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E. E. CLEMENT.

TELEPHONE SYSTEM.

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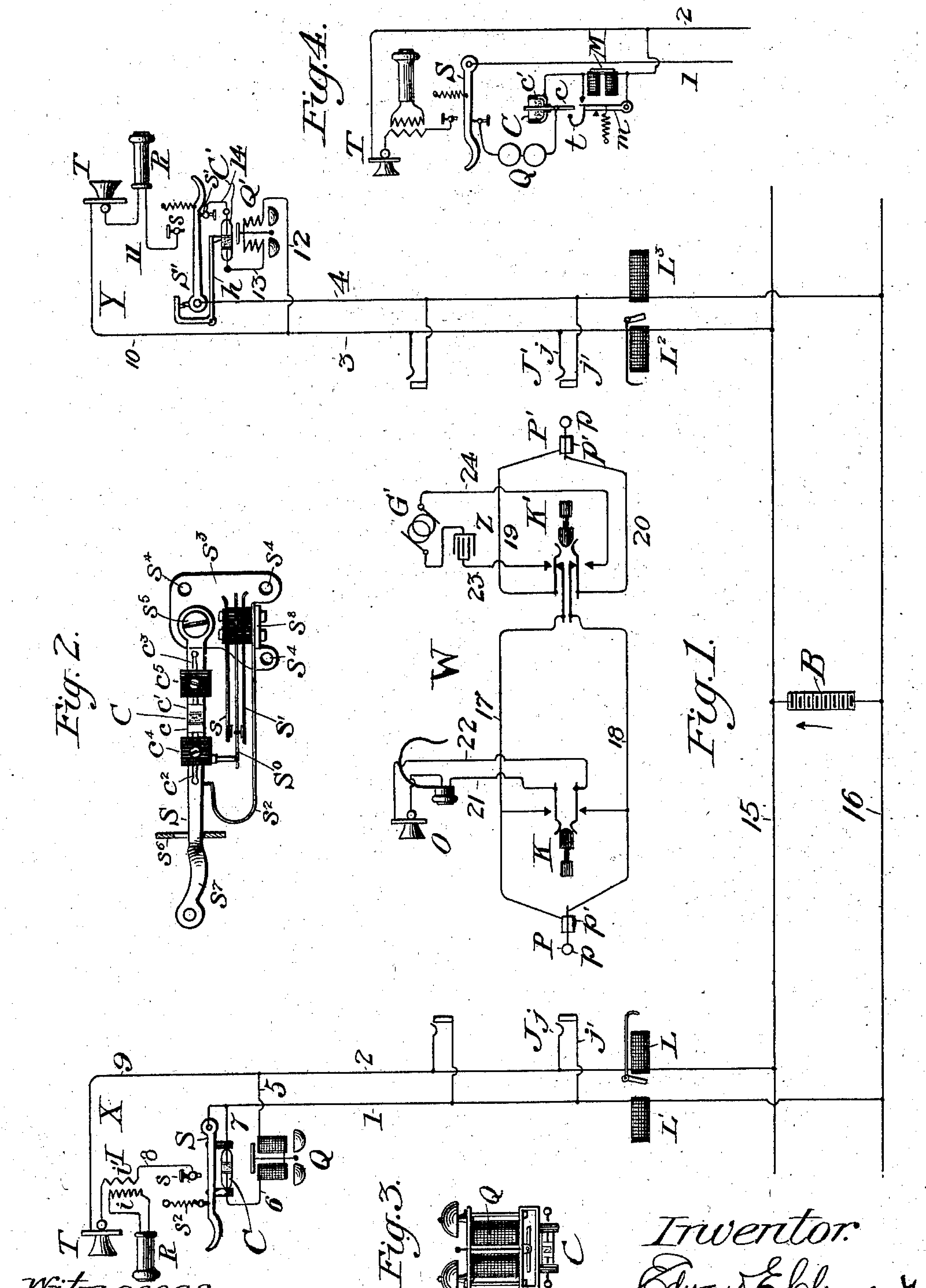
NO MODEL.



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UNITED STATES PATENT OFFICE.

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TELEPHONE SYSTEM.

SPECIFICATION forming part of Letters Patent No. 719,998, dated February 10, 1903.

Application filed June 4, 1901. Serial No. 63,052. (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 and county of Philadelphia, State of Pennsylvania, have invented a new and useful Improvement in Telephone Systems, of which the following is a specification.

My invention relates to telephone systems in general and to exchange systems employing a common battery at the central office in particular. In such systems it has heretofore been necessary to provide means at the subscribers' stations to satisfy the following conditions: line not in use and not being called—circuit open at subscriber's station and direct-current generator on the line at central; line being called—alternating-current generator connected at central, and a path closed for same at subscriber's station, but open to direct current; line in use—circuit closed at subscriber's station for direct current and maintained so until completion of the conversation; line disconnected at central from main-battery busses and connected through cord conductors to battery. In considering these conditions it is seen at once that the principal problem is that of differentiating between the direct and alternating currents that are applied to the line for calling in and calling out, respectively. To do this it has heretofore been the custom to use condensers in series with the ringers, and when the subscriber removes his receiver from its hook for a call or to answer a call to cause the ringer and condenser to be cut out or to be brought into such relation with the transmitting and receiving mechanism as not to interfere with the transmission of speech. According to one plan, the ringer and condenser are normally bridged across the line-wires, and the transmitter, receiver, and induction-coil are cut out. In using the telephone the hook rises and brings the ringer into parallel with the primary and secondary windings of the induction-coil in series and the condenser into a shunt of the transmitter and in series with one winding of the coil and the receiver. The condenser in that case acts to sharpen the variations in current sent to line during conversation as well as to hold the line open at other times. Such a condenser should have a capacity of approximately two microfarads and should stand a potential of one hundred volts or more without breakdown. Even a hundred-volt condenser will not always stand the strain put upon it by a large ringing generator, however, and in order to secure freedom from troubles it is necessary to exert considerable care in the manufacture, with the result that the average condenser in place represents considerable money.

It is the object of my invention to do away with condensers entirely at subscribers' stations, bringing the apparatus down to the simplest elements. The switch-hook becomes one with a single contact or at most two contacts. Moreover, as a part of the general scheme, I have devised the circuits and apparatus at central or simplified to do away with the necessity for the last condition named above, leaving the lines permanently connected to the main busses.

In attaining my object I employ in place of the condensers what have become well known under the name of "coherers" in other connections—that is, instead of maintaining a path open to direct current, but closed by static induction for the passage of alternating or changing currents, I employ a device in series with my ringer that is normally open for all practical purposes to any currents and unaffected by a considerable electromotive force if the same is steadily applied. When electromotive forces are impressed on the line, however, which are sharply varied or alternated, or when discharges are induced in the line that are more or less disruptive in their nature, the device will suddenly become passable to current of any kind and furnish a conductively continuous path for the ringing-current through the ringer-magnets.

I believe I am the first to discover that alternating currents having certain wave forms have the property of acting through poor contacts or "coherers," so called, lowering their resistance during their passage and, according to the character of the coherers, leaving them at normal high resistance, if self-decohering, or low resistance, as the case may be; that I am the first to use the same current both for cohering and for signaling through the coherer and the first to produce a device of any form which will offer great resistance to the passage of one kind of current, will respond to other forms of current or impressed electromotive forces resulting in currents by an internal action lowering or altering the said resistance, and thereby pass the current producing the change to affect ordinary translating devices, such as signals and the like. It has heretofore been supposed, before my discovery and invention, that it was impossible to construct a coherer that would have any substantial current-carrying capacity, and the use of a coherer in the same way as a relay of the ordinary type has been confined to very high potential primary transmitting-circuits, usually conveying electrical jerks of a highly discontinuous nature, while the use as a substitute for a condenser has not only been undiscovered, but, if thought of, would have been considered far from feasible. I claim that I have made another agency available which will be of great practical service in the electrical art, and I wish it to be understood, therefore, that I seek to cover, broadly, all forms of apparatus and systems in which my discovery may be employed, whether so contemplated specifically by me at the present time or not.

My invention is illustrated in the accompanying drawings, wherein the same characters of reference represent the same parts throughout.

Referring to the drawings, Figure 1 is a diagram of a complete system of connected circuits employing my invention. Fig. 2 is a side view of one form of switch-hook. Fig. 3 is a similar view of a ringer with the coherer mounted upon it. Fig. 4 is a modification, to be described.

Referring to Fig. 1, X and Y are two subscribers' stations, and W is a central office. The subscribers' lines 1 2 3 4 are permanently connected to the main-battery bus-bars 15 16, the battery being lettered B. At station X, T is the transmitter, R is the receiver, S is the switch-hook, Q is the ringer, and C is the coherer. Instead of including the receiver R directly in the line I avoid the pull on the diaphragm which the line-current causes by placing the receiver in the local circuit of a coil I, having its primary i' in the line and its secondary i in the local. On the switch-hook S, I mount the coherer, so that the movement of the hook when the receiver is removed or replaced will jar the coherer and decoherer. The details of the mounting are shown in Fig. 2. The hook proper, S, is pivoted by means of a shoulder-screw s^5 on a plate s^3, having perforations s^4 for attachment to the casing of the telephone and an upturned lip s^8, upon which a set of springs s S^0 s' are mounted. A larger spring s^2 is mounted beneath the others, having the purely mechanical function of keeping the hook S elevated.

s^6 is a slotted escutcheon-plate in which the hook oscillates. Mounted on the side of the hook are two blocks of hard rubber c^4 c^5, between which is supported, preferably by having its ends set in the blocks, a tube C, of glass or other suitable insulating material, with terminals c c' sealed into it and spaced far enough apart to receive a small quantity of metallic filings, preferably iron and nickel mixed and rather coarse of grain. Terminals for wires are led out from the tube through the rubber blocks at c^2 c^3, the connecting-wires not being shown in the figure. By this construction it will be understood that every time the hook rises sharply against the upper end of the slot in the escutcheon and every time it is depressed in a similar manner by the receiver the coherer is shaken up and the filings are restored to their condition of high resistance.

Returning now to Fig. 1, the hook at station X is shown down and the ringer Q and coherer in circuit. The talking-set is cut out. The normal resistance of coherers for this purpose, as I have determined to use them, is one hundred thousand ohms, approximately. This is a purely arbitrary figure, as it may be more or less without prejudice. With such a resistance, however, and the usual voltage at central in the main-battery circuit the leakage at any station is about .024 milliamperes, a little over one-fiftieth of a milliampere, which is a negligible quantity, even when multiplied by the largest number of lines not calling and idle in a large exchange. In other words, the circuits are normally open for all practical purposes. The conditions are therefore substantially the same as where a condenser is used for the ringer-circuit.

At the central office, B is the main battery, connected across bus-wires 15 16, to which all the line-wires are permanently connected.

L is the line-signal of the station X, and L' a balancing-coil. Similarly, L^2 is the line-signal of the station Y, and L^3 is its balancing-coil. It is desirable to maintain the lines perfectly balanced, especially in a multiple-board system, to prevent cross-talk and other disturbances.

J is the line-jack of line 1 2, having a pair of contacts j j', and, similarly, J' is the jack of line 3 4. Multiple jacks are also shown; but as they are not necessary to the consideration of the present invention they are not lettered. In the other applications to which I have made reference, however, the details of the present system are given in full.

P P' are a pair of plugs connected by the cord conductors 17 18 19 20.

The operation of the system shown in Fig. 1 may now be understood. Suppose the subscriber at X is desirous of calling Y. He removes his receiver from the hook and the circuit B 15 L 2 9 T i' 8 s S l L' 16 is closed. Line-signal L is therefore displayed. The operator inserts plug P in jack J, and line-signal L immediately is retired. The operator now cuts herself in by the key K and, ascertaining the number wanted, inserts plug P′ in jack J′. Then by depressing key K′ she puts calling-generator G′ on the plug P′ and so to line 3 4. The effect of the alternating current on the coherer C′ is greatly enhanced by having the coils L^2 L^3 in parallel and the condenser Z in circuit. Such a condition is not absolutely essential, however. The coherer responds to the first alternations by breaking down in resistance, so that the ringing-current passes to the ringer Q′ in the branch 12 13 through a low resistance which is non-inductive. The resistance of the average coherer when cohered can be brought as low as forty ohms. When the subscriber answers, he takes the receiver from the hook, and the lever *h* is raised and allowed to fall so that its tip strikes a tap on the coherer-tube, causing the filings to fall apart and decohere. At the conclusion of the conversation, when the subscribers have hung up, both coherers are again shaken up, that at X by the jar of the hook direct and that at Y by the lever *h*. During conversation the current from generator B passes to both lines in parallel, and K is a listening-key to connect the operator's set O across the cord, and K′ is a ringing-key to connect the ringing-generator G′ through its circuit 23 24 to the conductors 19 20, at the same time disconnecting the latter from the answering-plug P.

In order to enhance the effect of the ringing-generator G′ on the coherers, it is sometimes desirable to include a condenser Z in the generator-circuit, as shown. This is not an indispensable adjunct, however.

At station X in Fig. 1 I have shown the coherer carried on the switch-hook and jarred by the latter's movements to decohere. At station Y, I show a different arrangement. Here the coherer is supported independently, the hook having up and down contacts *s* and *s′*, so that when it rises the coherer and ringer are disconnected at the latter point, and a tapper *h* is shown worked by the hook to strike the coherer when the hook moves. I do not limit myself to any particular form of tapper, as many forms will suggest themselves to any one familiar with the various forms of coherers in use; but the tapper must be workable in both movements of the hook—*i. e.*, when it goes down as well as when it goes up—for the reason that when the ringer and coherer are thrown across the line after completion of a conversation the coherer must have been restored to its normal high resistance or there will be false signals given at central, or, at least, serious leakage from the main battery. I have therefore indicated a bell-crank lever having one arm provided with a projection adapted to be raised by a similar projection on the switch-hook when it moves in either direction. The variations due to changes in the transmitters are conveyed through the cord conductors past the generator, being prevented from passing the bridge by the choke-coils *g g*.

In some cases the arrangement shown in Fig. 1 may not be the most suitable, and in Figs. 2 and 3 I have shown modifications intended to make the coherer action and inaction reliable under all conditions. Thus atmospheric discharges or induced charges on the lines from other lines, as well as disturbances due to crosses, might cause the coherers to act, and in such cases the resistances being brought low enough to be comparable to that of the transmitter and receiver circuit the battery-current would flow, giving false signals at L or L^2, as well as wasting the current. The latter would be the most undesirable condition, as in the former case, if not too frequent of occurrence, the operator could call up and get the hook moved to decohere. In the case of continuous leakage, however, if the resistance of the ringer and coherer did not permit sufficient flow to energize the line-signal there would be no means of determining the trouble, or, at least, of locating it, without testing every line. There is a possibility also that the apparatus in Fig. 1 might fail to decohere, and this would leave the line closed after every conversation.

The general idea which I adopt to prevent the conditions named is that of making the decoherer self-acting in its decoherence. Of course in its usual application to wireless telegraphy a tapper is automatically actuated after every operation; but in the present case I wish to avoid expense, and intermediate relays are to be dispensed with. The preferable arrangement for economy is shown in Fig. 3. Here I show the coherer C mounted directly on the frame of the ringer Q and subject to all the vibrations caused by the oscillations of the armature and hammer. Moreover, the magnet of the ringer has a tendency to keep the filings in suspension and therefore decohered. The alternations in polarity of the cores also increase the effect, as all the filings employed are preferably (though not necessarily) magnetic. By this arrangement every impulse that moves the ringer-armature has to cohere and decohere, so that the statement may be literally taken that the ringing is done "through the coherer."

In Fig. 4 I show a method of producing the same effects as above by a separate mechanism. Here I provide a magnet M, having an armature *m*, carrying a hammer *t*, adapted to come into sharp collision with a stem *c*, forming one terminal of a coherer C. This coherer is different in form from those in the other figures. It consists, essentially, of an ebonite cup with metal sides or bottom *c′* and an insulated central pin *c*, the filings being disposed in the cup to bridge the pin and sides. Shaking the cup or striking the pin decoheres. The magnet M is included in the circuit of the coherer and ringer and is made rather sluggish, so that its armature will not respond to the alternations of ringing-current. When the latter has caused coherence, the bell Q rings, and, whatever the process may be in the coherer, it continues to ring as long as the generator G′ is to line. When the key K′ is released and the generator G′ consequently disconnected, direct current from generator G is again sent to line. Now, suppose that the coherer is still lowered in resistance. Battery-current will flow through the ringer branch and energize the magnet M, which will attract its armature, the latter closing a short circuit around the magnet, as shown, when it is fully attracted and at the same time striking a blow on the coherer to decohere it. If the decoherence takes place, current is cut off and the armature *m* falls back. If not, it again pulls up, and the coherer receives another blow, and so on until decoherence follows.

I wish it to be distinctly understood that I do not limit myself in any way in my selection of a coherer, as I may use any of the forms now well known or variations thereof. One point only is essential—that the coherer shall not break down under a steady difference of potential up to a considerable voltage. It should also when cohered have a sufficient safe carrying capacity to take the amperage permitted by the ringer-coils. This I secure by using terminals *c c′* of considerable size and coarse filings in somewhat greater quantity than in the wireless art. The original Lodge and Branly coherers give very fair results.

Many modifications of the invention herein described will suggest themselves to those skilled in the art. I wish it distinctly understood that I consider my invention generic in that I believe myself to be the first to find a method of keeping line-circuits open to signaling-currents without a condenser and yet leave them in condition to be closed for signals when required. This applies to grounded circuits as well as metallic. In toll-lines where grounded circuits are employed magneto-signaling systems are usually employed; but even in such systems this invention may find a place if it is desired to keep direct current off the line except under stated conditions. In connection with metallic circuits from modern exchanges the invention solves a serious problem.

It is to be noted that while I have described alternating current as operating the ringer at the subscriber's station and also as breaking down the coherer resistance, yet that is not by any means essential. A discharge of any kind can be used to break down the resistance, and when that is accomplished direct current may be employed to ring, supplied either from central or at the subscriber's station from a local source.

I may use several forms of coherer that have not been referred to, such as the oxidized copper balls or the suspended oxidized sphere described in the application before referred to.

In the claims I shall refer to the cohering device as a "disabling" device, because it prevents the line or signal from responding to signaling-currents, resisting the steady electromotive force. I shall refer to the ringer as a "responsive" device or a "magnetic responsive" device. Any substituted piece of apparatus that would be included in these terms I consider to be included in the scope of my invention; but this is not to be taken as meaning that I limit myself by the terms. They are used for convenience.

I shall use the words "opaque" and "transparent" in the claims in the sense of non-conducting or conducting, respectively—that is to say, the coherer or equivalent device is opaque to currents when it either completely or substantially opposes their passage. It is transparent when it lowers or removes its opposition.

The expression "sensitive resistance device" is employed to distinguish from the impedance-coils and condensers that are sometimes used for disabling devices to pass alternating but not direct currents.

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

1. In a signaling system, two stations and a connecting-circuit between them; a responsive device at one station and a source of current at the other, a sensitive resistance device at the first station normally holding the responsive device out of operative connection with the circuit, and a source of energy at the second station to alter the condition of the resistance device to bring the magnetic device into operative connection with the circuit, and to operate the same.

2. In a signaling system, two stations and an intermediate connecting-circuit, a signal-receiving device at one station and a disabling device normally rendering the same inoperative and the line substantially impassable for currents, together with a source of energy at the second station for affecting the disabling device to render the signal device operative, and to operate the same.

3. In a signaling system, two stations and a connecting-circuit therebetween, a signal-receiving device at one station and a signal-sending device at the other station, means at the first station to render the signal-receiving device normally irresponsive and the circuit substantially impassable for currents; and a source of energy at the second station to first render the circuit and signal device operative and then to operate the signal.

4. In an electric signaling system two stations, a connecting-circuit therebetween, a signal-receiving device at the first station and a disabling device of relatively high resistance included in its circuit, a source of current at the second station, together with means to affect the disabling device to break down and reduce its resistance and to cause the actuation of the signal.

5. In a telephone signaling system, two stations and a circuit connecting them, a magnetic signal device at one station, and a co-

hering device having normally a very high resistance in circuit with said magnetic device, a source of current at the other station to affect the cohering device and break down its resistance, whereby the current may reach the magnetic signal device and operatively affect the same.

6. In a telephone-exchange system, a subscriber's station, a central station, and a line-circuit connecting them; a source of current and a signal at the central station; switching means at the subscriber's station for determining a flow of current in the line; a signal and a high-resistance cohering device also at the subscriber's station connected in circuit but normally impassable for current; and means at the central station to break down the resistance of said cohering device, whereby the signal may be actuated.

7. In a telephone-exchange system, a subscriber's station, a central station, and a line-circuit connecting them; a source of current and a signal connected to the line at central, two bridges of the circuit at the subscriber's station, one normally open and including the telephone, the other normally closed and containing a signal device and a cohering device whose resistance renders the bridge impassable for signaling-currents; together with means at the central station to break down said cohering resistance when calling.

8. In a telephone-exchange system a subscriber's station and a central station and a line interconnecting them; a source of current and a signal connected to the line at central; two bridges of the line at the subscriber's station, one normally open and under the control of the subscriber to determine a flow of current through the line-signal at central, the other normally closed; a signal-receiving device and a coherer in the normally closed bridge, the resistance of the coherer rendering said bridge normally impassable for signal-current; and means at central to throw sharply-varying electromotive forces on the line to break down the coherer resistance, whereby current may pass and the signal may be operated.

9. In a telephone system, two stations and a connecting-circuit therefor, a signal device at one station and a cohering device of normally very high resistance in circuit with said signal device, and means at the other station operating through the connecting-circuit to break down the resistance of the cohering device and to actuate the signal device.

10. In a telephone system, two stations and a connecting-circuit therefor, two bridges at one station, speech transmitting and receiving mechanism in one bridge, a signal device in the other bridge together with a cohering device of normally very high resistance, and means at the other station connected to the circuit to reduce the resistance of the cohering device and operate the signal device.

11. In a telephone system, two stations and a connecting-circuit therefor, a signal device at one station and a cohering device of normally very high resistance in circuit with said signal device, means operable at the other station to reduce the resistance of the cohering device and to operate the signal device, and means at the first station operated by the normal operation of the station apparatus to restore the cohering device to its state of high resistance.

12. In a telephone system, two stations and a connecting-circuit therefor, a signal device and a hook-lever at one station and a cohering device of normally very high resistance in circuit with said signal device, means operable at the other station to reduce the resistance of the cohering device and operate the signal device, and means at the first station operated by the movement of the hook-lever to restore the cohering device to its state of high resistance.

13. In a telephone system, the combination with line-terminals, of two bridges across said terminals, a signal device in one bridge together with a cohering device of normally very high resistance, and speech transmitting and receiving mechanism in the other bridge.

14. In a telephone system, the combination with line-terminals, of a signal device together with a cohering device of normally very high resistance in one bridge across said terminals, speech transmitting and receiving mechanism in a normally open second bridge across said terminals, and a switch to close said open bridge.

15. In a telephone system, the combination with line-terminals, of two bridges across said terminals, a signal device in one bridge together with a cohering device of normally very high resistance, speech transmitting and receiving mechanism in the other bridge, and means to open and close the electrical connection from said terminals through said bridges.

16. In a telephone system, the combination with line-terminals, of a signal device together with a cohering device of normally very high resistance in a normally closed bridge across said terminals, speech transmitting and receiving mechanism in a normally open bridge across said terminals, and switching mechanism to open and close said bridges.

17. In a telephone system, the combination with circuit-conductors, of station apparatus connected to said conductors, a signal device together with a cohering device of normally very high resistance bridged across said conductors, and means operated by the normal operation of the station apparatus to decohere said cohering device.

18. In a telephone system, the combination with circuit-conductors, of station apparatus connected with said conductors, a signal device together with a cohering device of normally very high resistance bridged across said conductors, and connection between the hook-lever of the station apparatus and said coher-

ing device whereby the movement of said hook-lever operates to decohere said cohering device.

19. In a telephone system two stations and a connecting-circuit therefor, two branch connections of the circuit at one station, a signal device and a cohering device in one branch, speech transmitting and receiving apparatus in the other branch, and means at the other station to reduce the resistance of the cohering device and operate the signal device.

20. In a telephone system, two stations and a connecting-circuit therefor, a ground branch, with a signal device and cohering device of normally high resistance, therein, and speech transmitting and receiving apparatus for use in connection with the circuit, at one station, together with means at the other station for operating the signal device through the cohering device.

21. In a telephone system, two stations and a connecting-circuit therefor, said circuit composed of two conductors, a ground connection containing a signal device and a cohering device, and a metallic circuit connection with speech transmitting and receiving apparatus, at one station, together with means at the other station to operate the signal device through the cohering device.

22. In a telephone system, a metallic circuit having one or more ground-taps connected thereto and containing cohering devices and signals, speech transmitting and receiving apparatus adapted to be operated in connection with the metallic circuit, and means to operate said signal devices through the coherer or coherers and a ground-return.

23. In a telephone system, a metallic circuit, a central station and substations connected to said circuit, signaling devices and cohering devices in ground-taps from the metallic circuit, at the substations, and means at the central station to operate said signal devices through the cohering devices.

24. In a signaling system, two stations and a connecting-circuit therefor, a signal device at one station and a cohering device normally interrupting the circuit to the signal, and a source of varying current at the other station adapted to operate through the connecting-circuit and through the coherer device to actuate the signal device.

25. In a signaling system, two stations and a connecting-circuit therefor, a signal device at one station and a cohering device normally interrupting the circuit to the signaling device, and a source of alternating current at the other station adapted to operate through the connecting-circuit to break down the resistance of the cohering device and actuate the signal device.

26. In a telephone system, the combination with a line-circuit, of two branches, a signal device in one branch together with a cohering device of normally high resistance, and speech transmitting and receiving mechanism in the other branch.

27. In a telephone system, the combination with a metallic circuit of a branch from said circuit containing a signal device and a cohering device of normally high resistance, and a normally open bridge of said circuit containing speech transmitting and receiving mechanism, together with a switch to close said bridge for conversation or signaling.

28. In a telephone system, a metallic circuit, a normally connected branch circuit containing a signal device and a cohering device, a normally disconnected branch containing speech transmitting and receiving mechanism, and switching mechanism to open the normally connected branch and close the normally disconnected branch to line and vice versa, as required.

29. An electric transmission system comprising a circuit, means for supplying to said circuit currents of different characteristics, a translating device, and a disabling device connected to the circuit, such disabling device being normally opaque to all currents and preventing the operation of the translating device, but adapted to automatically change its condition under the influence of some currents and not others, to become transparent to such currents, whereby such selected currents may be caused to actuate the translating device.

30. In an electric transmission system, a circuit, means for supplying to said circuit currents having different characteristics, a translating device, and a sensitive resistance device connected to the circuit, said resistance device being normally opaque to all currents, but adapted to automatically change its condition under the influence of some of the currents, though not of others, to become transparent to such selected currents, whereby they may pass and be caused to actuate the translating device.

31. In an electric transmission system, a circuit, means for supplying to said circuit currents of different characteristics, a translating device, and a selective disabling device normally opaque to all the currents and holding the translating device out of operative connection with the circuit, but adapted to automatically change its condition under the influence of changing currents to become transparent thereto, to permit them to pass and actuate the translating device.

32. In a signaling system, a circuit having a signal and a high-resistance cohering device included in it, said signal and cohering device, a source of current, and means operable through the circuit to reduce the resistance of the cohering device and cause the operation of the signal by the source of current.

33. An electric system comprising a circuit, sources of alternating and of direct currents adapted to be connected thereto, a selective device in the circuit normally opaque to all currents, but automatically changing its condition under the influence of alternating currents to become transparent thereto, and a

translating device operable by alternating currents in the circuit.

34. In an electric system, a circuit, a selective device in connection with said circuit, normally opaque to the passage of electric currents, but adapted to automatically change its condition and become transparent to electric currents under the influence of some impressed electromotive forces but not of others, together with means to impress electromotive force having suitable characteristics on the circuit to cause the passage of a working current through the selective device and the circuit.

In testimony whereof I affix my signature in presence of two witnesses.

EDWARD E. CLEMENT.

Witnesses:

EDWIN S. CLARKSON,

D. W. EDELIN.