No. 719,999. PATENTED FEB. 10, 1903.

E. E. CLEMENT.

SIGNALING APPARATUS AND SYSTEM.

APPLICATION FILED JUNE 13, 1901.

NO MODEL. 2 SHEETS—SHEET 1.

Fig. 1.

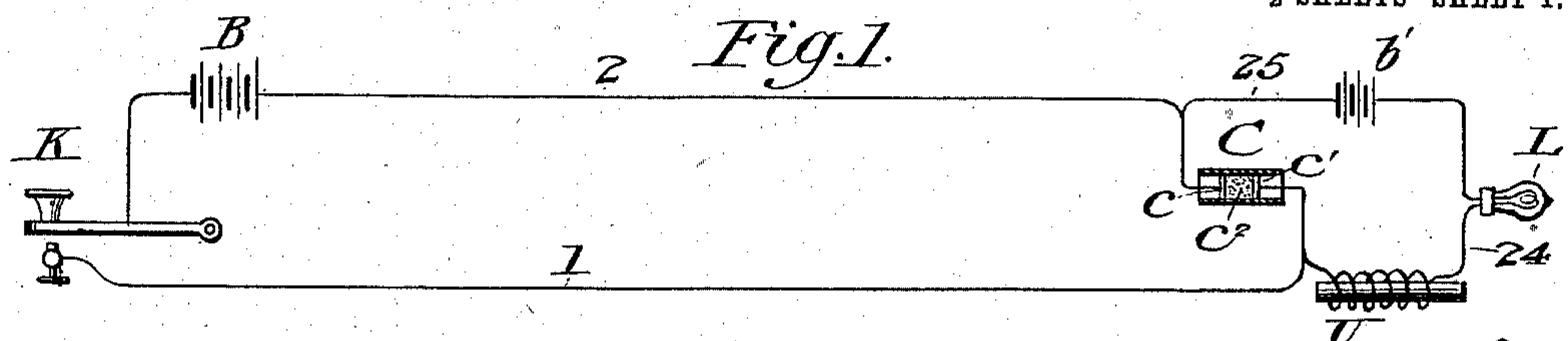


Fig. 2.

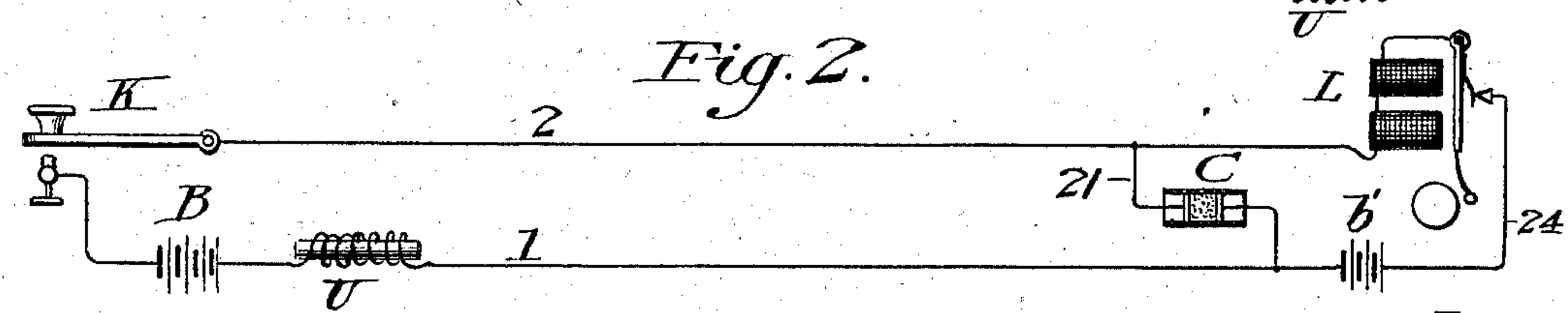


Fig. 3.

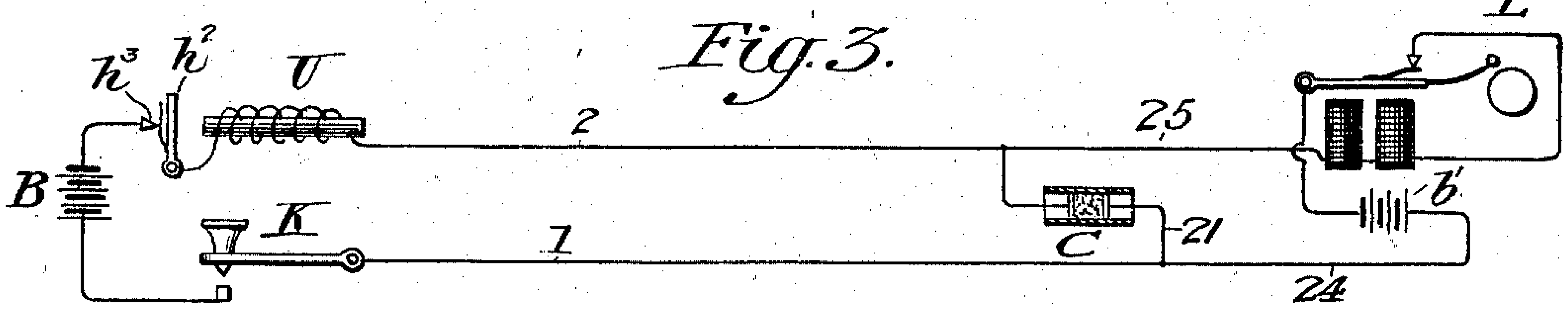


Fig. 4.

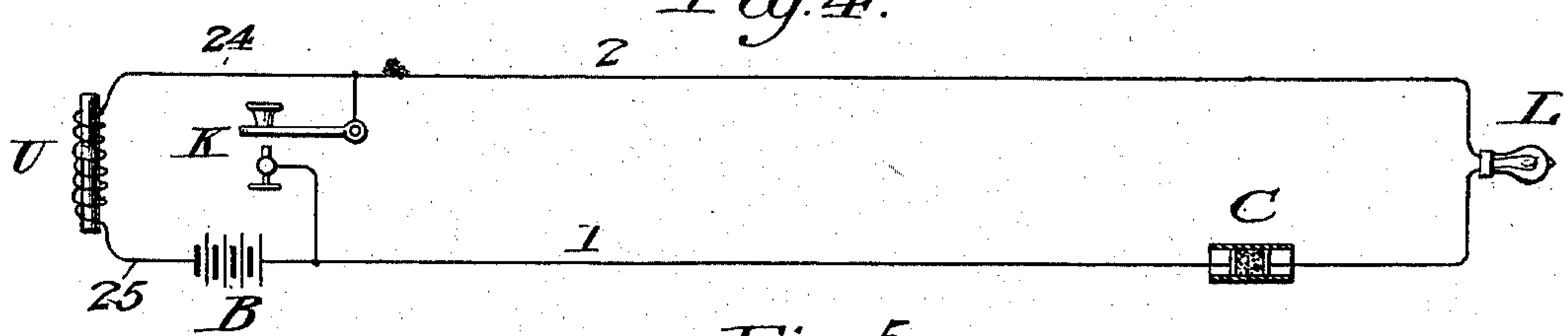


Fig. 5.

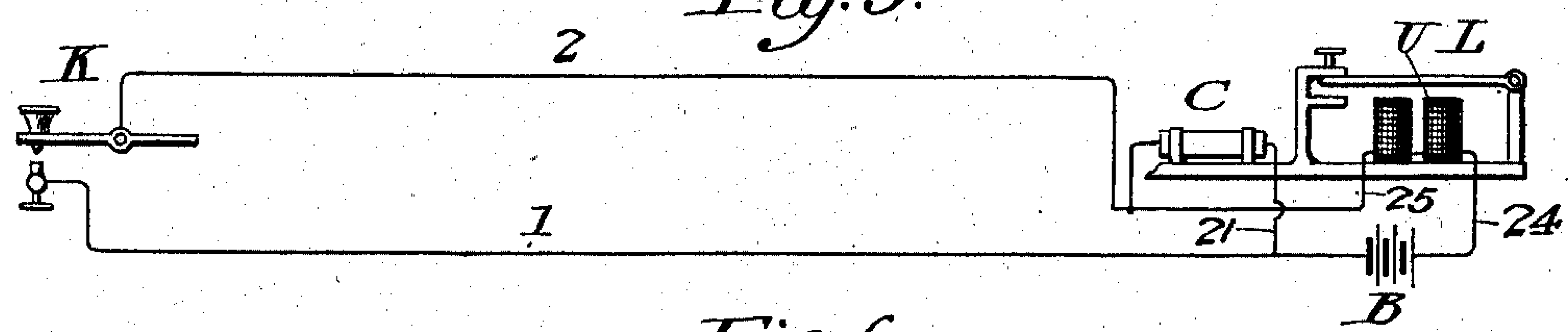
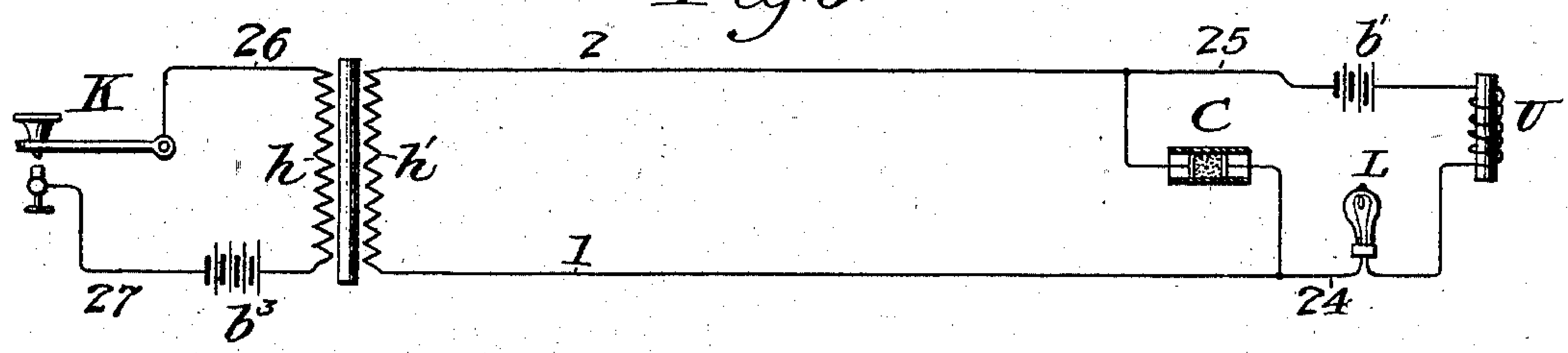


Fig. 6.



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THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

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SIGNALING APPARATUS AND SYSTEM.

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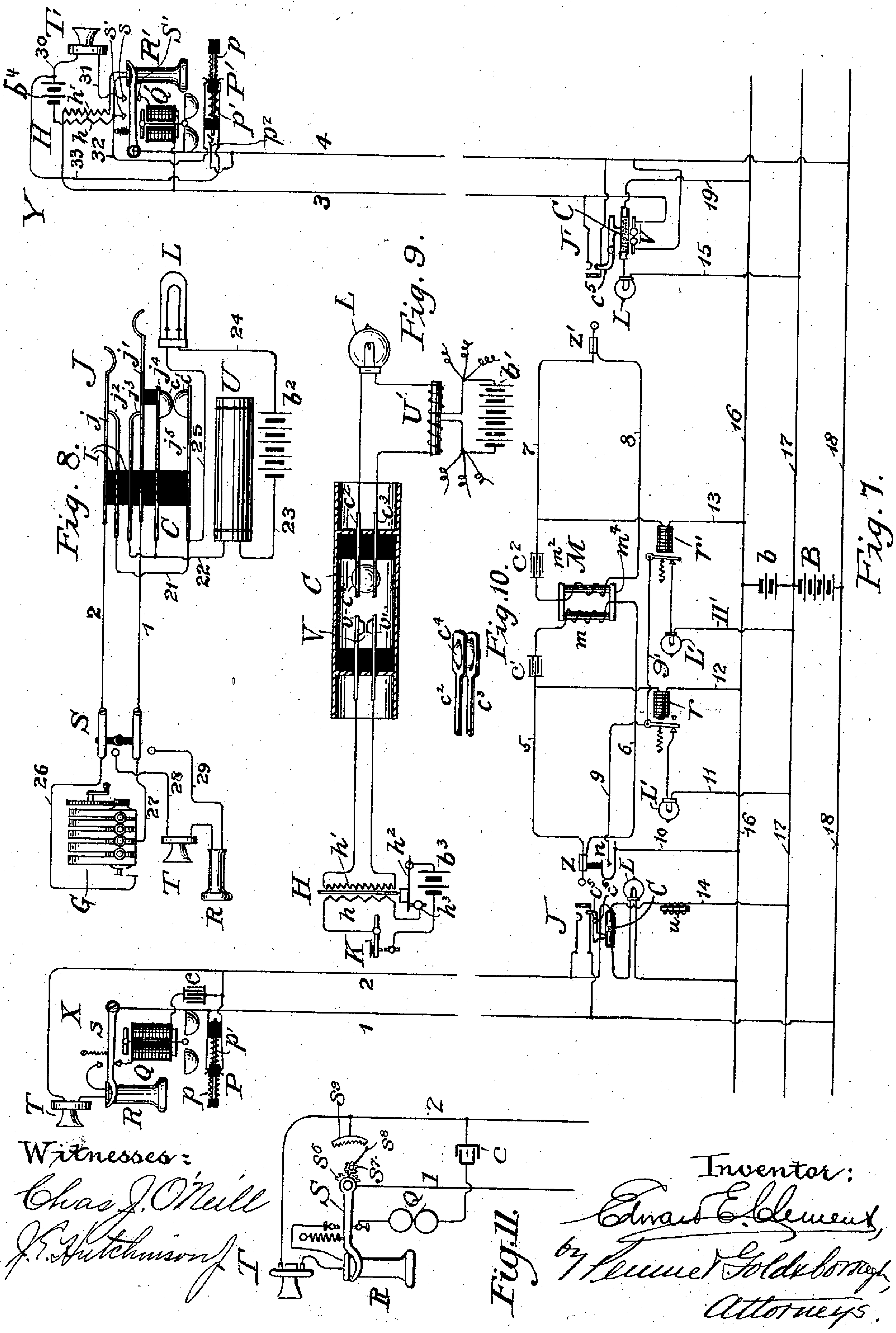
NO MODEL. 2 SHEETS—SHEET 2.



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UNITED STATES PATENT OFFICE.

EDWARD E. CLEMENT, OF PHILADELPHIA, PENNSYLVANIA.

SIGNALING APPARATUS AND SYSTEM.

SPECIFICATION forming part of Letters Patent No. 719,999, dated February 10, 1903.

Application filed June 13, 1901. Serial No. 64,426. (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 Philadelphia, county of Philadelphia, State of Pennsylvania, have invented certain new and useful Improvements in Signaling Apparatus and Systems; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to the art of signaling or conveying intelligence from one point to another, and particularly to signaling by means of electricity.

Heretofore the commonest mode of signaling electrically has been to produce changes in current flowing over a line by means of a transmitting device at one end of the line and to render these changes perceptible at the receiving end by means of an electromagnetic responsive device. The electric telegraph and the electric telephone both operate on this general principle, the single element in these and other cases that is vital to the operation of a system and that can neither be radically changed or dispensed with being the electromagnetic responsive device. In the telegraph this is the relay or sounder, or both, if both are employed. In the telephone it is the magnetic receiver, and in signaling generally it is almost invariably an electromagnet of some sort. I am aware that chemical devices have been used to some extent for receiving signals, the decomposition of some salt being relied on, and that the effects of the electric current in lessening friction between certain classes of substances, in promoting fluidity and lessening capillary attraction, &c., have been utilized at divers times; but none of these have been found sufficiently reliable and at the same time so easily adaptable to manifold purposes as the electromagnet. The latter has therefore come to supersede other forms of receiving devices almost entirely. In spite of its universal usefulness the electromagnet as a relay or a signal-receiving device has serious drawbacks well known to all engineers and electricians, not the least of which in many systems of communication is the expense involved. Thus in many telephone systems where relays of some sort must be employed the many electromagnets required are a source of great embarrassment and have formed the subject of much study both on account of their physical properties and their cost.

My invention has for its object the production of a signal-receiving device and other apparatus and circuits therefor whereby the use of electromagnets may be partially or wholly avoided, whereby also the signals can be transmitted over main lines whether long or short by changes in electric potential rather than in current-flow, and whereby the work required to be done in rendering the transmitted signal perceptible can be all done in a local circuit, the substitution being accomplished by an increase of efficiency in service and a substantial reduction of expense.

I attain my objects by the arrangement of circuits and transmitting apparatus which will be described herein or their equivalents and the employment of a novel form of receiving device. This is very similar in general design to the so-called "coherers" utilized in Hertzian-wave telegraphy, but differs therefrom in many features of construction and is radically different in its mode of application and operation. In general it may be said that I employ contacts which normally present a very high electrical resistance, such as oxidized-copper surfaces or points or iron or other filings, connecting them to line and with a battery and a translating device, such as a lamp or perhaps a coarsely-wound electromagnetic device. By then producing a suitable discharge in the line or impressing a considerable electromotive force thereon I lower the resistance of the said contacts to permit battery-current to flow and energize the signal. This arrangement constitutes a singularly simple but efficient receiving apparatus. The contacts or coherer are so made as not to "break down" or lower their resistance on the potential to which they are normally exposed; but by impressing a much higher electromotive force on the line the resistance at once breaks down, the phenomenon of "cohering" taking place, and current flows in the local circuit to give the signal.

My invention is illustrated in some of its many forms of application in the accompanying drawings, wherein corresponding characters point out corresponding parts in all the figures.

In the drawings, Figure 1 is a diagram of a line-circuit and a receiving device embodying my invention. Figs. 2, 3, 4, 5, and 6 are diagrams showing modifications. Fig. 7 is a diagram showing a telephone-exchange system with my invention applied thereto. Figs. 8 and 9 show modifications. Fig. 10 is a detail figure showing parts of the coherer structure in Fig. 9. Fig. 11 is a diagram to be read with Fig. 7 and showing modified circuits at a subscriber's station.

In Fig. 1 the simplest form of circuits and apparatus embodying my invention have been shown. The line-wires 1 and 2 extend from the transmitting-station at the left to the receiving-station at the right of the figure. The circuit formed by these line-wires 1 2, as also any of the metallic circuits hereinafter referred to or described, may obviously consist of a single wire and a ground return. Metallic circuits are described because they are demanded by modern practice. At the transmitting-station a key K and a main battery B are employed. At the receiving-station a local battery of comparatively few cells, a signal L, such as a lamp, a choke-coil U, and a coherer C, are provided. The main-line wires 1 and 2 are connected to the coherer-terminals, as are also the local-circuit wires 24 and 25. This coherer may be any one of a variety of types. I have found a number of forms to answer well, the main requirements being that the instrument shall not be too sensitive and that its current-carrying capactiy will permit a considerable flow for short periods. In both of these particulars my coherers differ from those employed to detect Hertz waves. The latter are required to be very sensitive and will carry only very small currents. Thus a three or four milliampere flow, sufficient to work a carefully-adjusted polarized relay, is all that is ordinarily employed in wave telegraphy. I must use, on the other hand, a sufficient flow of current and a sufficient voltage to enable a substantial amount of work to be done directly in the circuit 24 25, as I do not wish to employ other relays than the coherer itself. With regard to the relative sensitiveness of the two kinds of coherers that employed in telegraphy is adjutsed to great sensitiveness in order to cause it to break down readily under the influence of the Hertz waves. At the same time great care is taken to prevent breaking down under the difference of potential normally existing between the coherer-terminals due to the receiving-battery. On the contrary, I desire my coherer to break down with a certain difference in potential and not to respond to wave effects at all. The coherer to be used in my systems may consist of two or more oxidized copper or brass surfaces in light contact or, preferably, of a tube containing filings. The latter form must have terminals of large diameter, and consequently of considerable surface area, and the filings should preferably be coarse and of a somewhat refractory metal. Aluminium filings or even coarse iron filings give good results. In Fig. 1 and elsewhere I have shown the coherer C as consisting of a short tube with plug-terminals c and c' with interposed filings c^2.

Referring again to Fig. 1, the operation is as follows: Normally the key K is open and the terminals $c\,c'$ of the coherer C have a difference in potential due only to the local battery b', this not being sufficient to break down the coherer resistance, which may range from several thousand to a million ohms. When the key K is closed, the potential difference due to battery B is immediately communicated to the coherer-terminals, minus the drop due to the line resistance. This is sufficient to break down the coherer, and the resistance by path $c\,c^2\,c'$ is immediately reduced, ranging then from a few ohms to a few hundred. A path is now closed for current to flow from battery b' by wire 25 to coherer $c\,c^2\,c'$, by wire 24 to lamp L, and back to battery. The coil U is included in this circuit 24 25 merely to prevent the circuit forming an effective shunt around coherer C when the key K is closed. It has an additional effect, in that when key K is opened it gives an extra current direct momentarily, which assists in rendering the coherer certain.

In Fig. 2 I have shown an arrangement similar to that of Fig. 1, except that the coil U is placed in the main line 1 2, heightening the extra-current effect, producing a "kick," which serves to make coherence more certain. In this case a bell L is substituted for the lamp previously used and the self-induction of its windings serves to prevent shunting of the cohering impulse by path 24 25.

In Fig. 3 an arrangement similar to that of Fig. 2 is shown, except that the coil U is provided with an armature h^2, that vibrates against a contact h^3, thus serving to send out a series of sudden sharp impulses alternately direct and reverse as long as key K is closed.

In Fig. 4 I have shown a very simple arrangement wherein the line itself constitutes the "local" circuit heretofore referred to, or rather the local circuit is done away with and but one battery employed. Still another way of putting it would be to say the key-battery and coil U are in a local circuit 24 25 and the coherer C in the line. The key K when closed shunts the line 1 2 completely, and when it is opened there is a sudden discharge due to coil U, which breaks down the coherer C, steady current from battery B then flowing over the line and through the coherer to light lamp L.

Fig. 5 at first sight would appear to be a departure from the embodiments heretofore mentioned; but as a matter of fact the arrangement is the same as in Fig. 4, only omitting the lamp L and constituting the coil U the signal as well as the kicking coil. Key K is at one end of the line 1 2, the coils U, the battery B, and the coherer C being connected in parallel to line. I have shown the coils as those of a sounder L of the ordinary form used in telegraphy, the sounder and coherer being mounted on the same base. When key K is closed and then opened, there is a rapid charging of the line and an extra current due to discharge of coils U of the sounder into the coherer-bridge 21, the effect being to break down the coherer resistance, as before, and permit a current-flow from battery B by wire 21, coherer C, wire 25, coils U to wire 24 and back to battery. This energizes the cores of the coils and attracts the sounder-armature to give an audible signal. The concussion of the armature being communicated through the base to coherer C, decoheres the latter and the sounder is ready for another signal impulse.

In Fig. 6 the arrangement of the local circuit is similar to that in Fig. 1, with the coherer bridging the line 1 2. At the transmitting-station the key K is placed in a circuit 26 27, which includes a battery b^3 and the primary h of a transformer or induction coil, whose secondary h' is connected to the line 1 2. It is obvious that the transformer may be located at any desired point in the system; but it will be found particularly advantageous to place the transformer at or near the transmitting-station when it is desirable to employ a comparatively weak battery with a heavy line resistance. By properly proportioning the transformer ratio a comparatively high voltage may be put upon the line 1 2, which will be most effective in connection with the choke-coil U in "breaking down" the coherer to energize the local signal-circuit.

Referring now to Fig. 7, I have shown my invention applied to a telephone-exchange system. Here X and Y are two subscriber's stations connected by line-wires 1 2 and 3 4, respectively, with a central office. At station X a transmitter T and receiver R are provided with a switch S and ringer Q, the latter being included in a branch of line-wire 2, together with a condenser, this branch being normally connected to wire 1 by the switch S, while the latter is held down by the weight of the receiver. Included in a second branch, normally open, is a push-button switch or circuit-interrupter P, having a stem p', carrying an insulating-block normally separating two terminal springs, and serrations p, of conducting material, adapted to pass between the springs when the button is pushed in, thus rapidly making and breaking the circuit 1 2. At the central office a main battery B and an auxilary or lamp battery b are connected between the bus-wires 16 17 18. The line-wire 1 is connected directly to bus-wire 18, and line-wire 2 passes to one plug-terminal of coherer C, then by branch wire 14, through the windings of a choke-coil u, to the bus 17. The other terminal of the coherer is connected through lamp L to the bus-wire 16. A spring-jack J has its contacts connected to the two line-wires and is provided with a tapper or decoherer c^5, pivoted at c^6 and having an upturned end lying in the path of the head of a plug, so that upon the insertion or withdrawal of the plug the tapper is raised and let fall on the coherer C to decohere and restore the same. Station Y has a transmitter T', a receiver R', a ringer Q', and a switch-hook similar to that at the other station; but the arrangement of the circuits is a little different. Station X utilizes current from battery B at the central office for talking and signaling purposes, while station Y has a local battery b^4 for talking, which also furnishes the current for signaling. Battery b^4 at station Y is included in the circuit 30 31 and primary h of the induction-coil of the transmitter T', which circuit is normally open at the switch-contacts s s', and said battery is also in the normally open circuit 32 33, including the circuit-interrupter P', which is similar to the interrupter P at station X except that it is provided with a third spring p^2, connected to line-wire 4. The line-wires 3 4 are connected through the high-resistance ringer-magnet Q', the switch S', and its back contact. Line-wire 4 is connected to bus-wire 18 at central, and line-wire 3 is connected to one terminal of an emitter or spark-gap V on the switchboard. The opposite terminal is connected to 4. A spring-jack J' has its contacts connected to the line-wires 3 4. In proximity to jack J' and spark-gap V is a coherer C. One terminal of coherer C is connected by wire 15, through lamp L, to bus-wire 17, and the other terminal is connected to bus-wire 16 by wire 19, so that under proper conditions the lamp is lighted by current from battery b. A pivoted tapper, similar to that at station X, is mounted on the jack to be operated by the insertion or withdrawal of the plug. Connecting-plugs Z Z' of the usual type are provided for the use of the operator in establishing connection between the different spring-jacks. Located in the plug-circuit is a repeater M, comprising a core m^4, constituting a closed magnetic circuit, and two coils m and m^2. The coil m is connected to the tip and ring, respectively, of plug Z by wires 5 and 6, and coil m^2 has a similar connection with plug Z' through wires 7 and 8. Condensers c' and c^2 are inserted in the leads 5 and 7. A supervisory signal-circuit for station X comprises a circuit 9 10 11, bridged between bus-wires 16 and 17, a lamp L', back contact of relay r, and an operator's switch n. The supervisory signal-circuit for station Y comprises a lamp L' in a circuit bridged between bus-wire 17 and wire 9 and includes the back contact of relay r'. Relay r is connected to bus-wire 16 and wire 5 of the cord-circuit by a lead 12, while relay r' is bridged between bus 16 and wire 7 of the cord-circuit. The operation of the devices as described in establishing connection between two substations, as X and Y, may now be traced. The subscriber at station X actuates circuit-interrupter P, which in its movement inward and outward produces a series of rapid makes and breaks of the circuit of battery B over the following circuit: bus-wire 17, lead 14, including choke-coil u, line-wire 2, interrupter P, line-wire 1, bus 18, back to battery B. The kick of coil u causes coherer C to break down, thereby closing the circuit of lamp L adjacent to the spring-jack J. Current from battery b flows through and lights up lamp L by way of the following circuit: bus-wire 16, line-wire 2, lamp L, coherer C, line-wire 2, instruments T and R, switch-hook S, line-wire 1, bus-wire 18, back to battery b. In response to this signal the operator inserts plug Z in jack J to establish connection with subscriber X. The tip of plug Z upon entering the jack strikes the tapper 5, which rocks upon its pivot c^6, and as the tip passes over it said tapper falls, delivers a sharp blow to the coherer, and causes the metallic particles to decohere, so that the circuit through lamp L is immediately interrupted at the coherer and said lamp is extinguished. Having ascertained the desired connection by means of the usual operator's set and listening-key, (not shown,) the operator inserts plug Z' in jack J', corresponding to substation Y. Under these conditions the subscriber at X is in direct communication with subscriber at Y, the current for the instruments at X being derived from the common batteries B b by way of bus 16, lead 12, cord-wire 5, tip of plug Z, jack-spring to line-wire 2, transmitter T, receiver R, switch-hook S, line-wire 1, bus 18, back to batteries B b. The speaking-circuit between X and Y is traced as follows: transmitter T, line-wire 2, jack-spring, to tip of plug Z, cord-wire 5, through condenser c', coil m of repeater M, cord-wire 6, sleeve of plug Z to the engaging spring of jack J, line-wire 1, switch-hook S to receiver and transmitter. The induced current in the repeater passes by way of condenser c^2 and cord-wire 7 to tip of plug Z', jack-spring, to line-wire 3, to receiver R', switch-hook S', line 4, ring of jack J', sleeve of plug Z', cord-wire 8 to coil m^2 of repeater. During the period of conversation relays r and r' are energized by current from battery B and b and attract their respective armatures, thereby interrupting the circuits through the supervisory lamps L' L'. Should either subscriber at X or Y hang up his receiver, the high-resistance coils of the ringer-magnet would be cut into the circuit of the relays r and r', as the case might be, and the circuit from B b would be so far reduced that the said relay would no longer attract its armature, which would be retracted by its spring to close one of the breaks in the supervisory circuits. For example, should the subscriber at X hang up his receiver relay r would be deënergized, and then when its operator pressed the key n the circuit of lamp L would be lighted by current from battery b by way of bus 16, lead 10, key n, wire 9, armature of relay r, lead 11, bus 17, back to battery b, thereby indicating that subscriber X had finished. Should Y hang up his receiver, relay r' would be deënergized by reason of the reduction of current due to the resistance of Q. Upon actuating key n lamp L', corresponding to relay r', would be lighted by way of the following circuit: bus 16, lead 10, key n, lead 9, lead 9', armature of relay r', lamp L', lead 11', bus 17 to battery b. It is obvious, of course, that when both receivers are hung up both lamps L' L' will be lighted, indicating that both subscribers have completed the communication, and the operator may remove the plugs from the jacks, thereby restoring both lines to proper condition for another call. The arrangement of the signaling devices in connection with substation Y is somewhat different from that at X. In calling central the subscriber at Y actuates the circuit-interrupter P', which causes a series of makes and breaks of circuit from battery b^4 in the primary of induction-coil H of transmitter T, through a circuit comprising primary h of induction-coil H, lead 32 to interrupter P', lead 33 to battery b^4. The current induced in the secondary h' of coil H passes to the spark-gap adjacent to coherer C at central by way of the following circuit: secondary h', through receiver R', wire 32 to interrupter P', end spring p^2, line-wire 4, emitter V, line-wire 3, back to h'. The high-tension secondary current sets up oscillations at V, which pass to coherer C, breaking down its resistance and permitting a current to flow from battery b to light subscriber's lamp L. All subsequent operations are identical with those described in connection with the operation of station X.

Fig. 11 illustrates a modified arrangement of apparatus to be applied in lieu of that shown at X. In this instance the removal of the receiver from its hook sends a series of impulses to line by way of line-wire 2, serrated plate s^9, rotary contact s^8, pinion s^7, segment-gear s^6, hook S, and line-wire 1, thereby energizing the coherer C at central, as described.

The particular embodiment of my invention as illustrated in Fig. 8 represents a subscriber's station having a transmitter T and a receiver R, normally disconnected from the line 1 2 by switch S, which may be of any preferred type. A magneto-generator G, normally connected to line 1 2, terminates in the jack J, having the usual springs j j', mounted in an insulator I. Mounted between the springs j j' are two auxiliary springs j^2 j^3, which normally engage the respective springs j j'. Connected to the springs j^2 j^3 by leads 21 and 22 are two springs j^5 and j^4, having on their ends metal hemispheres c' c, which are pressed lightly together. A block of insulation connects springs j' and j^4. Lead 22 is connected also to one terminal of a choke-coil U, whose other terminal is connected to a battery b^2 by lead 23, while leads 24 and 25 connect a signal-lamp L to battery b^2 and lead 21, respectively. Upon the operation of generator G to call central current passes by way of lead 1 to spring j', to j^3, to 22, to choke-coil U, leads 23 24, lamp L, leads 25 21, springs j^2 J, lead 2, back to generator. The heavy kick from choke-coil U passes by way of lead 22 to spring j^4, to coherer-contacts c c', spring j^5, lead 25, lamp L, lead 24, battery b^2, lead 23 to coil U. Contacts c c' immediately cohere and permit current to flow from battery b^2 by the circuit last traced to light lamp L. The lamp L remains lighted as a call-signal until the operator inserts a plug in jack J, which moves spring j' downward and moves the spring j^4 upon the spring j^5, causing the coherer c c' to decohere, thereby extinguishing the lamp. The insertion of the plug in the jack also breaks the contact between j j^2 and j' j^3, preventing a repetition of the line-signal until the plug is removed.

Fig. 9 illustrates a further modification, wherein the transmitting-station is provided with a key K in the primary h of an induction-coil H, which is provided with battery b^3 and interrupter-terminals h^2 and h^3. The secondary is connected to line which terminates at the receiving-station in an emitter or spark-gap V, comprising two terminals v v', mounted in a metallic sheath. In juxtaposition thereto and inclosed in the same sheath is a coherer C, comprising a metallic ball c^4, held between perforated metal supports c^2 c^3, which are connected exteriorly with a circuit comprising a common battery b', a non-inductive resistance U', and a signal, as a lamp L. Impulses transmitted from H over the line generate an electrical stress at the terminals v v', which causes the normal resistance between ball c^4 and its supports c^2 and c^3 to break down and permit a current to flow from battery b' to energize lamp L. It is apparent that in using a common battery for several lines the kick from the battery or an inductional resistance in any of the receiving systems would cause all of the coherers in parallel with the battery b' to break down and light their respective lamps. To avoid this defect, an anti-inductive device, as U', comprising a core preferably having divided windings, is inserted in each of the lamp-circuits.

While I have shown my signaling system as particularly applicable to telephone systems, it is apparent that it is not limited to such use, but may be employed in any connection where electrically-actuated signals are used.

What I claim is—

1. In a signaling system, a transmitting and receiving station, a line-circuit interconnecting them and having two branches, a coherer in one branch, a self-induction in the other branch, a source of current, and a signal connected to the line, together with means to produce variations in the current on the line, such variations passing to and lowering the resistance of the coherer, to permit the actuation of the signal device.

2. In a signaling system, two stations, a line-circuit interconnecting them and having terminal branches, a cohering device in one branch, a self-induction in another branch, a signal at one station and a battery connected to the line, together with means at the other station to bridge the two sides of the circuit together, at will, whereby said cohering device is set, and actuates the signal when desired.

3. In a signaling system, a line-circuit, an inductive resistance and a source of electromotive force in said circuit, a coherer and a signal connected with the circuit, said coherer responsive to change in potential in the circuit due to said inductive resistance, to close an operative circuit from the line-circuit to the signal.

4. In a signaling system, a line-circuit, a signal, and a source of intermittent current therefor, branch circuits from said line, a coherer in one branch and self-induction in the other, said coherer being responsive to said intermittent current to close the signal-circuit.

5. In a signaling system, a line-circuit having branches, an inductive resistance and a coherer in separate branches, a signal device controlled by the coherer, together with a source of current and a current-interrupter for the line.

6. In a signaling system, a line-circuit having branches, inductive resistance and a coherer in said branches, a signal device in a local circuit composed in part of said branches and the line, together with a source of current and means to intermit the same at will.

7. A telephone signaling system comprising a subscriber's line including an inductive resistance and a source of intermittent current, a line-signal in a local circuit, and a coherer responsive to the impulses from said inductive resistance to operate said signal, and means operated by the engagement of the plug and jack to agitate the coherer.

8. A telephone signaling system comprising a subscriber's line including an inductive resistance and a source of intermittent current, a line-signal at central in a local circuit, and a coherer responsive to impulses from said inductive resistance, and a tapper mounted on the spring-jack and operated by the plug to agitate the coherer.

9. A telephone signaling system comprising a subscriber's line including an inductive resistance, a common central current-supply and means to intermittently close said line, and a line-signal apparatus at central comprising a local circuit having a lamp and a coherer therein, said coherer being responsive to impulses from said inductive resistance to operate the line-signal.

10. A telephone signaling system comprising a subscriber's line including an inductive resistance, a common central current-supply

and means to intermittently close said line, and a line-signal apparatus at central comprising a local circuit having a lamp and a coherer therein and a connection between said coherer and said line, whereby impulses from said inductive resistance in said line will operate the coherer to close said local circuit and energize the line-signal.

11. In a telephone system, a subscriber's station and a central station, and a circuit connecting them, a source of current and a signal, together with a cohering device controlling the latter, at the central station, and means at the subscriber's station to produce changes in the current on the line to set the coherer and thereby actuate the signal at the central office.

12. In a telephone-exchange system, subscribers' lines, a central station at which said lines terminate, and a signal device and connective devices thereat for each line, a cohering device for each line normally maintaining the signal inactive, and a source of current, together with means at each subscriber's station to produce variation of current in the line to set the coherer and thereby actuate the signal at central.

13. In a telephone-exchange system, subscribers' lines, a central station at which said lines terminate, and a signal device and connective devices thereat for each line, a cohering device for each line normally maintaining the signal inactive, and a common source of current at the central station for all the lines, together with means at each subscriber's station to produce variations of the current in the line to set the coherer and thereby actuate the signal.

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

EDWARD E. CLEMENT.

Witnesses:

F. A. HARTRANFT,

WM. WILMER ROWAN.