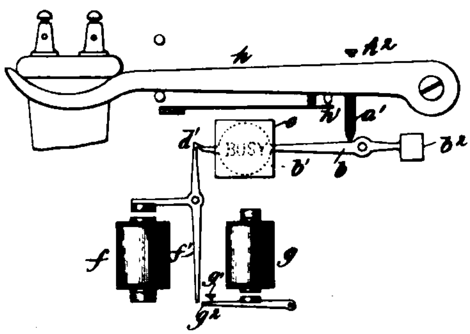


FIG. 9.— Busy Signal.

his telephone, the subscriber at E^1 desires also to use the line; he removes his receiver from its hook, and as before the lever of the hook first makes contact with c^2, and later with c^7. As soon as the contact is made with c^2, however, the magnet b at that station attracts its armature and pushes the stop-controlling lever b^4 into the path of the circuit-controlling armature a^3. The circuit through this magnet b may not be at first apparent, but may be traced as follows: From the line wire 6 through the magnet b at station E^1 to contact c^2 and to ground; thence to the ground at station E, where the receiver is also off its hook, and through the contact point c^7 at that station and magnet a to the wire 5. Current is supplied to this circuit from battery n. Since the lever a^3 at station E^1 cannot rise, it is impossible to complete the circuit through the telephone apparatus at that station at the point a^6, and is thus impossible for the subscriber at that station or at any other station to use his telephone until the subscriber at E has finished his conversation.

If the subscriber E^1 had attempted to use the line after the subscriber E had removed his receiver from the hook, but before the operator at the central office had inserted the plug into the jack, the same state of conditions would have obtained, except that the source of current would have been from the battery k; for when the subscriber at E removed his receiver from its hook, the battery k became connected with the wire 6, thus making the conditions such that when the receiver at any other station was removed from its hook the magnet b at that station would operate its lever to lock the apparatus.

The call-sending apparatus at central office and the call-receiving apparatus at the subscribers' stations are not shown, but such calling is accomplished by the use of the ordinary bridging bells.

When the subscriber at station E has finished his conversation he replaces the receiver on its hook in the ordinary manner. This breaks the connection which exists between the two sides (5 and 6) of the line, and therefore stops the flow of the current from the battery n. This allows the shutter of the clearing-out drop o to fall, it having been raised automatically by this current when the connection was established. This shows the operator that a disconnection is desired. As soon as the subscriber, who is connected by the plug l^1, hangs up his receiver, the shutter o^1 falls in a similar manner, thus indicating to the operator that both lines are free.

This system is instructive in many ways. It not only embodies a very ingenious method for securing privacy on party lines, but also exhibits the features of automatic calling on the part of the subscriber, and of the centralized transmitter batteries, now in common use by the Bell companies. The apparatus at the subscriber's station has no calling generator or batteries of any kind, all such being placed at the central office, where they undoubtedly belong.

Fig. 9 illustrates diagrammatically a mechanism for use on circuits practically the same as those in the system just described, with the added feature that a signal is automatically displayed for indicating to a subscriber when the line is in use at some other station. In this the stop-controlling lever, represented in this figure by f^1, carries also a catch or hook, d^1, which normally engages a lever b, which carries a target marked "Busy." Assuming that the line is not busy, any subscriber who raises his receiver from the hook will obtain control of the line, as described in the previous system. The magnet f, however, not having current, will not release the lever b, and will thus hold the target in its concealed position, even though the hard rubber lug a^1 on the hook lever allows it to rise. If while the line is busy, however, a second subscriber attempts to use it, the raising of his receiver will withdraw the lug a^1 from engagement with the lever b, and in the manner already described, the magnet f will take current. This will not only lock the lever g^2, but will also withdraw the catch d^1 from engagement with the lever b and allow the busy signal to rise. Thus the subscriber will not only be locked out, but will be notified of that fact by the signal. Upon the replacement of the receiver on the hook, the lug a^1 serves to restore the busy signal, thus doing away with all magnetic resetting devices.

THE LONG-DISTANCE TELEPHONE AND RAILWAY TRAVEL.

That the more and more extended use of the long-distance telephone between the larger cities would seriously affect the passenger travel on the railroads would hardly be believed except by those who have given the subject close attention. Not only has the travel been much diminished, but according to the statement of a railroad official the business of one of the limited trains between New York and Chicago has been practically ruined by the telephone, says the *Railroad Gazette*.

This result is not very surprising. One of the definite objects had in view in putting on 25-hour trains between New York and Chicago was the accommodation of brokers and business men of Chicago and the Northwest, who demanded quick time. Their trips to New York were taken on occasions of utmost importance, when a little time meant thousands of dollars. By means of the "Limited" the broker or business man was taken to New York in the quickest possible way. He talked as fast as he rode and made an equally quick return to Chicago. The business man was willing to pay the price assessed for this development in rapid transit.

The patronage of people whose time was less valuable to them was not expected to contribute much to the income of these trains, so that their whole dependence was expected to be, and was, on two classes: the business men aforesaid and pleasure travelers to whom a few dollars extra was not a noticeable item. Then came the introduction of the long-distance telephone. People at first were slow in realizing its benefits. Slowly but surely they have, however, come to appreciate its significance. A broker or grain dealer in Chicago has in mind a "big deal"; he telegraphs to New York asking for certain information and adds: "Call me up by long-distance telephone and give me your answer." The result is that for $15 or $20 a talk is held with the New York man. Having received the telegram, he has had an opportunity to concentrate his expressions to the shortest possible statements; he has even jotted them down, and at the proper time calls up his man and transacts his business. So it is done every day. Half a dozen grain men who had been in the habit of making frequent trips between Chicago and New York said that for $3 or $4 they could now transact business which formerly required a three-day trip.

JOHNSON says: "All the performances of human art, at which we look with praise and wonder, are instances of the resistless force of perseverance."

MILWAUKEE, WIS.— A new corporation, called the Citizens' Telephone Company, has made application for a franchise. It claims to have 1,600 subscribers promised, and that a franchise will be granted whenever it is ready to install the plant.

PARTY LINES.

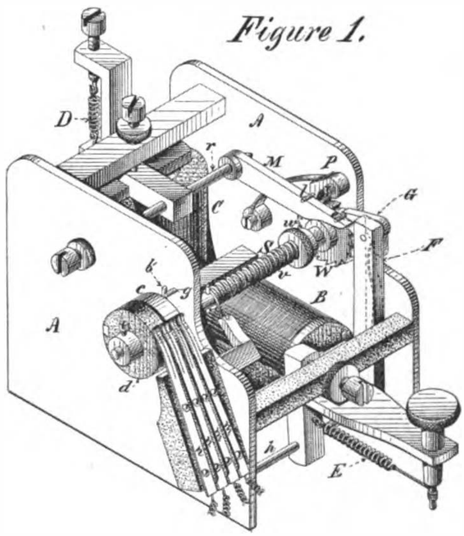
III.—BY KEMPSTER B. MILLER, M.E.

SELECTIVE SIGNALING—"STEP BY STEP."

We come now to the consideration of selective signaling on party lines, and it will be remembered that systems for accomplishing this result were divided into three distinct classes. The first of these classes, which will form the subject of this article, includes those systems depending on step-by-step mechanisms at the subscribers' stations, controlled from the central station in such a manner as to enable the operator to pick out or select the desired station and ring its bell to the exclusion of all others on the same line. It is well to state beforehand that this branch of party line work will be of interest mainly from a historical standpoint and will therefore be treated in that light. I am not aware of a single line in successful practical operation, using a system of this class; but this should not detract from the interest of the subject, for there is no doubt but that apparatus can be successfully operated on this plan, especially in view of the success of the "ticker" and other systems of telegraphy depending for their operation entirely on step-by-step movements. The use of step-by-step mechanisms in this class of telephone work has apparently from the very first offered the most plausible solution of the problem, and there are seemingly no insurmountable obstacles in the way of its being put into successful practice. Moreover, the fact that the patents on several of the systems to be described in this article have already expired, or will have expired before this article is fairly in print, will be of special interest to the independent telephone people.

One of the very first to apply step-by-step mechanism to the party line problem was E. N. Dickerson, Jr., as early as January, 1879. His substation mechanism is shown in Fig. 1, and the line and local circuits respectively in Figs. 2 and 3. Before describing the apparatus, however, it is interesting to note how clearly Mr. Dickerson, at this early date, had the requirements of party-line signaling in mind, by quoting from the preliminary portion of his specification, which reads as follows:

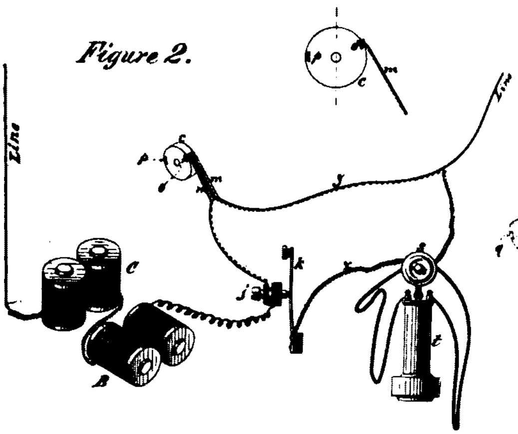
Figure 1.

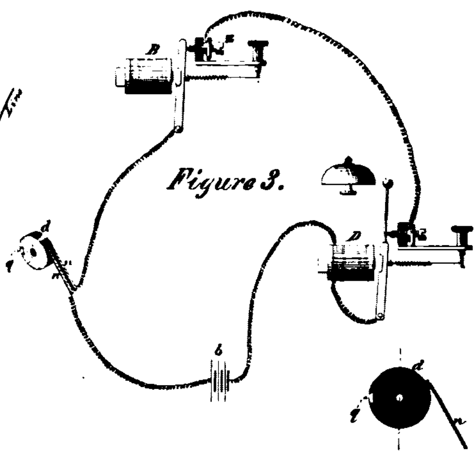


In the practical operation of . . . . . systems in which a series of instruments is placed upon a wire connecting with a central office, the different instruments of the series being distributed in localities where there are no experienced operators, it is important and desirable to possess an instrument which can be controlled from the main office, and will signal at any one of the line offices without disturbing or signaling any of the others.

The usual and most convenient method of signaling is by means of an electric bell or gong; and one of the objects of my invention is to provide a series of signaling instruments placed upon one wire, and so constructed that the controlling operator can cause the bell connected with any one of them to sound, while all the other bells will be silent. It is also important that any one of the line offices has the power to signal the central office at any time when the apparatuses are in their normal condition, or at the time when the central office is signaling the office in question, but shall not have the power to interrupt a message or signal passing between the main office and any one of the local offices.

My apparatus also accomplishes this result, and enables a line office to signal the central office in the normal position before movement of any of the apparatuses, and also in that position when communication is maintained with it from the central office.





It is important that no office except the one called from the central office have the power to overhear messages being transmitted between any other offices.

Referring now to Fig. 1, B and C represent two electro-magnets, placed in series in the line circuit. The armature of B is mounted on an arbor *h*, pivoted in the framework as shown. This arbor carries a lever F which is moved by the armature, and by means of a pawl G steps the ratchet wheel W around in an obvious manner. A second pawl P normally acts to prevent a backward movement of the shaft S on which the wheel W is mounted; a tendency to such backward movement being given to the wheel and shaft by the coiled spring *v* mounted on the shaft.

The magnet C, by the attraction of its armature, operates upon the arm M, pivoted with the armature upon the arbor *r*. The raising of this arm lifts both pawls out of engagement with the wheel W, allowing it to be rotated by the spring until the pin *b'* engages the stop pin *g*, when it is in its normal position.

Upon the end of the shaft S are two contact wheels *c* and *d* upon which rest four springs *m m* and *n n*. The periphery of the wheel *c* is all of conducting material with the exception of two insulating strips *o* and *p*, clearly shown in Fig. 2. The wheel *d* is of the reverse construction, all of its surface being of insulating material with the exception of the metallic contact strip *q*, as shown in the small cut in the left-hand portion of Fig. 3. In the normal position of the wheel *c* at each of the stations the springs *m m* rest upon the insulating strip *o*. The insulating strip *p* on the wheel *c* and the conducting strip *q* on the wheel *d* are arranged at different positions on the wheels of each station, and always so that when the particular number of impulses necessary to place the apparatus at that station in operative relation to the line, the two strips *p* and *q* will be respectively under the springs *m m* and *n n*.

The apparatus at the central station consists of batteries of three strengths; the weakest capable of operating only a high-resistance magnet at the central station; the next strongest capable of operating the magnets B, but not the magnets C; and the third, or strongest, of sufficient strength to operate the magnets C. In order to make C responsive to the strongest current only, the coiled spring D, which controls its armature, is given a higher tension than the spring E controlling the armature of B. The signal-transmitting apparatus at the central station consists of a toothed wheel or any other device for sending a predetermined number of impulses to the line, from either of the two stronger batteries. Normally, the weakest of the three batteries is left in line.

The normal condition of the line circuit through a station is shown in Fig. 2 where the springs *m m* rest on the insulating portion of the wheel *c*, and are therefore disconnected from each other. The receiver *t* is shunted out of circuit by the automatic hook switch *s* upon which it hangs. In this condition, therefore, the circuit through the station is from the line through magnets B and C in series, thence through switch *k*, hook-switch *s* and to line. The circuit is therefore complete when no one is using the line from ground at central, through the small battery and high-resistance annunciator or bell at that station, then through all the stations in series and to ground at the end station.

To signal central, a party at any station depresses the key *k* momentarily, thus breaks the circuit and releases the armature of the signaling magnet at central. The party may then communicate with central by removing his telephone from its hook.

In order for the operator at central to call up any station, a number of impulses from the battery of intermediate strength is sent to line. The first one of these impulses advances all of the ratchet wheels one step, and the springs *m m* therefore rest on the conducting portions of the contact wheels at all except the first station, which has the insulating strip *p* so arranged as to come under the springs at the first step. As a result the receivers at every station except station No. 1 are short-circuited through the by-path containing the springs *m m* and the disk *c*. Suppose the station shown in Fig. 2 to be No. 5, then five impulses will bring the strip *p* under the springs *m m*, when the receiver will be no longer short-circuited.

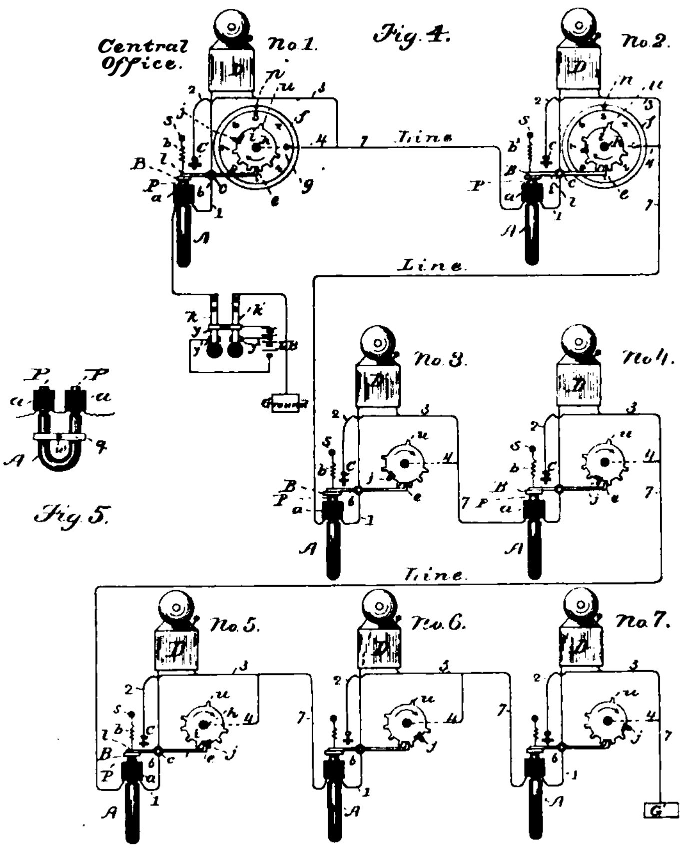
At the same time that the strip *p* comes under springs *m m*, the conducting strip *q* on the other wheel comes under springs *n n*, thereby completing the local circuit containing a battery *b* and a vibrating bell D, as clearly shown in Fig. 3.

The local circuit is only closed when the armature of magnet B rests against its back stop Z. This is to prevent the actuation of the bells D at the stations having a smaller number than the station desired, as it is obvious that the springs *n n* will wipe over the contacts *q* of all the stations in succession which have a smaller number than the one being called.

While this station is engaged in conversation the other stations are locked out by reason of their receivers being short-circuited. At the end of the conversation the strongest battery is thrown on the line, and the magnet C at each station causes the arm M to lift the pawls P and G, in consequence of which all the ratchets return to their normal position.

While any good telephone man could point out many features in this system of an extremely objectionable nature, such, for instance, as the inclusion of so many magnets in series in the line and the employment of three strengths of battery and a corresponding marginal adjustment of the magnets, the fact that such an ingenious arrangement could be devised at such an early date in the art would seem to bode exceedingly well for future development in this line.

At almost the same date George L. Anders produced a step-by-step system, depending on a somewhat different idea. All bells were left permanently in the line wire, and their hammers all actuated in unison when a pulsating current was sent over the line. A notched disk at each station prevented the bell hammer at its station from striking the bell except at such times as the notch was opposite the rod which carried the hammer. The disks were so arranged as to be stepped around by the vibrations of the bell hammers while impulses of one polarity were sent over the line. In calling a certain party a sufficient number of impulses were sent to bring the notch of the bell at the desired station into a position opposite the bell hammer rod, after which currents of the opposite polarity were sent over the line. These latter did not actuate the stepping device, but did actuate all the bell hammers as before, and the notch in the disk of the desired station allowed that bell to sound.



Dickerson used his stepping device to control a local circuit at each station. Anders left all his circuits unaltered and used his stepping device to control merely the length of stroke of the bell hammer.

Still another interesting example of the early art in this line is the system of Thomas D. Lockwood, designed early in 1881, which is well illustrated in Figs. 4 and 5. In this the toothed wheels *i* shown at the different substations are all adapted to be revolved by clockwork at exactly the same rate, so that when they are all released at once they will move with the same angular velocity until stopped. Each wheel is furnished with square teeth, corresponding in number to the stations on the circuit. These are placed at a suitable distance apart on the periphery, and in each case one tooth *j* of the series is composed of nonconducting material, which is inserted into the metal portion of the wheel. This nonconducting tooth *j* is, of course, differently placed at each station in the circuit, as shown in the drawings, where the central office wheel has its insulating tooth placed as the first tooth of the series. In station No. 2 it is the second tooth, and so on. The material of which this tooth is formed also extends forward for a short distance toward the base of the tooth in advance, so that when the lug *e* of the lever *l* strikes the insulating tooth in any instrument it shall not touch the metallic part of the wheel at any point.

Each circuit or escapement wheel is also provided with an extra tooth *u*, set at a distance from any of the others, and when the circuit is not being used, the lug *e* of each lever will be elevated and rest against the tooth *u*. This tooth *u* affords a convenient point at which each wheel may come to rest, so that after each revolution all the wheels shall be in unison.

The release magnet A, one of which is included in series in the line at each station, forms a unique feature of this system. It is shown more in detail in Fig. 5. A is a permanent magnet of hardened steel, to the poles of which are attached two soft iron pole pieces, P P, on each of which is wound a coil *a*. The strength of the permanent magnet may be adjusted by clamping the iron bar *q* at a point nearer to or farther from its pole pieces. The strength of the magnet at each station is so adjusted that it will just hold down the armature B mounted on the retaining lever controlling the toothed wheel *i* at that station.

The central office is provided with a battery and a key adapted to send a current of either polarity to the line, and also with an apparatus similar in all respects to that at each station, so that the operator may watch the positions of the wheels in their rotation.

The operation may now be readily understood. In order to start the wheels the operator depresses lever *k'* and holds it down. This sends to line a current of such a direction as to neutralize the polarity of each permanent magnet A so that all the levers are released, thus allowing all of the wheels to start under the influence of their clockworks. We will say that No. 5 is the station to be called. The operator watches the revolving wheel at the central station, and when the number 5 is under the index pointer *n*, she releases the lever, knowing that the insulating tooth at station No. 5 is then under the lug *e* on the lever at that station. The armatures of all the magnets are thus reattracted and all of the wheels again locked. The operator then depresses key lever *k*, which sends a strong current of the opposite polarity to line. This does not release the levers, as it strengthens the magnets A, but it does ring the bell at station No. 5, because the shunt which normally exists around the bells at each station has been removed from bell No. 5 by virtue of the lever resting against the insulating tooth on the wheel. The bells at all the other stations are short-circuited, and therefore do not ring. The contacts *c* at each station are provided for short-circuiting the bells when the levers are released. To bring all the wheels again to the normal position, with the tooth *u* of each resting against its lever, the operator depresses the releasing key as before and allows the wheels to rotate until the tooth *u* is almost reached. Each wheel is then stopped at the tooth *u*.

Several systems depending on the same general principles as this have been devised, but none have met with success, so far as I am aware. Much trouble is experienced in keeping the wheels in synchronism, and another and more serious difficulty is the maintenance of the contacts in proper condition. This latter feature occurs as a fault in all step-by-step systems.

The patents controlling the Dickerson and the Anders systems have expired, and that on the Lockwood system will expire on November 1 of this year. These systems have all related to signaling on a single grounded circuit with instruments in series. A similar system devised by F. B. Wood in 1888, placed all the step-by-step magnets in a controlling wire which formed a complete metallic loop, and used this circuit merely to govern the step-by-step movements which completed the desired circuits successively in a separate wire over which the signaling was accomplished. Space will not permit of a complete description of this system, nor of one invented by Mr. John I. Sabin, of the Sunset Telephone Company, in San Francisco. In this latter system the magnets of the step-by-step mechanisms were placed in a third wire and used to successively close bridge circuits containing telephone instruments and call bells at the various stations.

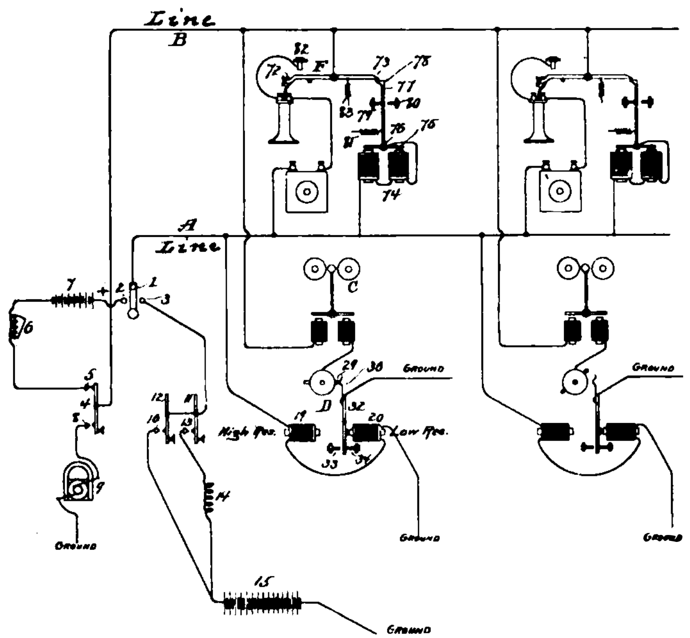


FIG. 6.

A more recent invention by Messrs. R. T. Reid and J. L. McDonnell, of Tacoma, Washington, is adapted for use on two wires only, and also contains lock-out and automatic calling features. This system is illustrated diagrammatically in Fig. 6, and some of its mechanism shown in Figs. 7, 8 and 9. In Fig. 6 (the central office) the apparatus, for the purpose of clearer illustration, is shown in a greatly simplified form, the signal-transmitting apparatus being represented by manual keys. The step-by-step mechanisms are shown in this figure at D, and are bridged between the line wire A and ground at each station. The call bells C are of the usual polarized type, and are each contained in a normally open circuit between the line wire B and ground. This circuit at each station is adapted to be closed by the step-by-step movement.

The step-by-step mechanisms are actuated and controlled by two magnets, 19 and 20, placed in series and wound to respectively high and low resistances. The magnet 19 will, therefore, operate with a comparatively smaller current than magnet 20, owing to its greater number of turns.

Magnet 19, by means of lever 25, acts to step the ratchet wheel 22 around, this wheel carrying with it the contact arm 29 and the stop arm 31. These parts are mounted on the shaft as shown, the notched wheel 28 being provided merely to secure a proper angular adjustment

FIG. 7.

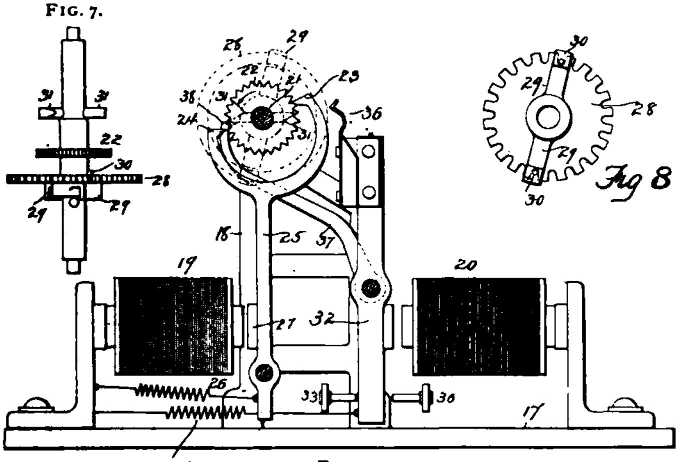


FIG. 9.

between the stop arms 31 and contact arms 29, this adjustment being different at each station. The low-resistance magnet 20 operates a contact arm 32, carrying a contact 36 insulated therefrom, and also a separate arm 37 adapted to engage the stop arms 31 and lock the shaft.

Referring again to Fig. 6, the lock-out mechanism is represented by magnets 74 and arms 76. These magnets are polarized so as to hold the arm 76 either under the hook lever F or away from it, according to the direction of the current traversing the coils.

The operation may now be understood. To call central, the subscriber removes his receiver from its hook, thus closing a circuit at his station across the two line wires and throwing the drop 6 at central by means of the battery 7. This attracts the attention of the operator. The circuit so closed between the two sides A and B of the line includes the magnet 74, and the current is in such a direction as to throw the lever 77 to the right, thus allowing the hook switch to rise and complete the telephone circuit at that station. After a plug and cord is attached to the line at the central station, a different battery of opposite polarity is connected with the line, and, should any other party remove his receiver from its hook, he will find the hook lever locked by reason of this reversed battery.

Fig 8

To call any particular party, the key 12 at central is depressed once and then released. This unlocks all of the lock arms 31 and moves all wheels forward one step. After this the key 11 is depressed a certain number of times. This throws a series of weak impulses on the line, which moves all the contact arms in unison. When a sufficient number of impulses have been sent, the arm 29 at the desired station is opposite the spring 36. The operator then depresses key 12 and sends a strong current to line and thus operates magnets 20. This closes the bell circuit only at the station desired, for the reason that the contact arms 29 at the other stations are not in the proper position to make contact with spring 36. The current from the calling generator is now thrown to line B, thus operating the bell of subscriber desired. After the required signal has been sent, key 11 is again depressed a sufficient number of times to bring all stop arms into engagement with their levers 37.

The systems described in this article have been chosen as representative of a large number of a similar nature. It has been thought best to give a rather complete and detailed description with intelligible diagrams of a few such systems, than to describe in a more general way a greater number.

THE CARTY BRIDGING BELL CASE.

BY EDWARD E. CLEMENT.

This was a suit in equity in the United States Circuit Court for the Western District of Pennsylvania, on a bill of complaint filed November 4, 1896, by the Western Electric Company against the Millheim Electric Telephone Company et al. The patent held to have been infringed is No. 449,106, to John J. Carty, granted March 31, 1891, on an application filed August 16, 1890. The decision handed down awarded to complainants the decree prayed for. The prayer was the usual one for a preliminary and a perpetual injunction, an accounting of profits, and damages, the destruction or delivery of the infringing apparatus, and costs.

It is not my purpose here to go into the decision, which is not only eminently fair in tone — although to interested parties perhaps illogical — but is much clearer technically than most patent decisions; but rather to give some insight into the subject matter of the patent and its claims, the apparatus alleged to infringe, and what the decision covers.

Mr. Carty's invention is directed to the solution of that problem which has vexed so many telephone engineers and exchange managers — the party line. In the early days the individual signal engrossed the attention of experts as the probable solution of the many-party connection — that is, the arrangement of selective devices that would permit one station and one only to be called, no others being at the moment free, or in circuit. In such a system many arrangements of the selective relays might be had which would not interfere with the voice currents, and it was permissible to have the signals or ringers entirely disconnected until required. The practical operativeness of such devices, however, was discovered to be — at least at that time — problematical, and until recently, when Messrs. Sabin and Hampton, Dean and others have again essayed the old path, it has been abandoned.

Mr. Carty tried a different tack. He took the common series line and studied it to perceive what its salient defect was, and how that might be eliminated. He decided that the actuation of all the signals for every call was a permissible evil if the voice transmission could be rendered somewhere near as good as it would be on a one-party line. According to his testimony in this suit he attacked the problem of necessity, and in order to save a long line that would otherwise have to be abandoned. The solution of the problem was found in the arrangement of circuits at each station shown in the accompanying diagram, Fig. 1, which contains the substance of Fig. 2 of his patent drawing.

Referring to the figure it will be observed that the ringer R is permanently

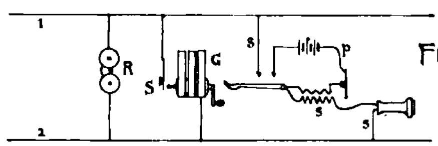


FIG. 1.

connected across the line wires 1 2. The generator G is in a normally open shunt adapted to be closed by a device represented in the figure as a strap key S. The talking set has its secondary circuit *s*, containing the receiver and secondary of the induction coil, in a second normally open shunt adapted to be closed, together with the primary circuit *p*, when the hook switch rises. The whole secret of the efficiency of this arrangement is the high resistance and impedance of the ringer magnets. Generator current in sufficient volume and of low frequency is able to pass through all the windings and ring all the bells, but voice currents are limited almost as completely to the two through line wires

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PARTY LINES.

IV.—BY KEMPSTER B. MILLER, M.E.

STRENGTH AND POLARITY SYSTEMS.

The term "strength and polarity" is borrowed from the Patent Office nomenclature, where it is applied to that class of selective calling devices which depend for their operation on changes in the strength or in the direction of a current, or on changes in both. The idea of selective signaling by changes in the strength and polarity of a current was well known in telegraphy before the birth of the art of telephony. The duplex and quadruplex systems of telegraphy of the present time afford the best possible demonstration of the utility and practicability of this system when properly developed. In the quadruplex, one key at each station operates to produce changes only in the strength of the current, while the other key at each station is capable of producing changes only in the direction of the current. Also at each station are two relays, one termed the "neutral relay," responsive to changes only in the current strength, being indifferent to changes in polarity, and the other termed the "polarized or polar relay," which is responsive to changes in the direction of the current only, being indifferent as to its strength. The arrangement is such that the key at one station governing the strength of current will operate only the neutral relay at the other station, while the key governing the direction of current will operate only the polarized relay at the other station. This system, therefore, not only admits of selective signals being sent one at a time, but also allows four to be transmitted simultaneously over a single grounded circuit, two in one direction and two in the other.

The problem is somewhat different in telephone work, but the same principles are involved, and the success of the quadruplex telegraph demonstrates beyond question that the strength and polarity system can be made thoroughly practical in telephony. At present, nearly all of the party lines successfully using selective signaling are operated on this general plan.

Among the first to attack the problem from this standpoint was George L. Anders, who in 1879 produced a two-party line system, having the call bells at the two stations polarized oppositely, and included serially in the line wire. Currents in a positive direction would therefore operate the bell at one station, and those in a negative direction that at the other. The call bell was arranged with two armatures, one polarized and one neutral, the latter serving to operate the bell striker, and the former serving simply as a lock for the striking armature. The bell would operate only when the current was of proper direction to cause the magnet to remove the locking armature from the path of the striking armature. The operator at the central station used a double lever key to send either positive or negative calling currents to line. This was the forerunner of several more successful plans recently devised.

The system shown in Fig. 1 is interesting as being one of the early attempts to utilize changes of both strength and polarity. It is typical of many of the early failures in this line of work, and is not here described because of any practical ideas it contains.

Eight stations are connected in series in the line, which is adapted to be grounded at central through the various keys and batteries as shown. Each of the controlling magnets consists of a permanent horseshoe magnet carrying soft iron pole pieces and bobbins. The armature of each magnet is normally attracted by the permanent magnetism, and thus holds open a local circuit, shown only at the first station, containing a battery and bell at each station. The magnets at stations 1 and 2 exert an equal pull on their armatures but are of opposite polarity, and likewise the two magnets in each other pair of stations are of equal strength but of opposite polarity. The strength of the magnets is, however, different for each successive pair of stations — those at stations 1 and 2 being the weakest, and those at stations 7 and 8 the strongest. Four different strengths of current of either polarity may be sent to line from central by the closure of the various switches. The magnet at any given station is supposed to release its armature only when a current of the proper strength and direction is sent over the line to exactly neutralize its permanent magnet. Thus, if it is desired to call station 1, switch lever 1 at central is closed. This sends a positive current from one set of cells over the line which is of the proper strength and direction to neutralize the pull of the magnet at station 1. This magnet will therefore release its armature. The armature at station 2 will not be released, because the current is in the wrong direction, and therefore strengthens the pull of the magnet. The armatures at the other stations will not be released, because the current is not strong enough. In call-

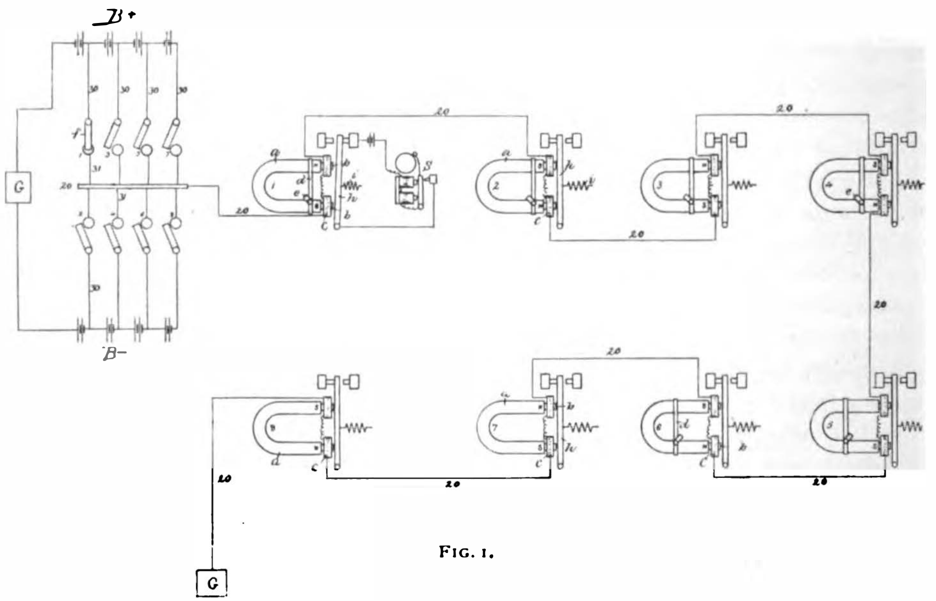

FIG. 1.

ing, say station 8, a strong negative current would be employed. This would more than neutralize the magnets of stations 2, 4 and 6, giving them an opposite polarity, and thus still attracting their armatures.

Coming now to the more practical systems, one due to Sabin and Hampton, and used to some extent on the Pacific coast, will be considered. This is not properly a strength and polarity system, but is described in this place because it contains several ideas upon which later systems have been based. The idea upon which this is based is that three circuits may be obtained from the two wires of a metallic circuit by using the two wires for one circuit, one of the wires and the ground return for another, and the other wire and ground for the third. In Fig. 2, two party lines of three stations each are shown connected through a cord circuit and the jacks and plugs of a switchboard at the central office. The circuits of one station are shown in the small detached portion of this figure. Between the two limbs of the metallic circuit are included the talking apparatus, composed of the transmitter t and receiver r, associated with the induction coil, battery and switch hook in the ordinary manner. The talking circuits at all of the stations are the same as this, but are represented merely by a circle in each station. The bell b of subscriber A is included with a condenser in a bridge circuit between the two sides of the line, the bell b of subscriber B is included in a branch between the side a' of the line and ground, while the bell b of subscriber C is similarly included between the other side, a, of the line and ground. The bells of stations D, E and F on line $d\ d'$ are similarly arranged.

The limbs $a\ a'$ of the metallic circuit extend to the line springs $a^2\ a^3$ of a spring jack on the switchboard, which normally rest against the contact anvils $a^4\ a^5$ between which are included the battery a^6 and indicator or annunciator a^7.

The operator's telephone set e is included in a normally open bridge between the tip and sleeve strands $e'\ e^2$ of the cord, a key e^3 being provided for bridging the telephone into circuit. A clearing-out indicator f and battery f' are included in a bridge between the two strands, a balancing coil f^2 being also located in said bridge. By means of a key g, a generator g' may be bridged between the strands e' and e^2, the generator g^2, by means of a key g^3 may be connected between the sleeve strand e^2 and ground, while the generator g^4, by means of the key g^5 may be similarly connected between the tip strand e' and ground.

Suppose subscriber A desires to converse with subscriber D. He removes

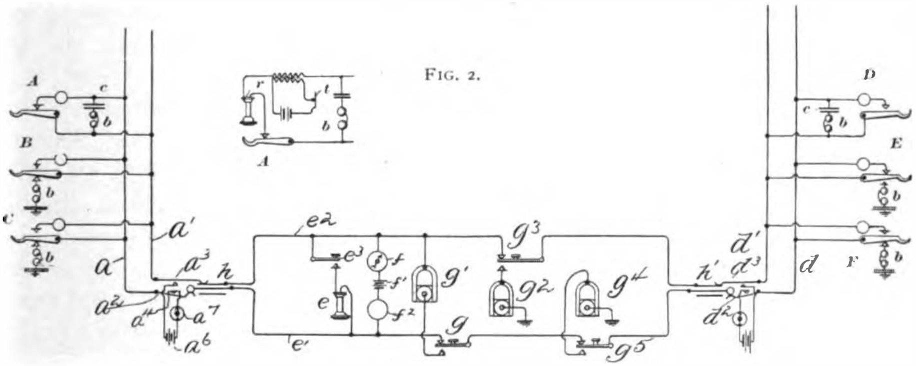

FIG. 2.

his telephone from its hook, thus completing the circuit of battery a^6 through indicator a^7 and thus calling the attention of the operator, who inserts answering plug *h* in the spring jack, thereby cutting out battery a^6 and indicator a^7. The operator then depresses the key e^1, thus bridging her telephone into circuit and receives the number of the called subscriber D. She then inserts calling plug *h'* in the spring jack in which the limbs *d d'* terminate, and depresses key *g*, thus sending a calling current from the generator *g'* over the metallic circuit to actuate the bell *b* at station D. Subscriber D removes his telephone from its hook and A and D are connected for conversation.

Had A desired connection with F instead of D, the operator would have depressed key g^5, thus ringing the bell *b* at station F over a circuit formed by the line wire *d* with ground return.

The condensers *c* at stations A and D are for the purpose of preventing the steady current from battery a^6 from leaking through the bridges in which the bells *b* at those stations are placed. These condensers form a break in these bridges through which an unvarying current cannot pass, but they allow the alternating currents from the calling generator to act inductively through them to operate the bells as though they were not present.

Where three stations are thus operated on a metallic circuit, much trouble occurs, due to the fact that the two bells on a line at the stations which are not being called are always in series in a circuit which forms a shunt to the bell at the station which is to be called. Thus if a generator current is sent over the metallic circuit to call station A, a part of this current will leak from limb *a'* through bell *b* at station B to ground, thence to ground at station C and through the bell *b* at that station to the other limb *a* of the line. This bridge circuit has about twice the resistance of the bridge at A (disregarding the condenser), and this fact must be depended upon to prevent the bells at B and C from ringing. The same conditions exist in ringing either of the other bells, and this difficulty has rendered the use of three stations on a line, according to this method, impracticable save in rare cases, as it is very difficult to so adjust the bells that they will respond only at the proper times. Two stations on a line, arranged as at B and C, may, however, and often do, give good service. On long lines, however, there is sometimes enough induction between the two wires of the metallic circuit to cause both bells to ring when only one is intended to respond.

A very successful four-station party line system devised by Mr. Angus S. Hibbard is shown in Fig. 3. In this system, as in several others, the idea first used by Anders, of placing two oppositely polarized bells on a single line, has been combined with that of Sabin and Hampton, just described, of ringing over different circuits formed by using the separate limits of the line with a ground return.

At stations A and B polarized bells *d* and *d'* are connected between the limb *a* of the line wire and ground. The bell at A is so polarized as to be operated only by currents sent over the limb *a* in one direction, while the bell at B will respond for a similar reason only to currents in the same limb in the opposite direction. In like manner, the bells *e* and *e'*, at stations C and D, are oppositely polarized and connected between the limb *a'* and ground, so that bell *e* will respond to current sent over line *a'* in one direction, while the other bell *e'* will respond to current over the same wire in the opposite direction. Thus, any one of the four stations may be called alone by sending the current in proper direction over one of the two wires.

The line terminates at the central station in a spring jack *f* composed of line springs f' and f^2 normally resting against anvils, connected respectively to a battery B′ and signal indicator S in substantially the same manner as in the Sabin and Hampton system. In this case, however, the signal indicator is an incandescent lamp adapted to be lighted by current from the battery B′ when the receiver at any station on the line is removed from its hook.

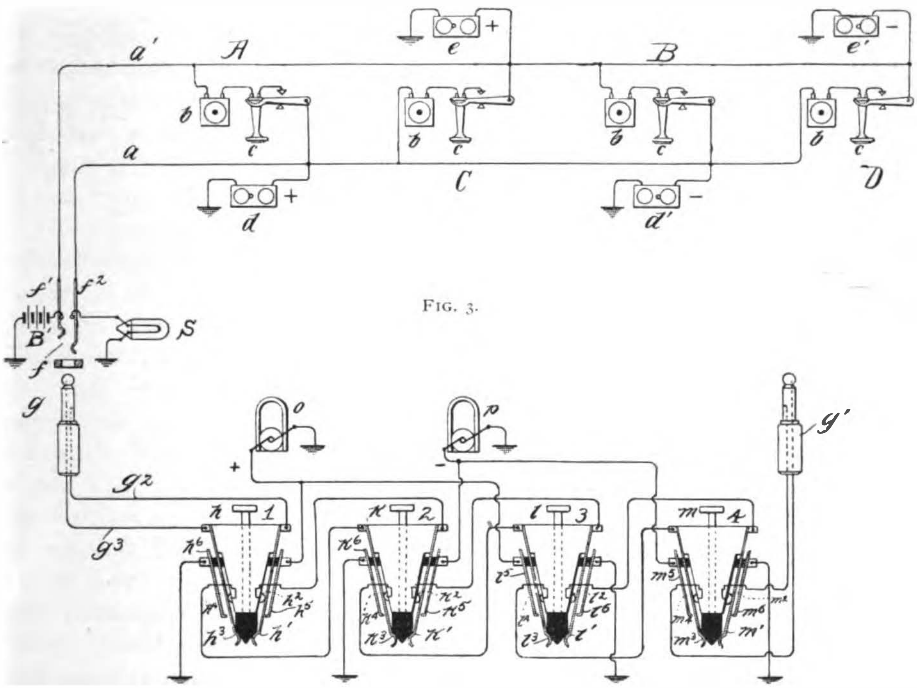

FIG. 3.

Four ringing keys, 1, 2, 3 and 4, are associated with the plugs *g* and g' in such manner as to enable the operator to connect the terminal of either of two grounded generators *o* and *p* with either the tip or sleeve strand of the cord, and therefore with either side a' or *a* of the line into the jack of which plug *g* is inserted. The generators *o* and *p* have opposite poles grounded, and we will say generator *o* is adapted to send positive impulses to line, and generator *p* negative ones.

When it is desired to ring the bell at station A key No. 1 is depressed, thus closing the circuit of generator *o* through contact h^5, spring h', sleeve-strand g^2, plug *g*, spring f^2, limb *a*, bell *d* to ground and back to the generator. A portion of the current also passes through bell d' to ground, but as this bell is polarized to respond only to negative currents it remains irresponsive. Should it be desired to ring the bell at substation B, key No. 2 is depressed, thus sending a negative current from generator *p*, to line *a* through k^5, k', h^2, h', strand g^2, and by the same path as before through bells *d* and d' to ground. Only bell d' will operate because *d* is responsive only to positive currents. Should it be desired to ring the bell at substation C, key No. 3 is depressed, while if it is desired to ring the bell at substation D, key No. 4 is depressed.

When the key No. 1, for instance, is depressed to connect the generator *o* in circuit with the limb *a* and ring the bell *d*, the spring h^1 is brought into engagement with grounded contact h^6, thus grounding the strand g^3 and the limb *a′* and preventing the accidental ringing of the bell *e*, should, for instance, one of the telephone-receivers be removed from its hook and a path thus provided to the limb *a′*. The current thus finds a short

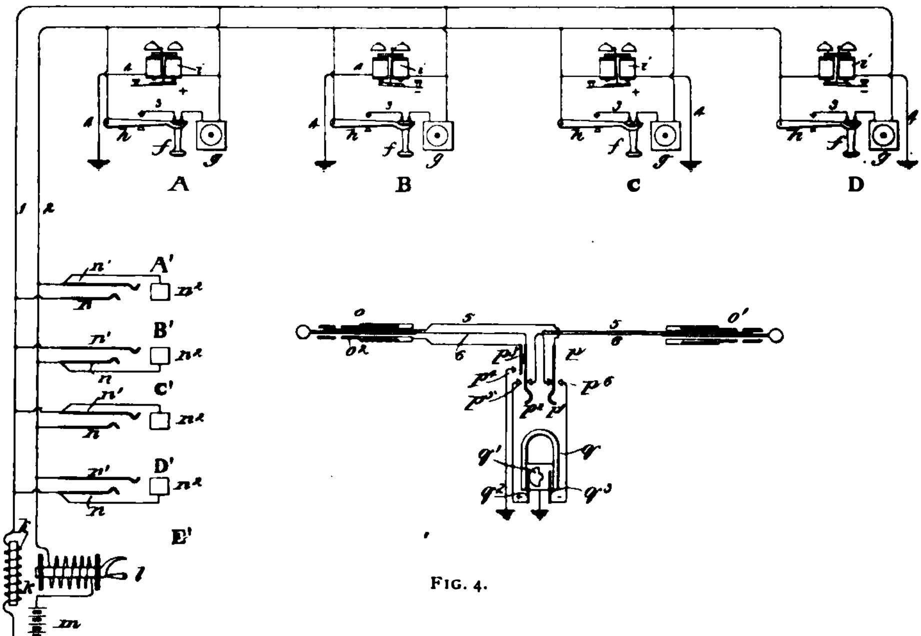

FIG. 4.

path to ground over the limb *a′*, strand g^3 and grounded spring h^6, and sufficient current will, therefore, not pass through the bell *e* to ring it.

Instead of providing four keys in each cord set, a single set of keys is usually provided, adapted to be connected by a suitable switch with any particular pair of cord conductors that may be for the time in use.

This system with slight modifications is used in a number of Bell exchanges and apparently is a success. The practice of putting the lamp signal directly in the line circuit has, however, not proven very satisfactory, even in cases where a separate metallic circuit serves each subscriber. Accidental crosses or grounds on the line expose the lamps to higher voltages than intended, thus frequently causing burn-outs. On party lines another difficulty arises, due to the difference in the resistance of the circuit when closed at the different stations, owing to the resistance of the line wire between the stations. Obviously the circuit formed by removing the receiver at A is of less resistance and will therefore expose the lamp to a greater voltage than that formed by removing the receiver at D. This, however, could be compensated for by winding the receivers of the nearer stations higher than those at the farther, or by inserting compensating resistance coils.

Another system using exactly the same method of selective signaling, but employing a very ingenious arrangement of apparatus for carrying it out, is one devised by Mr. F. R. McBerty, of the Western Electric Company. This is shown in Fig. 4. The bells at each of the stations and also the talking apparatus are arranged with respect to the two wires of the metallic circuit in precisely the same way as in Hibbard's system. As a safeguard to prevent the bells ringing by the wrong direction of current, a light spring acts on the pivoted armature of each to retain the armature normally in the position toward which it would be attracted by a current in a direction not intended to operate the bell. The operation of signaling central is identical with that already explained.

In connection with the line conductors 1 2 are four spring jacks, A′, B′, C′ and D′. Each of these has a short line-spring n, a long spring n', and a tubular thimble n^2. The connection of these springs and thimbles to the conductors of the line is different in the case of each jack, as examination will readily show.

The switchboard is provided with the usual plugs o o', forming the terminals of a plug-circuit 5 6, which includes a calling key p. This key p, in addition to the pair of switch springs p' p^2 and their normal and alternate contact anvils, has a spring p^3, which is adapted to register with an anvil p^4 when the spring is thrust outward. The spring p^3 constitutes the terminal of a contact piece o^2 of the calling plug o, which is constructed to register with the ring n^2 of a spring jack into which the plug may be inserted. The anvils p^5 p^6 of springs p' and p^2 constitute the terminals of a generator q of alternating currents. This generator is due to Scribner, and is of peculiar construction. It has an armature of the ordinary type, one of whose terminals is grounded permanently, and the other of whose terminals is led to a semicylindrical commutator q', which rotates between two contact springs q^2 and q^3. These springs are so placed with relation to the point at which the direction of the current in the armature is changed that spring q^2 receives in each revolution a pulsation of positively directed current, and the spring q^3 during the other half of the revolution a negatively directed pulsation. The operation of the key p therefore always connects the positive spring of the generator with the tip strand 6, the negative spring with the sleeve strand 5, and at the same time connects the plug contact o^2 with the ground. The arrangements of the jacks with respect to the line wires are such that the mere insertion of the plug o in any jack will establish the proper relations between the generator and the line, to operate the bell at the corresponding station upon the depression of key p. Thus suppose the operator wishes to call station A. She inserts the plug in jack A′ of that line, and depresses key p. A pulsatory current in a positive direction will now flow from the spring q^2 through the contact points p^5 p^2, thence through conductor 6 of the plug circuit to line conductor 1, and thence through branch 4 and bell i at station A to ground. The bell will be operated by this current. The bell at station B will also receive part of this current, but not be operated on account of its polarity. A pulsatory current, whose pulsations occur in the intermissions of current through spring q^2, and of opposite direction, will flow out from spring q^3 through conductor 5 of the plug circuit to spring n'; but from this point a short circuit is provided through the thimble n^2 to the contact piece o^2 of the plug, and thence through the contacts p^3 p^4 of the key to earth. Hence no signaling current will reach the line conductor 2, and the operation of the bell at station D will be prevented.

By tracing out the circuits through

the other jacks it will be found that in each case the spring jack into which the plug is inserted determines the signal connected with that line which shall be operated.

When the operator has made a connection with any spring jack, and has operated the signal at the corresponding station, the presence of the plug *o* in that spring jack indicates to her, during the existence of the connection, the station which has been signaled. If it should be necessary to signal the same station again, she does not have to remember which party on that line has been signaled, for she may be sure of again calling the same one by merely pressing the key *p*. If it should be necessary to make any charge, as in the case of a toll connection, the identity of the station signaled is ascertained by the presence of the connecting plug in the corresponding spring jack.

(To be continued.)

A SUCCESSFUL INDEPENDENT EXCHANGE.

It was in the year 1893 that the telephone situation at Lafayette, Indiana, through a combination of circumstances, attracted the attention of investors. The passage of the Indiana telephone law some years prior, regulating the rates, the evasion of the law under every technical point conceivable, the repeal of the law, and the enforcement of execrable service at an extortionate rate upon a long-suffering community by the Bell Telephone Company, caused a meeting of the citizens of Lafayette to be called in September, 1893. It was unanimously agreed that an independent company be incorporated.

Officers were named and active soliciting commenced at once. The construction of this plant began in October, 1893, the exchange being opened for service February 15, 1894, and the company, incorporated under the name of the "Lafayette Harrison Telephone Company," installed the Harrison telephones and switchboards, which were the best obtainable at that time.

At the time of the opening of the Harrison Company's exchange the Bell Company had in operation 250 instruments, at rates ranging from $48 to $102 per annum for business places, and $36 to $72 for residences. The Bell Company also rebuilt their exchange throughout the moment the Harrison Company commenced work, not leaving one particle of any material in the plant, thus placing itself in the best possible shape to give good service. The long-suffering public, however, did not greet the Bell Company's improvements with favor, as there was relief at hand from another source, the Harrison Company.

March 1, 1894, the Harrison Company commenced collecting rental with 402 subscribers in service at a flat rate of $30 per annum for business places and $18 for residences, the Bell Company cutting its rate at this time to $18 per annum for business places and $12 for residences. The Harrison Company did not meet the cut, however, but sustained its rates as regulated by its franchise.

During the year 1894 the Harrison Company's exchange grew to 550 subscribers. The Bell Company, with four solicitors, cheap rates, and in many cases free service, began losing ground. In 1895 the Harrison Company increased to 625 subscribers, the Bell crawling back to 250 by means of free service offerings. In 1896 the Harrison Company had increased to 728 subscribers, and had established a complete network of toll lines, the Bell Company increasing to about 333 in number, having thoroughly worked the public on its party line scheme, offering free service for from three to eighteen months to anyone who would permit them to run wires to his house.

In 1897 the Harrison Company showed a list of 850 subscribers, as against a claimed service of 400 'phones by the Bell Company; while at the present, in 1898, the Harrison Company is serving over 1,000 subscribers and 300 toll stations, as against less than 500 subscribers claimed by the Bell Company, which with all its guerilla tactics, free service, etc.,

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PARTY LINES.

V.—BY KEMPSTER B. MILLER, M.E.

STRENGTH AND POLARITY SYSTEMS — CONTINUED.

A system devised by Mr. W. W. Dean, now of the Western Electric Company, and based on the same principles as those of Hibbard and McBerty, but adapted for eight stations instead of four, as in each of those systems, is shown in Fig. 5. The Hibbard and McBerty systems may be called polarity systems only, the strength of the current playing no part in the selection of the particular station to be called. The Dean system, however, is one of the few examples of a true strength and polarity system — that is, one depending on both the polarity and on the strength of the current. In this system four stations are associated with each branch or limb of a metallic circuit line. The two call bells on each of the limbs at the four stations farthest away from the central office are oppositely polarized and bridged between the respective line wires and ground, in exactly the same manner as in the four-party lines of Hibbard and McBerty. In fact, the four stations at the farthest end of the line from the central office may be considered, so far as the signaling is concerned, as the counterpart of those systems already described. The two call bells on each limb at the four stations nearest the central office are low wound and placed in the line wires. They are also oppositely polarized. A relay is provided for each limb, each having a high-resistance magnet and bridged to ground at a point between the two high-resistance bells and the two low-resistance bells on each limb. Each of these relays, when operated, serves to ground the opposite limb of the line at that point.

The principle of operation of this system is that a current adapted to ring one of the high-resistance bridge bells at one of the four more remote stations will not be of sufficient strength, owing to the high resistance of the circuit, to ring one of the low-wound series bells at the four nearer stations. Therefore, under ordinary circumstances any one of the four stations having bridged bells may be called by exactly the same method as those described in connection with the Hibbard system. When, however, one of the four nearer stations is to be called, the relay on the limb to which the bell of that station is not attached, is actuated. This grounds the limb of the line on which the desired bell is placed and therefore cuts out the high resistance bells on the farther end of the line. A current of proper polarity is then sent over this limb, which current is now capable of ringing the desired bell on account of the low resistance encountered. This method of doubling up the capacity of a line by such simple means is characteristic of Mr. Dean's work in general, he being responsible for some of the most unique, and at the same time thoroughly practical, inventions connected with the telephonic art during the past few years.

A consideration of Fig. 5 will make clearer the operation and details of this system, and will also throw some light upon a very ingenious system for centralizing transmitter batteries, in which line Mr. Dean has done much work. 1, 2, 3, 4, 5, 6, 7 and 8 represent the subscribers' stations on a metallic circuit, composed of wires *b* and *c*. K and K' represent the calling and answering plugs respectively at the central office; *g* is a battery or other direct-current generator, while *d* is a generator from which pulsating currents of either positive or negative polarity may be taken as desired; l^1, l^2, l^3, etc., are keys adapted to send positive or negative pulsating currents, or direct current from the battery *g* over either side of the metallic circuit to which the plug K is connected by being inserted into the spring jack *a*.

At stations 1 and 2 the positively and negatively polarized high-resistance bells e^1 and e^2 are bridged between the limb *b* of the line and ground. A current from the negative side of the generator, if sent over the limb *b*, will therefore actuate bell e^2, e^1 not being actuated on account of its not being responsive to currents in that direction. This current will also traverse the ringer coils e^5 and e^6 at stations 5 and 6, but will not operate them because too feeble, these bells being wound to a rather low resistance and also shunted by a dead resistance in order to further reduce their sensibility. Suppose, however, station 6 is to be called; the operator first sends a direct current from the battery *g* over the line wire *c*, which current operates the relay *h* and causes it to hold its contact points closed. This, as will be seen, grounds the limb *b* at a point between the first high-resistance bell and the last low-resistance bell on that limb. A pulsating current from the negative side of the generator is then sent over the limb *b*, which passes through bells e^5 and e^6 and to ground at the relay *h*. Inasmuch as

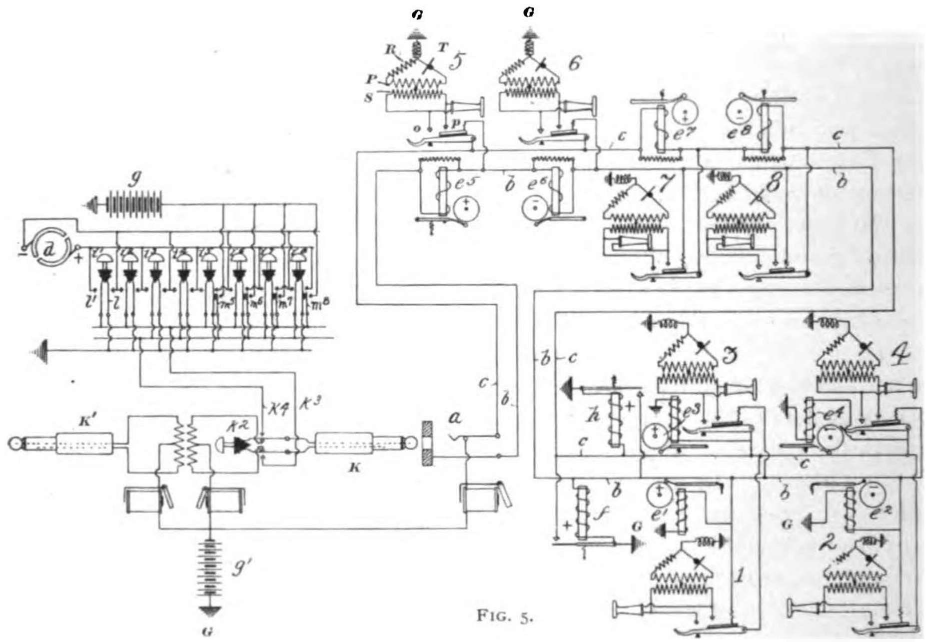


FIG. 5.

this current does not encounter the high resistance of the bell magnets beyond, it has sufficient strength to operate bell e^6, but does not operate bell e^5 because it is of the wrong polarity. The selection of any station whose bell is connected with the other limb *c* of the line is performed in exactly the same manner. The ringing keys l^1 to l^8, inclusive, are so arranged that pressure upon any one of them will send the proper current or currents to line. For instance, depressing l^1 will ground the negative side of the generator and connect the positive side with the limb *b*, which will therefore call station No. 1. If one of the buttons designed to ring the four nearer stations is depressed, it will, besides sending the proper pulsating current to line, also send the direct current from battery *g* to the opposite line, in order to operate the relay *f* or *h* as the case may be.

Although not forming a part of the selective signaling system, the arrangement for accomplishing the centralization of all transmitter batteries will be described, because it is of much general interest. The battery g^1 is connected to the centers of both sides of an induction coil placed in the cord circuit. Suppose the receiver of station 5 to be removed from its hook, the current from g^1 will proceed to the center of the induction coil in the cord circuit, where it will divide, passing in parallel over the two wires *b* and *c* of the line. It will then pass to the contact points *o* and *p* of the switch hook, and to the center point of the secondary of the induction coil at station 5. Here it will again divide, one-half passing through the transmitter T, and the other half through the resistance coil R to the ground at G. The coil R has the same resistance as the transmitter T, under normal conditions. When, however, the resistance of the transmitter T is lower, the greater portion of the current will flow through it, and a smaller portion through R, giving the equivalent of a current from left to right in the primary coil P of the induction coil. This will induce a current in the ordinary manner in the secondary, which will pass over the line and affect any other receiver connected with the circuit. An increase in the resistance of the transmitter T will produce an opposite result, thus causing an induced current in the opposite direction to flow in the line. Thus while the current from battery g^1 produces no effect on the apparatus in the line under ordinary circumstances, it supplies the current for the local circuit of a station which, when operated upon by the transmitter, affects inductively the secondary circuit connected with the line.

A system which is being put into practical operation, and is apparently meeting with much success, was recently devised by Messrs. Barrett, Whittimore & Craft. It depends for its operation on the sending of currents of either polarity, or different combinations of currents, over either or both of two line wires in combination with each other or with the ground. Thus calling one line wire A and the other B, and representing the ground by G, it is evident that without using wire B at all, a current could be sent over wire A with a ground return in either direction, thus giving means for two selective signals. Similarly leaving A out of the question, a current of either direction could be sent over B with a ground return, thus providing for two other selective signals. So far the combinations are identical with those of Hibbard. A current may also be sent in either direction over the metallic circuit formed by A and B, thus providing for two other signals; and lastly by using A and B, in multiple, currents could be sent in either direction, using a ground return, thus affording means for two more signals, or eight in all. Two other combinations might be obtained by sending currents in either direction over wire A, and using wire B and the ground in multiple, as a return; and similarly two others by using B for one side of the circuit with the wire A and ground in multiple for a return. These latter combinations, however, have been found to introduce undesirable features, as will be understood later on. The eight desirable current combinations may be tabulated as follows :

CURRENT COMBINATIONS.

	Line A.	Line B.	Ground.
1.....	+	o	—
2.....	—	o	+
3.....	o	+	—
4.....	o	—	+
5.....	+	—	o
6	—	+	o
7.....	+	+	—
8.....	—	—	+

In this table the plus or minus signs indicate which pole of the calling battery at central is connected to either line wire or ground. Thus, in the first combination, the positive pole is connected with line A, the negative, with the ground in order to utilize the earth return. Line B in this combination is not used at all.

Fig. 6 shows diagrammatically such an arrangement of apparatus at eight stations that the call bell D at each station will be actuated only when the one particular set of current combinations is sent over the line. A and B represent two line wires extending from a central station C to a number of substations S^1, S^2, S^3, etc. At each of the substations are two relays R and R^2 placed in earth branches *m* and *q*, from the two line wires A and B respectively. These two branches are united at *e* and connected with the ground at G. The signal bell D is connected with the local battery *s* in a circuit, the continuity of which is controlled by each of the relays R and R^2. Unless the armatures 13 of both relays rest against their back stops 12, the local circuit containing the bell will be opened at one or two points. The relays of each station differ in some way, either in construction or arrangement, from those of all other stations. Thus at station S the main conductor A is branched through a polarized relay made responsive to positive currents from the central office, and the main conductor B through a neutral relay R^2 adapted to respond to currents of either direction from the central office. It is thus obvious that if a positive current is sent over line A without sending any current whatever over conductor B, the bell at station S will be operated because the positive current will cause the relay R to release its armature, while the armature of relay R^2 is already released. Thus, both contacts 10 and 11 will be closed and the bell circuit complete. Station S^2 also has a neutral relay on wire B, and a negatively polarized relay on wire A. The third and fourth stations, S^3 and S^4, each have a neutral relay on wire A and a positively or negatively polarized relay on wire B. The fifth station S^5 has two polarized relays, one adapted to respond to positive currents and attached to wire A, and the other to negative currents and attached to wire B. The sixth station S^6 also has oppositely polarized relays, but their connection with the line is the reverse of that in station S^5. The seventh station S^7 has two positive relays and the eighth station S^8 two negative relays, one in each case being bridged between each limb of the line and ground.

Reference to the table of current combinations will show, in connection with

Fig. 6, that the sending of any particular combination to line will operate the relays of the station bearing the corresponding number in such manner as to close the local circuit at that station. Further consideration will also show that no combination will so operate the relays at more than one station.

At the central station B' is a generator of calling current, and G' an earth connection complementary to the earth connections G at the substations. K is terminals are brought from the line conductors A and B, from the ground connection G', and from the positive and negative poles of the battery to the various terminals on the signaling keys. The arrangement of the terminal contacts in each key is different, the differences corresponding with those of the substation relay arrangement.

To illustrate: In key No. 1 the contacts are so disposed that its operation will connect conductor A with the posi-

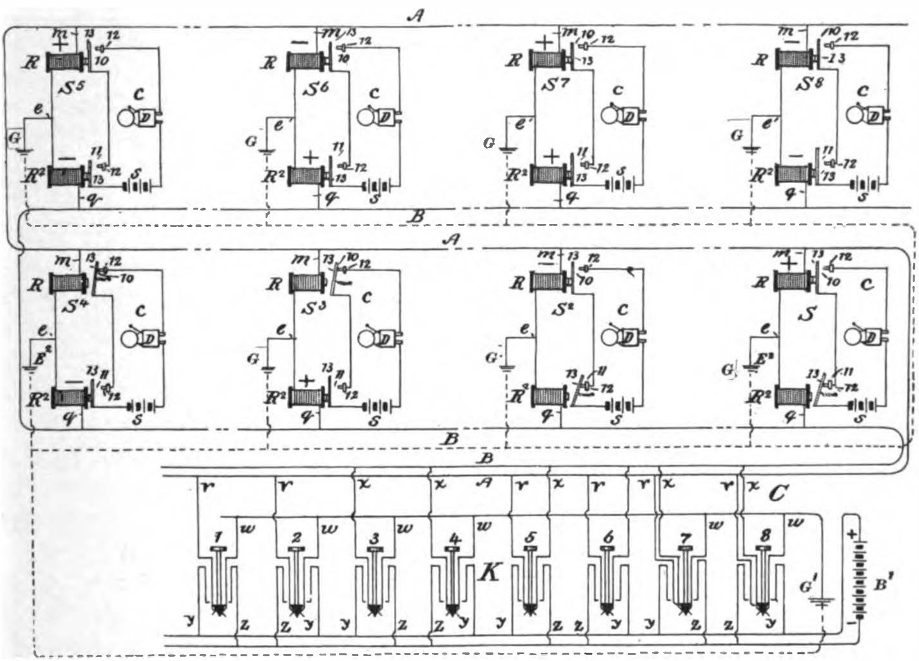


FIG. 6.

a group of signaling keys, each corresponding with one substation appliance, and when any particular key is pressed it sends the proper current combination to line so that the relays at the particular substation represented by it will coöperate to close the local circuit and give the signal there; but at the other stations no such effect will take place. Hence, to give a signal at any desired substation, it is only necessary to operate the particular key representing such station. To accomplish this, branch tive pole of the battery B' at contacts *v* and *y*, the minus pole of the generator with the earth terminal-contacts *z* and *w*, and will leave conductor B disconnected. By this means a positive current is sent over line A and is distributed through all the A relays at all of the substations in parallel, finding return through the earth branches; but as no current is transmitted over line conductor B, all of the eight B relays will remain unaffected. Under these conditions relay R at station S will close point 10 of its local circuit, and the point 11 being already closed by the armature of relay R^2, the normal position of which has not been changed, the local circuit *c* of station S will be closed and the bell at this station will be rung. Station S^2 will not be signaled, because plus currents have no effect on its polar relay R. Station S^3 is not signaled, because the effect of the plus current on main A is to attract the armature of neutral relay R, and thus open the local circuit, which is already open at point 11. Station S^4 receives no signal for the same reason. Station S^5 is not signaled because, though the positively polarized relay on A closes the open point 10 of its local circuit, the said circuit remains open at 11, there being no current on B; station S^6, because neither relay is acted upon, R being of minus polarity and R^2 having no current; station S^7, because R alone is operated, and station S^8, because both relays are of minus polarity.

In applying the principles already pointed out to a practical multiple-station circuit, it is desirable to reserve two of the current combinations for the operation of locking devices common to all stations.

The seventh and eighth combinations in the foregoing table have been found most convenient for this purpose. The seventh, that is, the positive current over both conductors A and B in parallel is used for locking the telephone apparatus at all stations and a negative current over both lines for unlocking the apparatus. Six combinations are thus left for signaling.

The locking device and a visual busy signal are shown in association with complete telephone equipments at two stations in Fig. 7. In these an additional electro-magnetic apparatus R^3 is shown in circuit with the relays R and R^2 at each substation, half of its winding being in the earth branch *m* of the relay R and half in the branch *q* of the relay R^2.

Two electro-magnetic helices *a* and *b* have the ends of their cores joined by soft iron yoke pieces to form the instrument R^3. Two soft iron polar extensions *h* and *f* project inwardly from the yoke pieces as shown. A polarized bar armature *j*, pivoted at j^2, has one of its poles projecting between the pole pieces *h* and *f*, and adapted to move to one side or the other under the influences of said pole pieces. If current is passed through coil *a* only, the magnetic polarity developed will be short-circuited through the yoke pieces and the core of coil *b*, so that very little strength will be manifested in the pole pieces *h* and *f*; if current be applied to the coil *b* only, the magnetic polarity will be similarly short-circuited, and, again, little effect will be manifested in the pole pieces. Again, if current be applied to both coils *a* and *b* so as to act in a complementary direction, the yoke pieces will satisfy the magnetic flux with very little polarity in *h* and *f*; but if current be applied to coils *a* and *b* in inductively opposed direction, as will be the case when the seventh and eighth combinations are transmitted, consequent poles of full strength and opposite polarity will be formed at *h* and *f*. The polarized lever *j* is, therefore, actuated by the seventh and eighth current combinations and remains unaffected by all others.

As shown at the right of Fig. 7, the lever *j* serves not only as a lockout device, but also as a busy signal. The apparatus is shown in its locked or busy position at station S^2 of this figure and in its unlocked or free position in station S^1. When the lower portion of the lever is moved to the left it forms a stop to lug j^3 on the hook-switch *z*, and thus prevents the latter from rising should the receiver be removed from the hook. At the same time the small target B on the other end of the lever is displayed through a hole in the box, thus showing the party at that station that the line is busy. When in its other position, the busy signal is not displayed and the hook-switch is free to rise.

When the operator at central presses the locking key, say key No. 7, all of the locking levers on the line, including

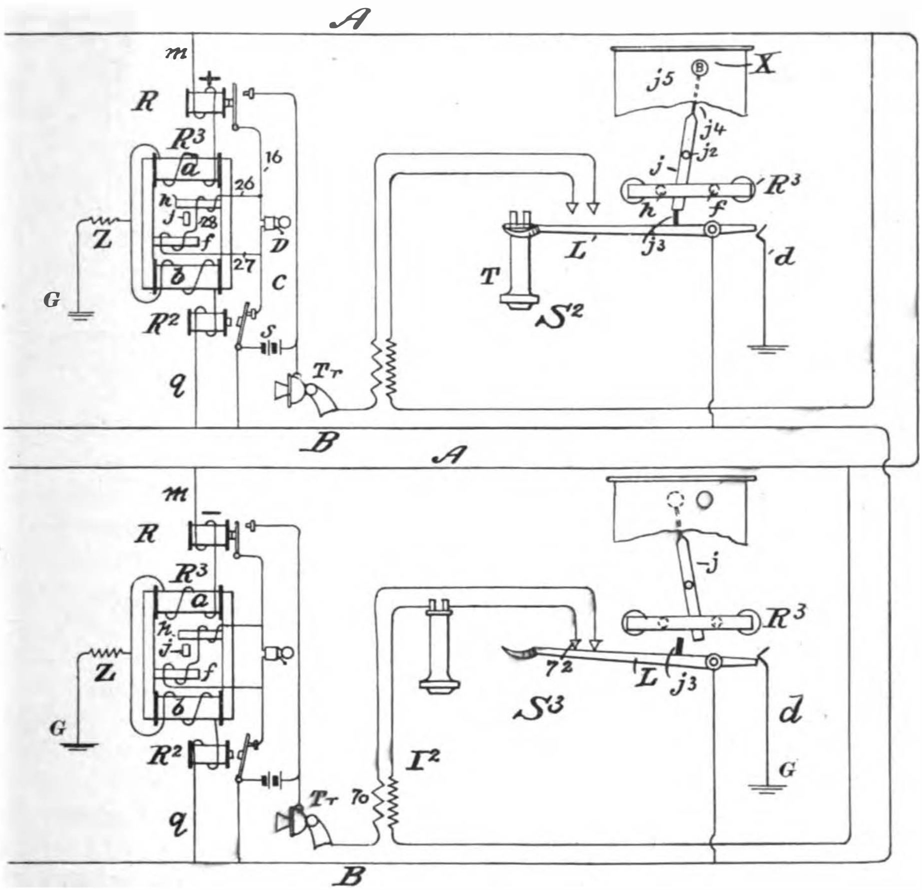


FIG. 7.

that of the party to be called, will be actuated. In order that the party being called may not be thus locked out, the windings 27 and 28 are provided around the polar extensions *h* and *f* on each instrument. This winding has no function except at the station being called. In that station part of the current from the local circuit, which is closed only at that station by the action of the relays, finds path through this winding, and the magnetism so developed serves to unlock the mechanism and to allow the party at that station to use his instrument.

In Fig. 8 is shown a six-party line, the equipment at each station being of a similar character to that shown in Fig. 7, but simplified for the purpose of clearer illustration. The two sides of the line terminate in the line springs of a spring jack J, which springs normally rest on anvils connected to the windings 31 and 32 of a differentially wound switchboard drop. These two windings pass around the core of the drop magnet in opposite directions, after which they unite at the point 60 and pass to ground through a battery B². The relative direction of the windings on the drop is such that the current from this battery circulates around the core in opposite directions, and thus does not affect the drop. It then divides equally between the two main conductors A and B, and finally returns by the ground connections G at each of the several stations. The current thus flowing to the two conductors from

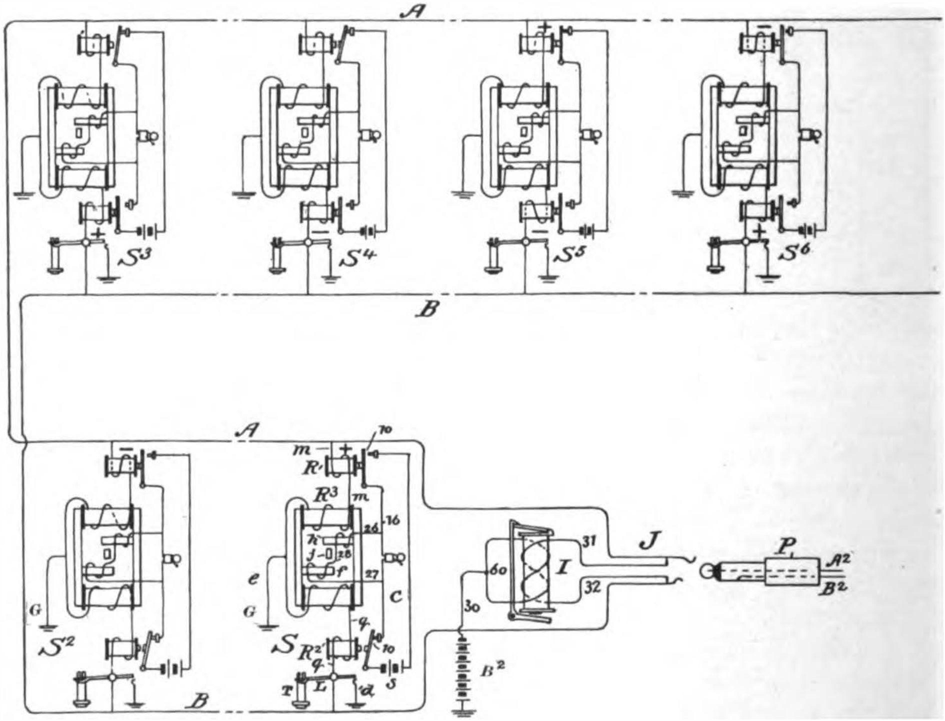


FIG. 8.

the battery B² is in a negative direction, and thus tends to maintain the apparatus at the several stations in its unlocked condition.

When any subscriber removes his receiver from the hook, the short arm of the hook lever L makes contact momentarily with the spring *d* which grounds the main line wire B, and thus allows a heavy current to pass through the winding 32 of the drop I. This throws the drop, and attracts the attention of the operator. The operator answers the call in the ordinary way by the insertion of one of the plugs P with which the ringing keys *l* in Fig. 6 are associated.

When a substation is to be signaled, the calling plug P is inserted into the socket in the spring jack, which cuts off the annunciator and connects the keys K with that particular circuit. Key l^7, which sends the plus current over both mains in parallel, is then operated to lock the apparatus at all stations without ringing any of the bells; and then the key representing the desired station is pressed, which results in ringing the bell and at the same time in releasing the telephone apparatus at that station by the means already described. At the close of any conversation, the key l^8, sending a negative current over both mains in parallel, is operated to release the apparatus at all stations, restoring the circuit to its normal condition.

PARTY LINES.

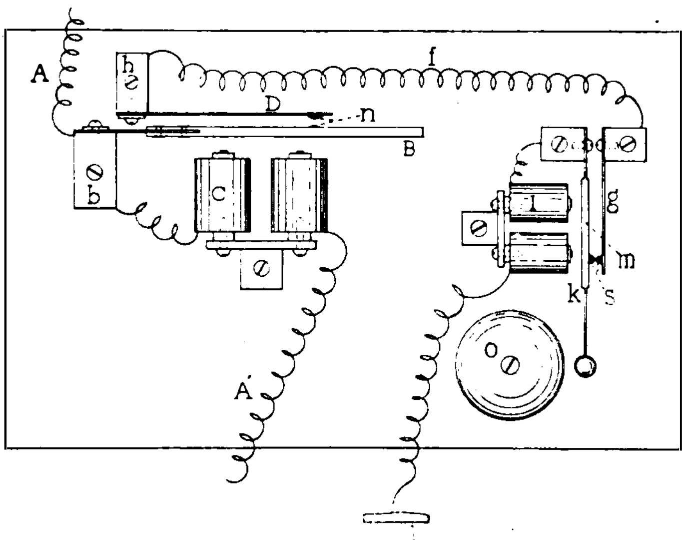
VI.—BY KEMPSTER B. MILLER, M.E.

(*Concluded.*)

HARMONIC SYSTEMS.

The third general method of selective signaling on party lines makes use of the fact that every pendulum or elastic reed has a natural period of vibration, and that it can be made to take up this vibration by the action of a succession of impulses of force occurring in the same period as that of the reed or pendulum. An everyday example of this is found in one person pushing another in a swing. The swing has its natural period of vibration, depending on the length of the ropes, and a gentle push applied at proper intervals by the person on the ground will cause the swing to vibrate with a considerable amplitude. If the pushes are applied at intervals not corresponding to the natural period of vibration of the swing, many of them tend to retard rather than help its vibrations, so that a useless bumping results, which produces but little motion.

Fig. 1.



The utilization of this principle has given inventors a very attractive field of work; but as in the case of the step-by-step systems, the results attained have been of little practical value in telephony, except in so far as they have contributed to the general stock of knowledge on the subject.

The idea of selective signaling between different instruments in the same circuit was used in telegraphy before the birth of telephony. A number of currents of different rates of vibration were impressed upon the circuit by as many different transmitters, each particular rate of vibration being capable of operating a reed in one of the receiving instruments, and producing no effect upon the others. By this means each receiving instrument was capable of picking out only those signals sent by the transmitter having the same rate of vibration, and thus all of the transmitters could be used simultaneously in the same circuit, producing a system of multiplex telegraphy.

The idea as applied to telephony is shown in Fig. 1, where C is an electromagnet connected with the line wire A, A′, in series with similar magnets at all of the other stations. B is an armature of soft iron mounted on the post *b* by a short flat spring, thus forming a reed which it is obvious will have a fixed rate of vibration for any particular adjustment. When a number of current impulses are sent over the line wire having a frequency corresponding to the rate of vibration of the reed B, the latter will be thrown into vibration. If the frequency of the current impulses does not correspond to the rate of vibration of the reed, then the reed will vibrate but slightly, if at all. D is a flexible spring forming a part of a secondary circuit containing an ordinary vibrating bell. When the reed B is thrown into a sufficiently wide vibration, this latter circuit is closed at the point *n*, and the bell is sounded.

The reeds at all of the stations are so adjusted as to have different rates of vibration, and by impressing current impulses of a proper frequency upon the line at the central station, the bell at the desired station can be sounded. This illustration is that of a device invented by Messrs. Currier and Rice in 1880.

Fig. 2 shows a signal-receiving instrument designed three years later by Elisha Gray and Frank L. Pope. M is an electro-magnet having polar extensions m and m^1 (best shown in the plan view) between which is pivoted the polarized armature P. This will be attracted toward one or the other of the polar extensions, according to the direction of the current through the coils. O is a vibrating reed having one end rigidly mounted on the post O^1. The rate of vibration of this reed may be varied by the sliding weight o, which may be clamped in any desired position by the thumbscrew o^1. N is an armature by which the electro-magnet M may exert its influence on the reed O. R is a separate lever pivoted as shown and normally making contact with the reed.

Three such receiving instruments are shown connected in a line circuit L in Fig. 3. At the top portion of this figure is shown the transmitting apparatus at the central office. The three transmitters B^1, B^2, B^3 each has a vibrating reed b playing between two pairs of electro-magnets E and e and maintained in constant vibration by the alternate passage through these magnets of currents from the local batteries F. The reed of each transmitter is attuned to the rate of vibration of the reed of the corresponding receiver, and therefore current impulses sent to line from any transmitter will operate only one of the receivers.

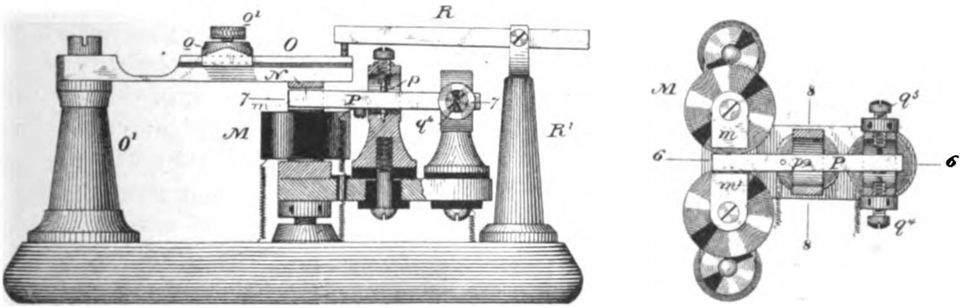


FIG. 2.

A constant current is maintained upon the main line L by means of a main battery, G, at the central office. When the apparatus is at rest, the circuit may be traced as follows: From the earth at the central office by the wires w and w^1 to the contact point v^1, thence by the contact springs s^1 to the contact stop v^2, thence by the contact spring s^3, wires

w^2 w^3, and contact stop w^8 to the contact spring x, and thence by the wire w^4 to the positive pole of battery G; thence from the negative pole by the wire w^5 to the contact spring x^1, thence by contact stop w^9 and wires w^6 w^7 to the electromagnet of the signal bell D, and thence

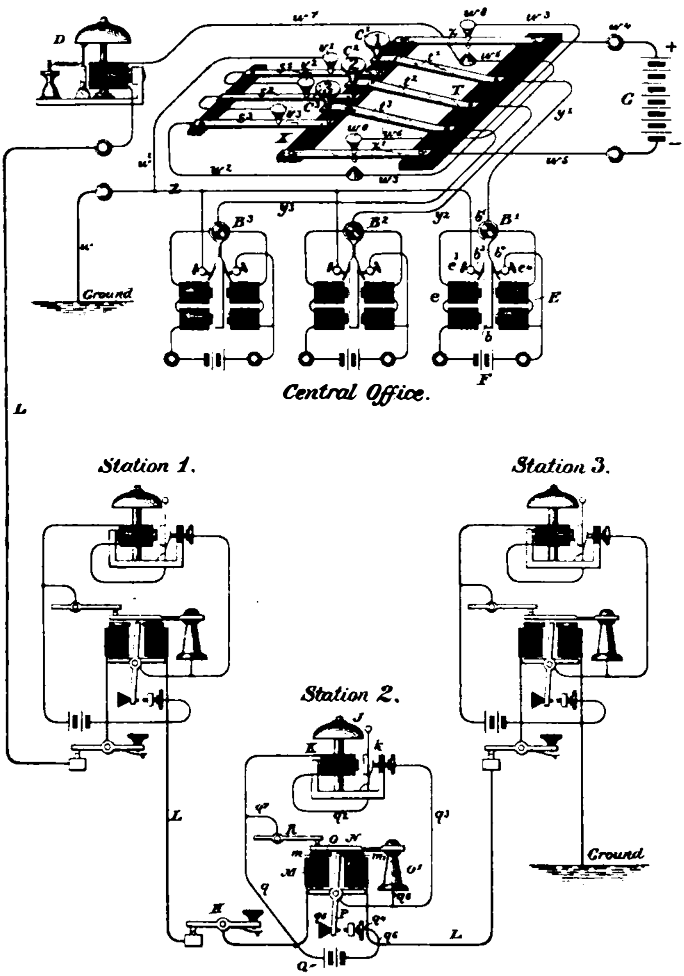


FIG. 3.

to the line L, which extends to and through the several stations, and finally to earth at the terminal station.

Upon an insulating support, T, is mounted a series of metallic springs, t^1, t^2 and t^3, carrying buttons c^1, c^2 and c^3, the free ends of which *springs* project over the free ends of the series of contact springs s^1 s^2 s^3. The contact springs x x^1 are also mounted upon the insulating support T, their free ends being united by a nonconducting bar, X, which passes directly underneath the free ends of the springs s^1. s^2 and s^3. The key springs t^1 t^2 t^3 are connected by wires y^1 y^2 y^3 with the respective reeds of the transmitters B¹ B² B³, after which they are united to a common wire z, which is connected directly with the earth.

At each substation is placed the receiver already described, a key H, a battery Q and a vibrating bell J. The polarized armature P of the receiver is held in such a position by the normal current from the battery G at central as to hold the local circuit open at the point q^4. Besides this, a shunt is normally closed around the bell magnet K at each station, by the closure of the contact between the reed N and the arm R.

To call central the party at a substation has only to depress his key H. This breaks the line circuit and allows the hammer of the central office bell D to strike one blow. When the operator at the central office wishes to transmit a call to one of the substations — for example, Station 2 — she depresses the key C². This establishes a connection between the springs t^2 and s^2, and at the same time breaks the contact previously existing between the spring s^2 and the stop v^2. By the same operation the bar X is depressed and the springs x x^1 are respectively removed from contact with the terminals w^8 and w^9, and brought into contact with the wires w^7 and w^2. This operation produces the twofold effect of switching the main-line circuit through the appropriate vibrating transmitter reed B^2 and of reversing the polarity of the main battery G with respect to the line. the reed of the transmitter B^2, will be set in vibration, and this vibration will cause the loosely-pivoted bar R to hop up and down, interrupt the shunt-circuit, and allow the magnet K to become active, thus causing the bell J to ring. The bells at all the other substations, being cut out by the action of their respective shunts, will remain quiescent. The bell of any other station is actuated in precisely the same manner, the only difference being that the reed-armature O in each instance is adjusted to vibrate in harmony with its corresponding transmitter at the central office and to respond only to currents sent to line by it.

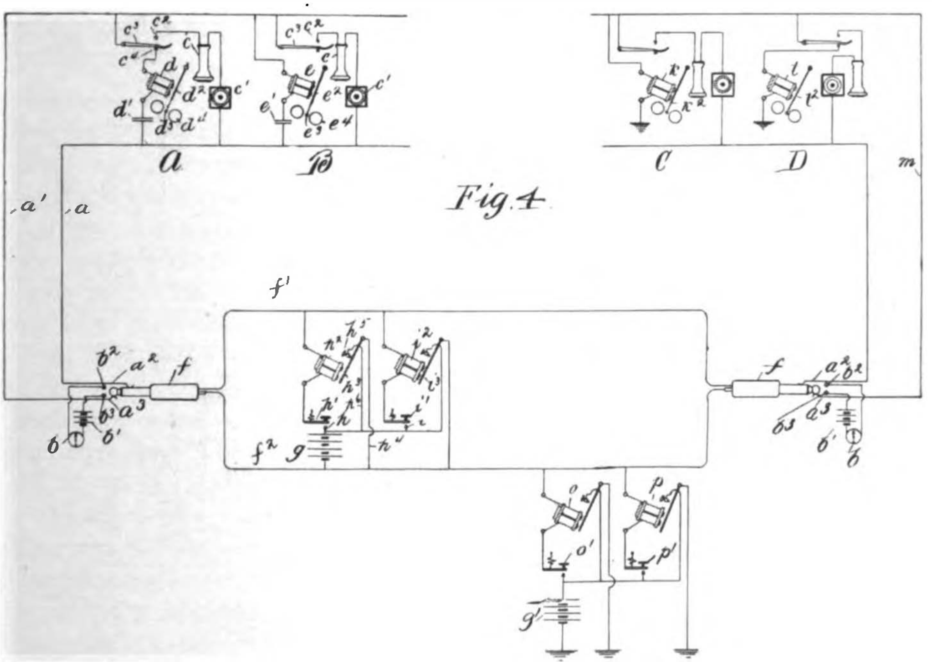


Fig. 4

The change of the polarity of the main-line current causes the polarized armature P at every substation to be deflected from its normal position, thus bringing it in contact with the stop q^4 and closing the circuit of the local battery Q. The closing of the local battery in this manner will, however, in itself produce no effect upon the electro-magnet K of the bell, as the latter is shunted by the contact between the reed O and the bar R, which rests upon it. The reed O at station 2 being adjusted to vibrate in response to

The device of Currier and Rice depended on the vibrating reed to close the circuit through the call bell, while in that of Gray and Pope the reed served only to break a shunt around the bell. In Fig. 4 is shown a system designed by J. A. Lighthipe, of San Francisco, in which the gongs are struck directly by the reed, without the use of an auxiliary magnet. This will be understood from the diagram without much explanation. The reeds d^2, e^2, k^2 and l^2 carry hammers adapted to play between the gongs at the substations when acted upon by their magnets *d*, *e*, *k* or *l*. At stations A and B these magnets are bridged directly across the two sides of the metallic line, while at stations C and D, on another line, they are bridged between one side of the circuit and ground. A condenser, d^1 or c^1 is in each bridge wire in the former case, to prevent the leakage of current from the signaling battery b^1 when the telephones are not in use. Associated with the cord circuit of a pair of plugs at the central office are the signal transmitters, each having a reed tuned to the rates of vibration of the several reeds of the call receivers. Pressure of the button *h*, for instance, closes the circuit of battery *g* through electro-magnet h^2 over the limb *a* of the telephone line through the electro-magnets *d* and *e* at the substations and back by the limb a^1 to the opposite pole of the battery.

The magnet h^2 is thus excited, and attracts the reed, which in its forward movement completes a short circuit around the battery. The reed vibrates back and forth, sending current impulses over the circuit, and as its rate of vibration is the same as that of reed d^2 at station A, these impulses will have the proper frequency to actuate that reed and sound its bells. Calling central from the subscribers' stations is performed in precisely the same way as in the Sabin and Hampton and other systems already described.

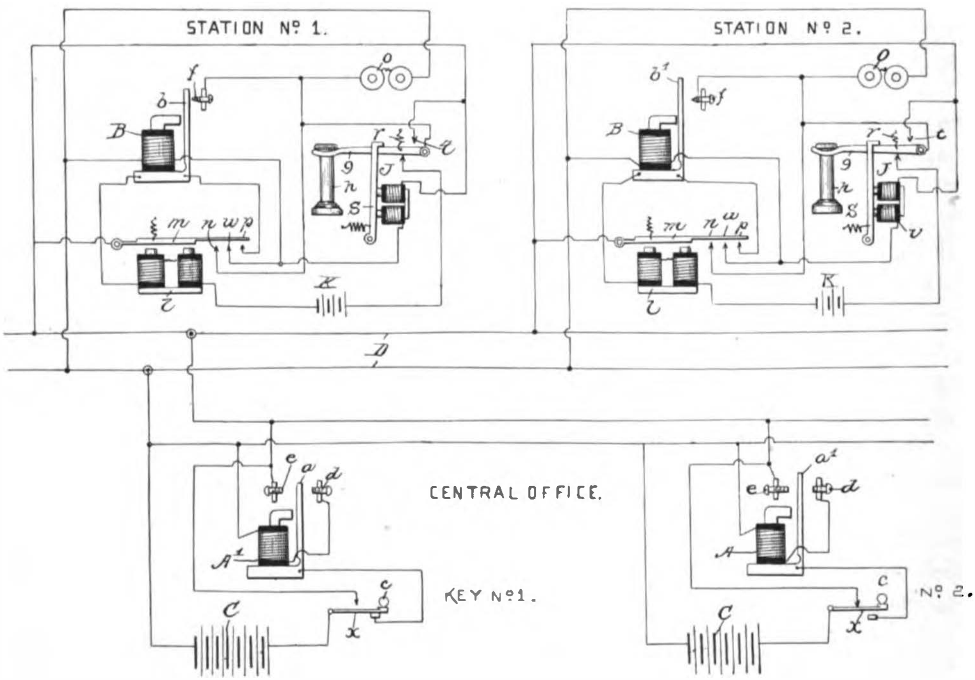


FIG. 5.

As the apparatus in this system is arranged on the bridging plan, it is of course necessary that the bell magnets should possess high impedance in conformity with the requirements of bridged lines.

Fig. 5 shows a somewhat elaborate

system, invented by Mr. William H. Harter, of Great Falls, Montana, and embodying a lockout mechanism in addition to the signaling devices. In this figure two substations, 1 and 2, are shown connected by a metallic circuit line, with two transmitting devices at the central office. Instead of this connection being permanently made as shown, it would be brought about in practice by a spring jack and plugs, the transmitting devices being connected across the cord circuit.

The reeds *b* and *b*' at the substations 1 and 2 are tuned to the same pitch as reeds *a* and *a*' of their respective transmitters at central.

Upon connecting the cord circuit with the circuit of the line, the battery C is thrown across the two sides of the line, and current therefrom passes through each of the locking magnets *v* in multiple, attracting their armatures *s*, and locking all of the receiver hooks in their depressed position. Pressure of key No. 1 (for the purpose of calling station No. 1) establishes a local circuit through transmitter magnet A and the back contact of its reed, thus throwing it into rapid vibration. By means of its front contact *e* and the reed *a*, impulses of current from C are allowed to flow over the line circuit, through the magnets B of the substations; and as these are of the right frequency to actuate the reed at station No. 1, this reed is thrown into vibration, the others remaining quiescent.

The reed *b* in its vibration completes a local circuit containing a magnet *l* and local battery *k*, and causes it to attract its armature against three contacts, *n*, *w* and *p*. The circuit closed at the contact *n* allows the impulses of current coming over the line from the battery C to operate the bell *o*. The circuit closed at the contact *p* includes also the contact *n*, and contains the magnet *l* and local battery *k*, and thus serves to keep the armature *m* depressed, regardless of the action of the reed. The circuit closed at the contact *w* short-circuits the locking magnet *v*, thus releasing the hook lever at the station being called.

It will be seen that the act of plugging-in locks all stations, and the closure of key No. 1 throws reed *b* at station No. 1 into vibration. This operates magnet *l*, which closes the bell circuit and also unlocks the hook lever at that station.

In practice a modification of the central office circuits would be necessary, for, as shown, the contact made between the vibrating reed at key No. 1 and its contact *e* simply closes a circuit from the battery C, which is already made at key No. 2. Each key should, therefore, be disassociated from the other keys during the transmission of the vibratory currents.

These are only a few of a large number of systems depending on the general principles outlined. The harmonic idea is attractive, and may be applied in a great number of ways to the solution of the problem. It has, however, as before stated, been productive of but few practical results. In fact, I know of but one harmonic selective signaling system in practical operation in the United States. It is in use by the local Bell Company at Sacramento, California, and is not an unqualified success, although it has been used over three years. This slight use of the harmonic principle should not detract, however, from the interest in the subject, for a knowledge of the experience of others is a valuable aid in any branch of work, and in none more so than in telephony.

CAMBRIDGE, ILL. — The Cambridge Telephone Company has been incorporated with a capital stock of $900. The incorporators are J. A. Kirkland, G. A. Vawter and James Pollock.