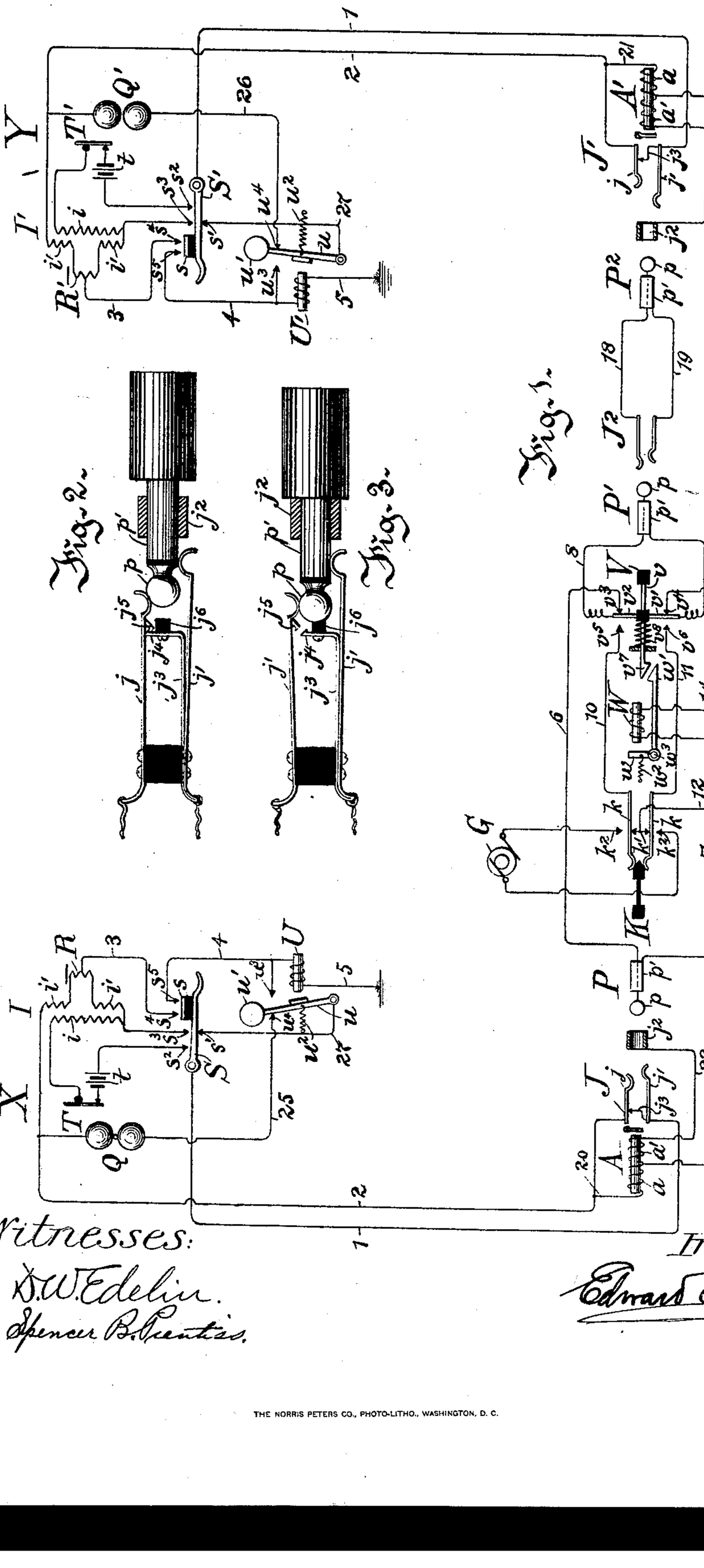
No. 646,681. Patented Apr. 3, 1900.

E. E. CLEMENT.

TELEPHONE EXCHANGE SYSTEM.

(Application filed Apr. 21, 1899.)

(No Model.)



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UNITED STATES PATENT OFFICE.

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TELEPHONE-EXCHANGE SYSTEM.

SPECIFICATION forming part of Letters Patent No. 646,681, dated April 3, 1900.

Application filed April 21, 1899. Serial No. 713,881. (No model.)

To all whom it may concern:

Be it known that I, EDWARD E. CLEMENT, a citizen of the United States, residing in the city of Washington, District of Columbia, have invented a certain new and useful Improvement in Telephone-Exchange Systems, of which the following is a specification, reference being had to the accompanying drawings, forming part thereof, wherein the same letters and figures of reference point out the same parts throughout.

My invention relates to systems of telephonic intercommunication wherein substations provided with telephonic instruments are connected to a common center or centers, whereat a switchboard or boards enable the lines to be connected together for conversation, as desired, and it has particular reference to systems of this general character wherein each subscriber's line is connected to but one terminal connective means, such as a spring-jack, and the connection of lines whose terminals happen not to be in immediate proximity to each other is accomplished through the agency of transfer or trunk lines. In systems of this kind it is the usual custom to provide calling means at each subscriber's station whereby he can operate a signal attached to his line, means whereby the answering operator can receive his order and communicate it to another operator if the desired line is not connected on her own board, and means whereby the last-named operator can call the wanted subscriber. The operation of such a system entails the use of listening-keys and calling-keys for all the operators and a divided responsibility, for if the second operator fails in her duties the first one, having no check but the oral one depending on inquiry, cannot be held responsible. In such systems the calling means provided for the subscribers have been either hand generators at the substations, with annunciators adapted to be thrown thereby, or circuit-closers at the subscribers' stations and a source of current-supply at the central station normally connected to the lines. The latter arrangement permits of diversion of the current when an operator plugs in to answer a call, whereby the automatic restoration of the annunciator is accomplished. Where such current-supply is temporarily or permanently connected to a line, however, disturbances of a more or less serious nature are liable to occur. Thus when the answering operator inserts a plug in the jack of a calling line the addition to, subtraction from, or change in the current already flowing is apt to produce an explosive sound in the receiver, which being then at the ear of the listening subscriber is in the best position to disturb him. So far as I know these explosive noises, more or less pronounced, are common to all centralized battery systems so far devised.

In systems of the general character referred to signals are usually provided for the operators, whereby the condition of the lines connected or to be connected can be observed without listening in repeatedly. Many ways of connecting these signals have been proposed, the commonest of which in modern installations is to have relays included in the connecting cord-circuits, control-lamps, or other signals in local circuits. This is objectionable because it introduces impedance into the talking-circuits and because when lines of very different resistances, due to different lengths, are connected the current strength is not the same in the relays and their respective lines unless artificial balancing resistances are used.

In practically all centralized battery systems self-restoring annunciators are used. In some cases the annunciators are operated by a flow of current through their coils to pull up an armature, and their restoration is accomplished by simply cutting off the current either by a special relay called a "cut-off" relay or by having the plug when inserted lift the line-springs from anvils constituting their terminals. In other cases the annunciators are magnetically lifted after having been permitted to fall by gravity, the lifting being accomplished by separate magnets or (the usual way) by short wire-wound extensions on the same magnets that perform the tripping. All these methods of operation and restoration have faults. Thus the first may fail to restore by reason of the armatures sticking to the cores, and if they do restore, the inevitable explosion caused by the cut-off in the subscriber's receiver is bound to oc-

cur. In the second, additional windings are required on the magnets, the operative parts require careful adjustment, and the connections of the switchboard, not to mention the plug-circuits, are complicated by the additional circuits, which in trunk systems are very undesirable, since they cannot be utilized, as in multiple boards, for test purposes. In some of these systems using self-restoring annunciators the restoration has been effected by neutralizing-coils on the annunciator-magnets. Of course unless such neutralizing-windings perfectly balance the operating-windings in ampere-turns and in effective action on the cores imperfect results are to be expected. In such arrangements the neutralizing-coils have been placed in local circuits usually closed by the plugs when inserted. This gives rise, however, to some difficulty, for unless every line has exactly the same resistance or unless every line has its neutralizing-coil adjusted to balance the line and operating coil resistance the whole may prove inefficient. Of course it is out of the question to wind a special coil for each line in a large exchange, so the matter simmers down to artificial resistance for the line or the local circuit. The present invention does away with the necessity for balancing resistances altogether and leaves the full benefits of the differential connections to be taken advantage of without a drawback.

In all manual telephone-exchange systems where disconnection, as well as connection, is performed by operators much annoyance is sometimes caused by reason of failure of the operators to promptly pull out plugs when clearing-out signals have been given. In such cases if the subscribers attempt to call they either get the same correspondents with whom they have already conversed or get no one. In a centralized battery system the only effect of calling after clearing out and before the plugs are removed is to oscillate the clearing-out signal, and sometimes if that is a permanent signal not even that will follow.

My present invention has for its object the general improvement of exchange systems and the elimination of the faults enumerated and many others.

In order to attain my objects, I employ a construction and arrangement which may be broadly stated as follows: Each subscriber's station is provided with balanced apparatus. The talking apparatus is normally disconnected and the usual polarized bell is connected across the two line-wires. When the subscriber calls, however, or during conversation, the bell is disconnected, the talking apparatus is connected across the lines in its place, and a ground-tap containing a relay and signal magnet is also connected from the median point of the talking set in such manner that the divided portions of the coils balance each other as regards the effect of currents flowing to ground. At the central station I employ an annunciator and spring-jack of any desired pattern, the spring-jack being provided with three contacts and the annunciator being provided with a double-wound coil whose median point is connected through a calling-battery to ground. One end of the annunciator-coil is permanently connected to one side of line. The other side of line is so connected in the spring-jack that it will be normally, while the line is in disuse, crossed with that side to which the aforesaid end of the winding is connected, and the other end of the annunciator-winding is connected to the third normally-open spring-jack contact. The cord-circuit arrangement is very simple. It is normally complete and consists of but two conductors, including no apparatus whatever, extending from plug to plug. Mechanism is provided, however, by whose action, when desired, the cord-circuit may be severed into two portions, that connected to the forward or calling plug being then prolonged through a signal and a signalling-battery to a common return-wire which extends to all of the line-jacks. The answering-plug at the same time is left disconnected entirely. Suitable means are provided whereby the cord-disconnecting mechanism is restored by the called subscriber in answering the call. It follows from this construction that when a subscriber calls by removing his telephone-receiver from the hook in the usual manner the current flows from the main calling-battery through his annunciator-winding and through both sides of his line to his station, there finding a path through his talking apparatus, which it does not affect, and through his relay and signal magnet to ground. The signal-magnet thereupon acts to disconnect the bell and to make a new connection for itself preparatory to the clearing-out signal, which will be mentioned later. At the same time the annunciator at central displays its signal. When the operator inserts the answering-plug, a peculiar arrangement of the jack, which will be described in detail in the body of the specification that follows, enables the connection of the opposite end of the annunciator-winding to one line-wire to be effected before the two line-wires are broken apart by the complete entrance of the plug. This feature of my invention is very important, as it absolutely does away with the explosive sounds heretofore experienced in systems of this general character. Whatever sound is heard upon the insertion of the plug is so faint as to be only perceptible to one who expected it. The operator may employ any suitable means for listening in without disturbing the other features of the system; but in order to fully attain the objects of my invention, and because of the perfection of the signals herein attained, I preferably use the means of connecting the operator's set which is shown and described in a prior application of Wm. D. Gharky and E. E. Clement, filed August 20, 1898, Serial No. 689,119, being claimed therein.

According to the matters specified in the above-mentioned application the operator's set remains connected to the cord-circuit as long as the second or calling plug of the pair is in its seat, and therefore the operator has but to insert the answering-plug, when she is immediately connected to the subscriber's line and may inquire of him the number wanted. Having ascertained, it may be assumed, that the desired number is located upon another section of the switchboard and has no terminal within her own reach, the operator removes the second plug from its seat and inserts it in the jack of a trunk-line leading to the section whereon the desired line has its terminal, at the same time working the mechanism before mentioned, which dissevers the cord-circuit and also informs the operator at the other end of the trunk-line through the usual instruction-circuit of the number wanted. When said second operator, whom I shall for convenience designate the "trunk operator" herein, has received her instructions, she proceeds to connect the trunk-plug with the terminal of the desired line. By making this connection she completes a circuit which affects the signal of the first operator, mentioned above, thus informing her that the connection is complete and enabling her to connect a calling-generator to the forward plug of her pair. It will be observed from this that the trunk operator has no duty to perform beyond the completion of the connection according to instructions, the responsibility for both answering and calling being thus fixed upon the answering operator, who is enabled by means of her signals to accurately supervise, and by her instruction-circuit to control, the work of the trunk operator. The supervisory signal before referred to remains visible to the answering operator until the wanted subscriber has answered, when it disappears, and at the same time the mechanism which had previously held the cord-circuit dissevered is actuated automatically to reconnect the cord-circuit straight through from plug to plug with but one contact and no mechanism whatever included. If during the connection either subscriber should hang up his telephone-receiver, no effect whatever at the central office would be produced. If, however, both subscribers, having finished their conversation, hang up their telephone-receivers, a new circuit for each line is thereupon completed through the signal-relay and one side only of line to central, through the annunciator, to battery, and to ground. The annunciator thereupon becomes active in each case, both line-signals thus becoming visible to indicate that disconnection is desired. This state of affairs will continue as long as the plugs remain in the jacks; but as soon as the plugs are withdrawn two changes take place—first, the second end of the annunciator-winding is disconnected, thereby breaking the circuit last-above mentioned and permitting the signal-relay at the subscriber's station to let go its armature and restore the bell-circuit, and, second, the two sides of the line are at the last moment of withdrawing the plug again crossed together, whereby the line is put into condition for further calls.

My invention is fully illustrated in the accompanying drawings, wherein—

Figure 1 is a diagrammatic view of the system consisting of two subscribers' stations connected to separate switchboard-sections in the same or different central stations, together with the apparatus necessary for the full operation to be described. Figs. 2 and 3 are detail views of a spring-jack and plug.

X indicates one subscriber's station and Y another, each being connected to the central office by line-wires 1 2. Each subscriber is furnished with the usual apparatus, consisting of the transmitters T T′, the receivers R R′, the switch-hooks S S′, the induction-coils I I′, each consisting of a primary winding *i* and a secondary winding *i′* and the bells or ringers Q Q′. I have indicated the induction-coils and the receivers in a purely conventional manner in order to make the diagram clear. It will be understood, therefore, that the receivers R R′ are preferably bipolar receivers having balanced coils and that the ground tap connection is made between the coils. This is not necessarily so, however, as I may double-wind a single coil and make connection with its middle point instead.

In addition to the above-mentioned apparatus at each subscriber's station I provide a relay and signal magnet, (lettered U at the station X and U′ at the station Y.) This magnet has a double function and forms a very important element in my system, as will be seen from a further description.

At the central station the respective lines are provided with annunciators (lettered A and A′ and only conventionally indicated) and spring-jacks, (lettered J and J′.) The connections existing between the subscriber's apparatus and these pieces of terminal apparatus at the central station are as follows: Line-wire 1 is connected at the subscriber's station to the switch-hook S and at the central station to the line-spring *j′* of the spring-jack J. The line-wire 2 is connected at the subscriber's station to one side of the secondary winding *i′* of the induction-coil I and at the central station is connected to the short spring *j* of the spring-jack J and to the wire 20, constituting one terminal of the windings *a a′* of the annunciator A. The other extremity 22 of said windings *a a′* is connected to a collar or third contact j^3 in the jack. The two line-springs *j* and *j′* are normally when the line is in disuse crossed together through the medium of the contact j^3, which will be fully described in connection with Figs. 2 and 3. From the line-wire 2 the bell Q is connected through wire 25, and the bell Q′ through wire 26, to a back-stop, (in each case lettered u^4,) against which the armature *u* of the magnets U or U′ is normally impelled

by the spring u^2. The armature u in each case is connected by a direct wire 27 with the down contact s' of the switch-hook S or S'. From this it results that with the switch-hook depressed by the weight of the receiver and the armature u retracted a circuit is normally complete from line-wire 1 to switch-hook S through wire 27 to armature u, through wire 25 to bell Q, or through wire 26 to bell Q', and thence to line-wire 2. The transmitters T and T' are each connected in a local circuit and contain a battery t and the primary winding i of the usual induction-coil. This circuit is adapted to be closed by the switch-hook rising and impinging upon contacts s^2 s^3, the contact s^3 likewise serving to connect the secondary winding i' with the line-wire 1. Upon each switch-hook an insulated piece s is provided, which serves when the hook is up to connect the contacts s^4 and s^5, thus completing the ground-tap containing the relay U. In connection with this ground-tap I provide a branch of the wire 4 to a front stop w^3 of the relay U or U'. Upon the upper end or connected to any convenient part of the armature-lever u is a target or visible signal u'. At the central station the middle point of the winding a a' of each annunciator A A' is connected by a wire 16 to a point 15, from which a branch wire 17 passes to the main battery B and ground. The connective circuits at the central office are divided into ordinary plug-cord circuits and trunk-lines.

In Fig. 1, P P' are answering and calling plugs, respectively, of the plug-cord circuit, consisting when intact of conductors 6 and 8 and 7 and 9. J^2 is a trunk-jack supposed to be located at the same board-section as the plug-cord circuit just referred to. P^2 is the plug at the other extremity of said trunk-line, supposed to be located at the board-section upon which the line from subscriber Y terminates, and 18 19 are the trunk-conductors connecting the jack and plug and supposed to pass between said board-sections. Each plug P P' P^2 is provided with a tip and a sleeve-contact, and in the cord-circuit the tips and the sleeves are respectively connected to each other when the cord-conductors are united, while the springs of the jack J^2 are so connected to the tip and sleeve p p' of the trunk-plug P^2 that the trunk-line forms to all intents and purposes a continuation of the plug-cord circuit.

The mechanism connected with the plug-cord circuit consists of an operator's talking set (not shown, but which may be of the usual or any desired construction) and plunger-switch V, with a detent for holding it depressed, and a magnet W for controlling the same, and, finally, a ringing-key K. The plunger-switch V consists in its simplest form, as shown, of a spindle v, provided with a suitable push-button head and having two metallic insulated arms v' and v^2. The lower end of the spindle v is prolonged to extend through a frame or a portion of the switch-board, upon which abuts a coiled spring v^8, which normally serves to hold the spindle v, with its attached parts, in the position shown. The extreme end of the spindle is provided with a detent v^7, having an inclined face and a shoulder portion adapted to engage with the face and shoulder, respectively, of the detent w' upon a bell-crank armature-lever w, pivoted at w^3, and adapted to be moved in one direction to lock the plunger V, by means of a spring w^2, and in the other direction to release the plunger by the magnet W. The conductors 8 9, connected to the plug P', are also connected directly to insulated arms v' v^2, which normally rest, as shown, against contacts v^3 v^4, forming terminals for the conductors 6 and 7 of the plug P. When the plunger is depressed, the arms v' v^2 leave the contacts v^3 v^4 and come into contact with others v^5 v^6, forming terminals for wires 10 11, connected to the springs k k of the ringing-key K. These springs normally rest, as shown, upon a double anvil k', which is connected by a wire 12 to a lamp or other signal L, thence by a wire 13 to the winding of the magnet W, and thence by wire 14 to a signal-battery b and to the point 15 of connection with the wire 16. When the push-button of the ringing-key K is depressed, the springs k are spread apart, leaving the anvil k and forming new contacts with the anvils k^2, which are terminals of the circuit of a calling-generator G.

In Figs. 2 and 3 I have shown one form of spring-jack which is adapted to carry out the principle of my invention. It consists of springs j, j', and j^3. The spring j^3 is formed by doubling back an extended portion of the spring j' and bending up the inner end therein at right angles to its body, the extreme tip being provided with a small hook or detent j^4. Just below the hook j^4 I attach a plug of fiber or rubber j^6. Punched out of the upper spring j is a tongue j^5, extending down and provided with an inclined face and a shoulder to coöperate with the detent j^4 on the spring j^3. The normal position of the parts is substantially as shown in Fig. 2, where a plug is shown just entering the spring-jack. Fig. 3 shows the position of the parts when the plug has fully entered. It will be observed that upon the entry of the plug the following successive operations take place: First, the sleeve j^2 and the spring j' are crossed together through the sleeve p' of the plug; second, the spring j is lifted by the tip p of the plug, carrying with it, by virtue of the engagement of parts j^4 j^5, the spring j^3; third, when the plug has been fully inserted its tip p, coming against the plug j^6, forces back the end j^4 of the spring j^3 sufficiently to permit the disengagement of parts j^4 j^5, when the spring j^3 will fall in the position shown in Fig. 3. Now when the plug is removed the spring j is, first, allowed to drop by the removal of the tip p; but this drop is not sufficient to allow the parts j^4 j^5 to come to-

gether; second, the spring j' and the sleeve j^2 are disconnected by reason of the plug-sleeve p' leaving the end of the spring, and, third, when the plug is entirely withdrawn the springs j' j^3 rise together and the parts j^4 j^5 again engage, as shown in Fig. 2. The operation of my invention as thus described will now be understood.

We will suppose that subscriber X desires to converse with subscriber Y. He removes his telephone-receiver from the hook S, which thereupon rises, leaving the contact s', connecting together the contacts s^2 s^3 and also the contacts s^4 s^5. Current will then immediately flow from the main battery B through wire 17, wire 16, coil a of annunciator A to the line-wire 2, and also through the jack-spring j, the spring-contact j^3, and the spring j' to line-wire 1, through both line-wires in parallel to the subscriber's station, the current from wire 2 finding a path direct through half of the secondary winding i' and half of the receiver-winding R to wire 3, while current from wire 1 will pass to switch-hook S, contact s^3, and to the other half of secondary winding i' and of the receiver R to wire 3, and thence all the current will pass through contacts s^4 s^5, wire 4, relay U, wire 5, and to ground, and thence back to battery. Both magnets A U will thereupon be energized, the former to display its signal and the latter to pull up its armature u, thus cutting off the bell Q and connecting the wire 27 to contact u^3, as well as displaying its signal u', which will thereafter remain visible until the end of the communication. The operator, perceiving the signal A, inserts the plug P in the jack J. According to the sequence of operations related in connection with Figs. 2 and 3 it will be observed that the parts j^2 and j' are connected before the parts j and j' are disconnected. It should now be observed, therefore, that the act of inserting this plug will produce no sound in the receiver R, for obviously current from the main battery B will flow through the coil a' to the part j^2 and the spring j', as well as through the other coil, before the two springs are separated, a current thus passing through both coils to both sides of line in equal proportions, and both sides of line having an equal impressed electromotive force there can be no variation in the current produced by separating them. This is a very important point in the invention. The admission of current to the second winding a', which in its relation to a is differential as regards the core, has produced a neutral condition of the latter, whereupon the signal is promptly retired. This perfectly-neutral condition, which results from the fact that the two sides of the line are balanced against each other, the resistance of the two sides being presumably always very nearly equal, has a very important effect in addition to the certainty of retirement of the signal. It will be observed that with the plug in the jack the winding a a', considered in its entirety as a continuous winding of one direction, is bridged across the two line-wires. Now it is desirable, and, in fact, necessary, to render the impedance of this coil so bridged high enough to prevent short-circuiting of voice-currents passing over the metallic circuit. It is a well-understood fact that an impedance-coil in order to render the most effective service in choking back alternating currents should have its core in a neutral condition. This is perfectly attained by my arrangement. Having ascertained from subscriber X that he desires to converse with Y, the answering operator inserts the plug P' in the jack J^2 of a trunk-line leading to the board upon which the line-terminal of subscriber Y is located. At the same time the answering operator informs the trunk-line operator through the ordinary instruction-circuits, which it has not been thought necessary to show, as to the connection desired. The answering operator also and simultaneously with giving the order should depress the plunger V. This disconnects plugs P and P' and connects both contacts of the plug P' through wires 8 9 10 11 and springs k with the lamp and magnet-circuit 12 13 14. The answering operator is now free to attend to other business. The trunk operator, on the other hand, having received her order, lifts the trunk-plug P^2 and inserts it in the spring-jack J' of the desired subscriber. By this act a circuit is immediately closed, which may be traced as follows: from battery b to point 15, through wire 16, through both windings a a' in parallel of the annunciator-magnet A', through the spring j and the sleeve j^2 to the tip and sleeve p p', respectively, of plug P^2, through the conductors 18 19 of the trunk-line, through the jack J^2 and plug P', through the conductors 8 9, contacts v^5 v^6, conductors 10 11, springs k, wire 12, lamp L, wire 13, magnet W, and wire 14 to battery b. The current that will immediately flow through this circuit is insufficient, by reason of the low voltage of the battery b, to energize the magnet W; but it is sufficient to light the lamp L, (or energize a signal, if the latter is used.) As soon as the answering operator perceives the lighting of the lamp L she knows that the trunk-plug has been inserted in the wanted-subscriber's line-jack, and she thereupon depresses the calling-key K, which throws generator-current from the machine G through the plug P' and the trunk-line upon the called-subscriber's circuit to ring his bell Q'. If after repeated ringings the subscriber should fail to answer, (which the operator knows by reason of the continued incandescence of lamp L,) the plugs may be withdrawn and the first subscriber informed that he cannot get his correspondent. If, however, subscriber Y answers by removing his telephone-receiver from the hook-switch S', he closes by that act the various circuits heretofore gone into with respect to station X, and a new path for current from main battery B is immediately formed, as

follows: from battery B through wire 17 to battery b, through wire 14, magnet W, wire 13, lamp L, wire 12, springs k, wires 10, 11, 8, 9, and 18 19 in parallel, plug P^2, and jack J' to the line-wires 1 2 in parallel, through both sides of the secondary i' of the induction-coil I', through both sides of the receiver-winding R' in parallel, through wire 3, contacts s^4 s^5, wire 4, relay U', wire 5, and ground and back to battery. The electromotive force of the small battery b is thereupon immediately augmented by the much greater superimposed electromotive force in the battery B, and the amount of current flow in the circuit rises momentarily to such large proportions that the magnet W is immediately energized to attract its armature w. By this means the long arm of the bell-crank carrying the detent w' is thrown out sharply and the plunger V thereby released. This plunger V then rises under the influence of the spring v^8, carrying the arms v' v^2 away from the contacts v^5 v^6 and again into contact with the contacts v^3 v^4. Thus the battery b, the lamp L, and the magnet W are cut off from the plug P' and a through connection from plug P to P' is reëstablished, consisting only of the plain conductors without any interposed apparatus whatever. As soon as the answering operator perceives the extinguishment of the lamp L she knows that the called subscriber has answered, and thereafter she uses the ringing-key no more.

During the continuance of the conversation current from the main battery B is constantly flowing through windings a a' of the respective annunciator-magnets and through the connected line-wires in parallel to the subscribers' stations and there to ground. Of course a generator of continuous current instead of a battery might be employed; but inasmuch as the electromotive force of such generators is not altogether constant and inasmuch as the most infinitesimal lack of balance between the windings in the subscriber's apparatus would result in a variation of current on the line, producing sounds in the receiver, I prefer to use a secondary battery. As the system is operated this current produces no effect whatever, being totally inaudible while the conversation is proceeding. If for any reason one of the subscribers should hang up his telephone-receiver during the continuance of the connection, no effect would be produced upon his annunciator for the reason that current would still flow through both the windings thereof from the battery and back through the cord-circuit in parallel to the other subscriber's line and out to the subscriber's station, there finding a ground as long as that other subscriber keeps his telephone off the hook. When, however, both subscribers have finished their conversation and hung up their telephones, both annunciators will again display their signals. This results from the formation of certain new circuits, which I shall trace at the station X alone, the other being a duplicate thereof. Current from battery B will flow through the wire 16 to and through the winding a', through wire 22 to sleeve-contact j^2, to spring j', through line-wire 1 to the hook-switch S, to contact s', to the armature u, to the contact u^3, through the winding to magnet U, and through the wire 5 to ground and back to battery. Current will not flow through the winding a for the reason that that winding is connected to the line-wire 2, which when the hook-switch has been thus depressed is opened at the subscriber's station. It should be particularly noted here that this operation is entirely due to the relay U. When that relay was first energized by the original call it pulled up its armature against the front stop u^3, thus completing a partial circuit from wire 27 through its own coils to ground. Now in the actual mechanism as constructed the hook-switch makes contact with the anvil s' before it leaves the anvil s^3, and thus the armature u is held up continuously, because the new path for current through wire 27 to the relay and ground is completed before the former path is broken. Having perceived the clearing-out signals, the operators proceed to remove the plugs. Obviously it is necessary in order that the relay U may release its armature that the connection between the spring j' and the sleeve j^2 should be broken before the springs j and j' are again permitted to come together, for otherwise as there is a constant connection between the battery (through coil a) and the spring j the relay would never let go its armature and the annunciator A would always display its signal. By the sequence of operations, however, which was described in connection with Figs. 2 and 3 it will be observed that the insulation which separates the sleeve p' from the tip p of each plug actually passes the end of spring j' before that spring is allowed to rise to again cross with its neighbor. Thus the circuit through which the clearing-out current had previously been flowing over line-wire 1 is momentarily broken. A mere momentary break is sufficient, for the very instant the break occurs the armature u starts to retract, and it has been found that so slight an interval between the armature and the contact u^3 is required for successful operation that it is practically impossible to withdraw a plug from a jack with sufficient quickness to prevent such operation. Obviously the retraction of the armature u, carrying with it its target u', announces to the subscriber in each case that the plug has been withdrawn from his spring-jack and that he may proceed to make a new call.

While I have described and illustrated a single arrangement of circuits and specific forms of mechanism for carrying out the principles of my invention, I wish it to be distinctly understood that I do not limit myself to such specific forms either of the circuits or of the apparatus, but that I consider my-

self to be the first person to successfully use differential annunciators for both calling and clearing out without the use of artificial or balancing circuits. In various other respects I consider my invention to be broadly new, and I therefore include within its scope and purview such similar arrangements as might be devised by skilled electrical workers in view of the principles which I have herein disclosed.

What I claim, and desire to secure by Letters Patent of the United States, is—

1. In a telephone system a line connecting two stations, a signal-magnet at one station having one extremity of its windings directly connected to the line, the other extremity normally open, and the inductively middle point thereof connected to a generator-circuit; means at the other station to complete a connection from the other side of said generator-circuit to the line, and means at the first station for connecting the open extremity of the signal-magnet windings also to the line, whereby the magnet may be alternately energized and deënergized substantially as described.

2. In a telephone system a line consisting of two limbs, a signal-magnet at one station having one extremity connected directly to one of said limbs, having its other extremity normally open, and the inductively middle point of its windings connected to one side of a generator-circuit; means at the other station for connecting both limbs of the line to the other side of said generator-circuit, and means at the first station for connecting the normally-open extremity of the signal-magnet windings to the second limb of the line, whereby the core of the magnet is rendered neutral substantially as described.

3. In a composite telephone and signaling system, a metallic conversation-circuit between two stations, a signal-magnet at one of said stations having inductively-balanced windings a portion only of which is in normal connection with the circuit, means at the other station whereby signaling-current may be thrown upon both sides of the line, and means operative during conversation whereby the open extremity of the windings of the signal-magnet may be connected to form a neutral bridge across the metallic circuit substantially as described.

4. In a composite telephone and signaling system a metallic conversation-circuit provided with means at one extremity to connect a source of current to both sides of the circuit, a bridge containing a signaling-magnet at the other station permanently connected to one side only of the circuit and adapted to be connected to the other side during conversation, and a connection from the inductively middle point of the windings of the signal-magnet to the circuit of the generator aforesaid substantially as described.

5. In a telephone system a metallic conversation-circuit between two stations, a signaling-magnet at one of said stations having balanced windings normally connected in one direction only to both line-wires, means to break apart the line-wires and connect said magnet in opposite directions to both line-wires, an intermediate connection from said magnet to the one side of a source of energy, and means at the other station to connect or disconnect the other side of said source of energy to or from both line-wires at will, substantially as described.

6. In a telephone-exchange system a subscriber's station, a central station and a metallic circuit connecting the same, a spring-jack and an annunciator therefor at the central station, the former keeping the two sides of the metallic circuit closed together when the line is in disuse, and the latter having balanced windings, one extremity of which is permanently connected to one side of the metallic circuit, the other extremity of which is connected to a normally-open contact and the inductively middle point of which is connected to one side of a generator, a switch at the subscriber's station for connecting the other side of said generator with both line-wires, and a connecting-plug coöperative with the jack in making connection with the line to separate the line-wires from each other and means to bridge the annunciator-windings across the circuit, substantially as described.

7. In a telephone-exchange system a subscriber's station and a central station and a line connecting the same consisting of two limbs, a signal-magnet at the central station having balanced windings adapted to neutralize each other, a source of current connected to said windings, means whereby the subscriber may cause current to flow through one of said windings to line for a call, means whereby the operator may connect the other or neutralizing windings to also receive current passing through the line during conversation, and a switching mechanism at the subscriber's station for cutting off current from one only of said windings at will, substantially as described.

8. In a telephone-exchange system a subscriber's station, a central station, and a line connecting them, calling means at the subscriber's station and call receiving and connective means at the central station, a signal-magnet and signal at the subscriber's station brought into connection with the line upon the operation of the calling means, and thereafter maintained in connection with the line and under the control of the operator until the latter has finally disconnected the line at the central station, substantially as described.

9. In a telephone-exchange system a subscriber's station and a central station, and a circuit interconnecting the two, calling means at the subscriber's station and call receiving and connective means at the central station, a relay-magnet at the subscriber's station controlling the call-receiving means at the central station brought into operative relation with the line upon the operation of the sub-

scriber's calling means and a branch circuit closed by said relay through its own windings whereby after having been once brought into connection with the line it thereafter remains under the control of the central-station operator, substantially as described.

10. In a telephone-exchange system a subscriber's station, a central station, and a metallic circuit interconnecting the same, a generator of electric current having a branch from its circuit entering the subscriber's station, and a switch thereat adapted normally to disconnect the line-circuit from said branch but to connect the branch to both sides of the line-circuit at its first operation when the subscriber calls, and thereafter when again actuated to leave the generator branch connected to but one side of the line-circuit; a signal-magnet at the central office having balanced windings with their neutral point connected to the aforesaid generator-circuit so as to be at a different potential than the subscriber's branch, one extremity of said magnet-windings being permanently connected to one side of the line-circuit and the other extremity being adapted to be connected to the opposite side of the line-circuit during a connection with the line at the central office; the whole so arranged that when the subscriber first actuates his switching mechanism the signal-magnet at central will be energized, when the operator makes connection with the line its windings will both receive current and thereby neutralize each other, and finally when the subscriber at the conclusion of the conversation again actuates his switching mechanism that but one of the windings of the signal-magnet will receive current, in order to render it again operative, substantially as described.

11. In a telephone-exchange system a subscriber's station, a central station, and a circuit interconnecting the two; a switch and a relay at the subscriber's station, the latter brought into operative connection with the line when the former is actuated, a signal-magnet at the central station normally connected with the line and under the control of the subscriber but adapted to be restored by the operator in making connection with the line, a generator of current connected to said signal-magnet and having a branch of its circuit entering the subscriber's station, and contacts under the control of the relay thereat whereby current is caused to again energize the signal-magnet at central at the close of the conversation, substantially as described.

12. In a telephone-exchange system a subscriber's station, a central station, and a circuit connecting the two, a signal-magnet and a connective means at the central station and a signaling-switch and a relay at the subscriber's station, the switch and relay adapted to control the signal-magnet at central at the beginning and end of a communication, and the relay adapted to be controlled from the central office through the said connective means, substantially as described.

13. In a telephone-exchange system a subscriber's station, a central station, and a line-circuit interconnecting the two, a generator of electricity and means at the subscriber's station for determining the flow of current in the line, a signal-magnet at the central station having windings normally in series with the line-wires in parallel and means controlled by a plug in making connection with the line, to break the series connection and connect the windings in a bridge across the line-wires, substantially as described.

14. In a telephone-exchange system a subscriber's station, a central station, and a metallic circuit interconnecting the two, a switch, a ringer, and a relay, at the subscriber's station, the armature of said relay controlling a local signal and also controlling the ringer-circuit, a signal-magnet at the central station having windings connected to one side of the metallic circuit and to one side of a generator the other side of which has a branch connection to the circuit of the relay-magnet at the subscriber's station whereby when the subscriber's switch is actuated his ringer is disconnected and the relay brought into connection with the line, and when his switch is restored after an operator has effected a connection with the line the relay will act to energize the signal-magnet at central until the operator shall have disconnected the line, substantially as described.

15. In a telephone-exchange system a central station and subscribers' lines with connective terminals therein, operators' cord-circuits, switching mechanism for each cord-circuit, a controlling-magnet therefor and a signal connected with the cord-circuit through the switching mechanism, a source of current, means controlled by an operator in completing a connection between two subscribers' lines to connect a portion only of the source in circuit with the signal and the magnet, and means controlled by an answering subscriber to bring the entire source of current into circuit therewith, whereby at first the signal is energized and finally the switching mechanism is operated, to disconnect the same, substantially as described.

16. In a telephone-exchange system a central station and subscribers' lines terminating in connective means thereat, normally-continuous operators' circuits for interconnecting the subscribers' lines, a continuity-switch, a controlling-magnet therefor, and a signal, for each circuit, a main and an auxiliary source of current, a connection from both of said sources through the signal and controlling-magnet to each cord-switch, and a connection from the auxiliary source to the subscriber's-line terminals, whereby after the operation of the cord-switch and the completion of the connection the signal alone will be energized, but when the subscriber answers

the switch will be restored and the signal and magnet disconnected, substantially as described.

17. In a telephone-exchange system a central station and subscribers' lines terminating in connective means thereat, operator's connecting-circuits having suitable terminals for engaging with the line-terminals, and normally continuous, a switch interposed in each connecting-circuit adapted when actuated to sever the same, a second switch having contact-springs then brought into connection with the forward terminal of the connecting-circuit, and a double set of contact-anvils for said springs, one set connected to a signal-circuit, and the other to the circuit of a generator, substantially as described.

18. In a telephone-exchange system, a switch board or boards divided into separate sections, subscribers' lines terminating each upon one section only, trunk-lines interconnecting the sections and connecting cord-circuits at each section, arranged to connect the subscribers' terminals with each other or with the trunk-lines, a supervisory signal and a ringing-key, with a generator-circuit, for each connecting-cord, and circuit connections from the cord-circuits to the various line-terminals such that upon the completion of a transfer or trunk connection the originating cord-circuit signal will be energized, enabling the operator at that section to manipulate the ringing-key, and, upon the subscriber answering, said signal will be retired, substantially as described.

19. In a telephone-exchange system a central station and subscribers' lines terminating therein, a local signal-battery connected to the various lines at the central office, connecting-plugs and cord-circuits, a switching mechanism separate from the plugs, and a signal for each cord whereby said signal and said local battery may be brought into connection with the cord-circuit when a call is answered, for supervisory purposes, substantially as described.

20. In a telephone-exchange system a central station and subscribers' lines terminating therein; cord-circuits for interconnecting lines; a switch, a controlling-magnet therefor and a signal brought into connection with the cord-circuit when the switch is actuated; a circuit including the controlling-magnet and signal, together with a local battery, the latter connected to the subscribers' lines, a main battery of relatively-higher electromotive force, also connected on one side with said circuit, and a branch from the other side of said main battery entering each subscriber's station, with switching mechanism thereat to control the same, substantially as described.

21. In a telephone-exchange system a central station and subscribers' lines having terminal jacks therein, connecting cord-circuits terminating in plugs adapted to coöperate with said jacks, a switch for each cord-circuit normally maintaining the same continuous, but adapted when actuated to sever the same, a detent for said switch, a magnet controlling the detent, and a signal, a local battery, and a connection from one side of said battery through said magnet and signal in series to the cord-switch and thence to the forward or calling plug, and from the other side of said battery to subscriber's-line jacks, a branch containing additional battery from said last-named connection to each subscriber's station, and means at each subscriber's station for connecting said branch to the subscriber's line at will, substantially as described.

22. In a central-office connecting-circuit for subscribers' lines an answering and a calling plug, a switch, pairs of contacts normally together in said switch and connected respectively to the answering and the calling plug, a pair of contacts in such switch connected to a second switch and there adapted to be alternatively connected to either a signal or a generator circuit, and means for actuating the first-named switch to separate the answering from the calling plug contacts, and to bring the latter into operative connection with the second switch, substantially as described.

23. In a connecting cord-circuit for telephone-exchange systems an answering and a calling plug, a ringing-key, a cord-switch having contacts connected to the calling-plug and normally in engagement with terminals connected to the answering-plug, but adapted to be separated therefrom and engage with the ringing-key terminals, said ringing-key having springs therein normally resting upon a double anvil and thereby both connected to a supervisory signal, but adapted to be shifted from said anvil to generator-contacts, substantially as described.

24. In a telephone-exchange system a subscriber's station, a central station, and a metallic circuit connecting the two, talking instruments at the subscriber's station having their windings divided into equally-balanced portions and the middle point connected to a terminal, a signal-magnet at the central station having its windings connected to one side of the circuit, and to a generator, and mechanism normally crossing both sides of the circuit together, a switch at the subscriber's station adapted to connect the neutral terminal of the talking instruments to the other side of the generator for effecting a call, and means at the central office becoming operative upon making connection with the line to first bridge the signal-magnet windings and connect the generator therethrough to both sides of the line-circuit and then to break the normal connection between the latter, substantially as described.

25. In a signaling system a pair of line-wires connecting two stations, a signal-magnet at one station having differential coils, one of which is directly connected to one line-wire, and a short circuit between the line-wires; means at the other station to determine a flow of signaling-current through both

wires to affect said coil; means at the first station to connect both coils to both wires to receive current, and also to break the short circuit; means at the second station for removing current from one line-wire but allowing it to flow through the other and through a return-signal magnet, and means at the first station to finally break the circuit thus formed, whereby two signals are given in one direction and one in the other, substantially as described.

26. In a telephone-exchange system a subscriber's station, a central station and a metallic circuit connecting the two; a normal cross connection between the line-wires at the central station, and a generator of calling-current permanently connected to one of said wires, a switch at the subscriber's station for connecting the subscriber's talking set to the line and to determine the flow of calling-current from the line-wires therethrough equally, and in opposite directions, and means at the central station for first directly connecting the generator-circuit to the second line-wire and thereafter breaking the normal cross connection, whereby no sounds are produced in the subscriber's receiver, substantially as described.

In testimony whereof I have hereunto set my hand, this 20th day of April, A. D. 1899, in the presence of two witnesses.

EDWARD E. CLEMENT.

Witnesses:
SPENCER B. PRENTISS,
W. BERTRAND ACKER.