(No Model.)

2 Sheets—Sheet 1.

T. SPENCER.

TELEPHONE CIRCUIT AND SIGNAL.

No. 528,040. Patented Oct. 23, 1894.

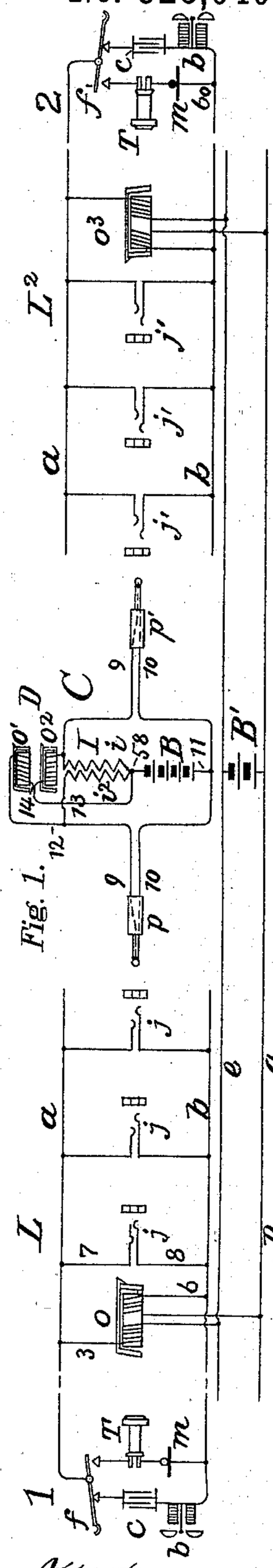

Fig. 1.

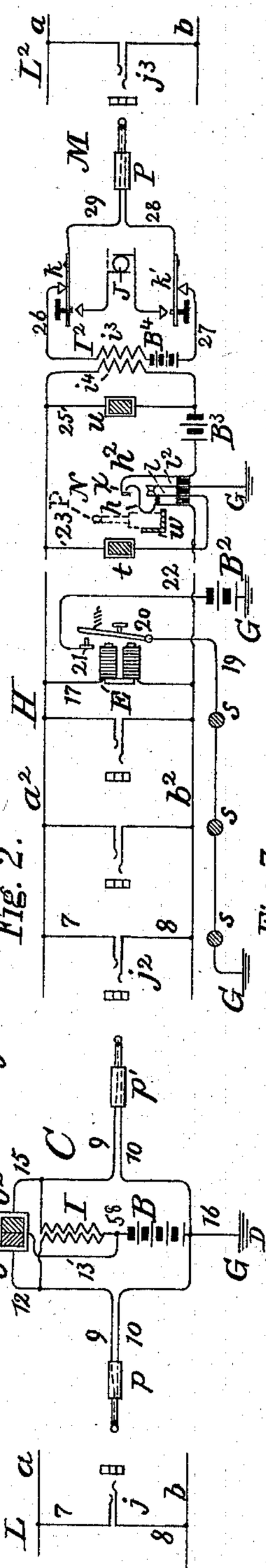

Fig. 2.

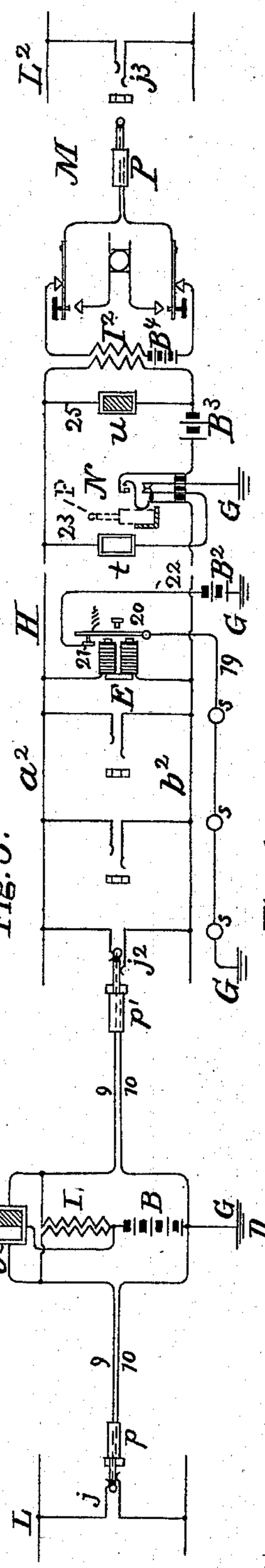

Fig. 3.

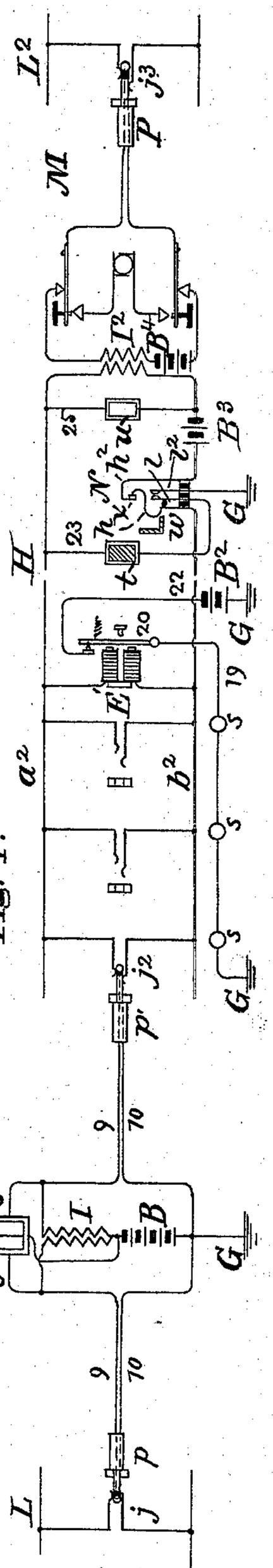

Fig. 4.

Attest.
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Inventor:
Theodore Spencer

(No Model.) 2 Sheets—Sheet 2.

T. SPENCER.

TELEPHONE CIRCUIT AND SIGNAL.

No. 528,040. Patented Oct. 23, 1894.

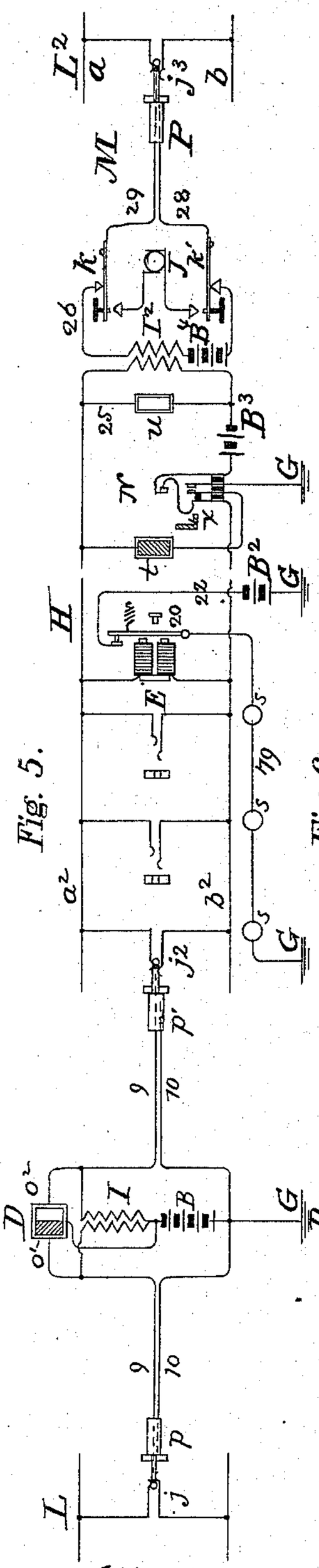

Fig. 5.

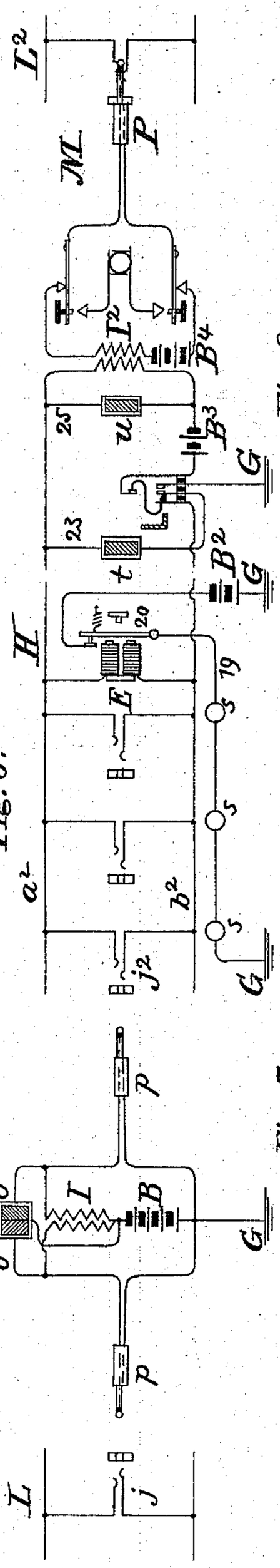

Fig. 6.

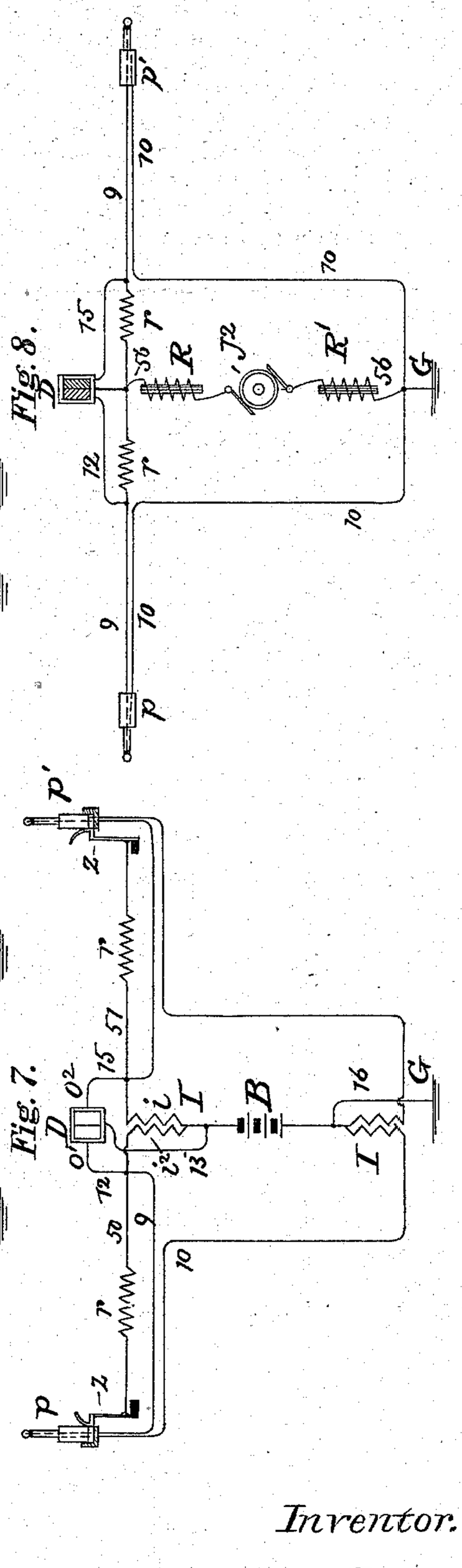

Fig. 8.

Fig. 7.

Attest.
Thos. D. Lockwood
Geo. Willis Pierce

Inventor.
Theodore Spencer.

UNITED STATES PATENT OFFICE.

THEODORE SPENCER, OF CAMBRIDGE, ASSIGNOR TO THE AMERICAN BELL TELEPHONE COMPANY, OF BOSTON, MASSACHUSETTS.

TELEPHONE CIRCUIT AND SIGNAL.

SPECIFICATION forming part of Letters Patent No. 528,040, dated October 23, 1894.

Application filed November 18, 1893. Serial No. 491,330. (No model.)

To all whom it may concern:

Be it known that I, THEODORE SPENCER, residing at Cambridge, in the county of Middlesex and State of Massachusetts, have invented certain Improvements in Telephone Circuits and Signals, of which the following is a specification.

This invention relates to circuits and apparatus by means of which telephonic connections and disconnections are made at one or more central stations in order that subscribers at substations which are electrically connected with such central stations may be enabled to converse with one another.

Owing to the increased use of the telephone in large towns and cities, it has become necessary to divide the work of effecting electrical connections with two associated substations, between operators who may be stationed, first, at the separate sections of a divided switchboard located at a central station, or, second, between operators who may be stationed at switchboards located at central or switching stations which may be widely separated from each other; in either of which cases the circuit connections are effected over what are denominated trunk lines or circuits. With such trunk lines there is associated a system of signals whereby the operators are instructed automatically, or otherwise, as to the connections or disconnections made or required to be made for the purpose of arranging a circuit for conversational purposes between two substations.

My invention relates to a system of trunk circuits and signals in connection with divided switch boards, and also in connection with two or more widely separated central stations, and in association with a common or centralized battery by means of which signals are sent from the substations to the central station; and also in association with a common or centralized source of electric current by means of which the telephonic transmitters at the substations are energized, and by means of which various automatic visual signals are set in the central stations, at which the substation lines terminate.

I prefer to employ metallic circuits between the substations and the central station and to extend them through the switchboard with open branch terminals at each section thereof, and provide them with line annunciators whose helix is split in its center to include in its circuit a battery common to a number of line annunciators. The apparatus at the substation is so arranged that when the telephone is on its hook, the circuit is through a call bell and a condenser, or a high resistance call bell alone, and when the telephone is off the hook, the circuit is through the telephones, similar to the arrangement, shown in United States Patent No. 474,323. Between the plugs of each connecting loop at a switching station is a source of current, in a bridge, and an induction coil having its two windings interposed in one of the said conductors on different sides of the junction of said bridge, and automatic annunciators or other visual signals in shunt circuits around the said induction coil helices. This source of electric current, which may be a battery, serves to energize the substation telephone when one of the loop plugs is inserted in the answering jack of the circuit, and also serves to set the busy and attention signals at other operators' stations or sections.

The looping arrangement may be used to connect together the terminals of two substations directly, or through the mediation of a double conductor trunk circuit. In the former case the insertion of the loop plugs into answering or calling jacks links into circuit the induction coil and the common transmitter battery; and in the latter case the common battery energizes the substation transmitters, and at the same time sets the busy signals at all the trunk line switchboard sections, and an additional "attention" signal at the opposite end of the trunk circuit.

The trunk circuit consists of a metallic circuit with bridged open terminals at each switchboard section, and an electro-magnetic busy signal operating device, and terminates at its opposite end in one helix of a repeating coil; and is provided with an attention signal normally in a grounded leg from the tip side of the circuit and a second signal in a bridge between the two sides of the circuit; and a normally open battery in the sleeve

side of the circuit, whereby the busy signals are continued set when the loop plug is disconnected from the trunk circuit. The second helix of the repeating coil is in a loop with the connecting plug of the trunk circuit and a centralized battery; and the plug itself when in its seat, and when removed therefrom to be inserted in the jack of the called line, operates successively signals to indicate at each end of the trunk circuit the conditions of the line, all of which will be fully described hereinafter.

I describe two modifications of the apparatus located between the loop plugs. In the first, the double clearing out signals are normally set, and continue so when the associated plugs are inserted into line or trunk jacks, but when serving as disconnecting signals they are reset. The second modification relates to the employment of a common dynamo as a supplier of electric current instead of a battery, and the method of connecting the automatic annunciator in between the looping plugs when associated therewith.

In the drawings Figure 1 is a diagram illustrating the connections between a central station and two substations, embodying portions of my invention. Fig. 2 represents an operator's looping or linking in apparatus, a trunk circuit, and the terminals of two substation lines; and Figs. 3, 4, 5 and 6 represent the same circuits and show the changes which successively take place when the several operations are made to connect two substation lines through the mediation of two switching stations and a trunk line. Figs. 7 and 8 represent modifications of the looping or linking connections of an operator's outfit.

In Fig. 1, L and L^2 represent two metallic circuits extending from substations 1 and 2 to the central station C and terminating thereat in open branch terminals *j* in plug sockets bridged in between the two sides or conductors *a b* of the circuits, and in their line annunciators *o* and o^3. At the substations, when the telephone is on its hook, the circuit is closed through the bell *b* and condenser *c*, and when the telephone is removed from the hook, the circuit is through the telephones *m* and T. The helices of the line annunciators *o* and o^3 are split centrally, and are connected to the wires *e* and *g* between which is bridged the battery B′. When the telephone is on its hook the battery B′ is inoperative as the circuit is open in the condenser *c*, but when the telephone is taken from its hook, the circuit is closed through the branch 60, and the battery B′ energizes the helices of the line annunciators and causes them to display their signals. The battery B′ is common to a number of line annunciators.

So much of the operator's outfit is shown in the drawings as is necessary to illustrate my invention. The operators' telephones are not shown.

The looping or linking devices are shown at C; *p* and *p′* being the plugs which are connected with each other by the cord conductors 9 and 10, the former conductor having one end of each of the two helices of the repeating coil connected in as shown, their opposite ends being joined together at the point 58. A battery B is connected in between the repeating coil helices and the opposite side of the sleeve cord 10. The clearing out annunciator D is arranged for a double automatic indication, one from each side of the loop, and is in a shunt 12, 15 from the tip cord conductor 9 around the repeating coil I, and consists of two separate helices o' o^2 wound in opposite directions with a branch 13 from a point 14 at which the helices are united, to the point 58 between the repeating coil I and battery B. Any of the electro magnetic resetting signals, such as shown in United States Patent No. 506,883, may be used. In this diagram, the operation is as follows: When the telephone is removed from its hook at either substation say No. 1, the battery B′ energizes the line annunciator *o*, causing it to give a signal, as previously described. The operator at C inserts plug *p* into answering jack *j* thereby permitting current to flow into the line L from battery B to energize the substation transmitter. Upon receiving the number of the substation wanted, the operator connects the other plug *p′* into the jack *j′* of the line wanted thereby effecting a signal at the substation 2, all in a manner well understood from the United States Patent No. 474,323, previously referred to. During the continuance of the connection, the transmitters at both substations are energized by the battery B, the circuit being through the substation lines *a b* of L and L^2, transmitters *m*, receiver T, and helices *i* of induction coil I, causing a fall of potential across the terminals 12, 15 of the signal D through which a current flows and the signal *o′* is set to indicate that the line is in use. When either substation replaces the telephone T upon its hook, the circuit is opened through the condenser *c*, and the current ceases and the signal *o* of the double indicator D included in that substation line is reset and indicates that the line is not in use.

I have described the line annunciators and double clearing out signals D and their operation in a connection through a central office switchboard directly. I will now describe the operation of the same through the mediation of a trunk circuit, and its signals, after first describing the latter.

Figs. 2, 3, 4 and 5 refer to the same circuits and show the successive changes in the circuits and signals when the several operations are made to effect connections and disconnections. L and L^2 represent the line terminals of two substation circuits upon different switchboards, which may be located in the same or in widely separated offices. Their line annunciators are not shown, but it will be understood that the circuits are in all respects the same as those shown in Fig. 1.

C represents a central or switching station,

the operator's outfit there being the same as in Fig. 1, except that it has a branch 16 to ground.

H is a trunk circuit having at one end thereof open terminal branches j^2 at the several sections of the switchboard at central station C, with a busy signal s at each of the said sections arranged upon a wire 19 which is grounded at one end and connected to an armature 20 at its other end. The armature is normally drawn to a back stop by its spring. Its front stop 21 is connected by a wire 22 which includes a battery B^2 to ground. E is an electro-magnet or relay, wound to a resistance of about one hundred and fifty ohms, bridged by wire 17 between the conductors a^2, b^2 of the trunk circuit, and when energized operates the armature 20 in the local "busy" circuit. The other end of the trunk circuit H is located at a second switching station M, and terminates in one helix i^4 of a repeating coil I^2, the other helix i^3 including an operator's outfit consisting of a generator J, calling keys k, k' a common centralized battery B^4 and a plug P. The trunk circuit terminal at the switching station M has a polarized resetting visual signal u in a bridge 25 between the conductors a^2, b^2, and another resetting visual signal t in a branch 23 from conductor a^2 which is the "tip" side of the circuit, the said branch being connected to spring l of switch N and from it to spring l^2 and then to ground. The switch N is operated by the presence and absence of the plug P which normally rests in a seat w as shown in dotted lines, and forces the spring h away from contact with the spring h^2, and as these springs are parts of the conductor b^2 it is thereby normally opened at point x. At the same time the springs l and l^2 are pressed together.

Upon the removal of plug P the circuit b^2 is closed at point x and the circuit 23 is opened by the springs $l\ l^2$. A battery B^3 is included in conductor b^2 between the spring h^2 and the point 24 of bridge 25, and is poled to oppose the main battery B between the loop cords when the plug p' is inserted in a jack j^2 of the trunk circuit.

The operation is as follows: Fig. 2 shows the normal condition of the circuits. The telephone T at substation No. 1 having been removed from its hook and the attention of the operator at C having been called by the signal displayed by the line annunciator o, the plug p is inserted in terminal jack j, and the number of the called substation ascertained. Plug p' is inserted in the terminal j^2 of trunk circuit H. The act of inserting the plug p into jack j closes the main battery B to the substation circuit No. 1, and sets the signal o' of double annunciator D, the current flowing from the battery B, conductor 13, helix of annunciator o', conductor 12 out by conductor 9 and back by conductor 10 to the other side of the battery, and the act of inserting the plug p' into jack j^2 closes the battery B through tip cord 9, conductor a^2, bridge 17, conductor b^2 and sleeve cord 10, energizing the helices of electro-magnet E, and attracting its armature 20 to its front contact 21 to include the battery B^2 and ground of branch 22, and thereby set the visual signals s at all the switchboard sections as "busy." At the same time a portion of the current from battery B passes over conductor a^2, branch 23 through springs l and l^2 to ground, setting the attention signal t at the second operator, or at the switching station M. This state of the circuits is shown in Fig. 3.

The operator at M seeing the visual sign t set, receives the number of the substation to be called in any suitably provided way, and to make the connection, withdraws the plug P from its resting socket N and inserts it in the terminal jack j^3 of the called substation. The changes effected by this action of the second operator are shown in Fig. 4. Upon the withdrawal of the plug P from its resting socket w the springs h and l are retracted, the spring h closing upon the point x of spring h^2 thus making continuous the conductor b^2, and bringing into circuit the battery B^3, which is poled to oppose the battery B, and being much smaller is overpowered by it; and at the same time the springs l and l^2 are separated thereby opening the branch 23 and resetting the automatic visual sign t. The closure of the conductor b^2 at the point x allows current from the battery B to circulate from conductor a^2 through branch 25 and back by conductor b^2 and cause the automatic visual signal u to be set; and the additional current which the closing of this contact permits to flow through the helix i of the coil I causes the operation of the automatic signal o^2. By depressing the key k, the operator at M throws an alternating current upon the substation line L^2 which operates the bell b through the condenser c, thus effecting a call at substation 2. Upon the removal of the telephone at substation 2 the current from battery B^4 flows through helix i^3 of repeating coil I^2, wire 26, cord conductor 29, conductor a of line L^2 through the telephones at station 2 and conductor b of line L^2, cord conductor 28, to the other side of battery B^4 by wire 27. If the called substation line is busy, the operator at M can notify the operator at C of the fact by intermittently opening and closing the circuit h at x causing a fluttering of the signal o^2.

To recapitulate the operations of the successive signals, taking the telephone T from its hook at the substation, operates the line annunciator o. Insertion of plug p into answering jack j sets the signal o' at central station C. Insertion of plug p' into jack j^2 of trunk circuit sets the busy signals s at all of the switchboard sections and sets the attention signal t for the second operator at switching station M. Withdrawal of trunk connecting plug P resets the attention signal t and sets the signal o^2 at the central station

C to notify the operator there that the attention signal has been seen and will be attended to, and by the same act the signal *u* is set and indicates to the operator at M that the connections are all right at central station C. When the connection is no longer desired, the telephones T are hung upon their hooks thereby opening the lines through the condensers *c* and the operator at central station C is made aware of the fact by the resetting of the signal *o'* as shown in Fig. 5. The operator thereupon withdraws the plugs *p* and *p'* from the line and trunk jacks *j* and j^2 respectively, thereby switching out the battery B, which causes the resetting of signal o^2 at the central station C, and of signal *u* at station M, as will be readily seen by Fig. 6. The resetting of the signal *u* indicates to the operator there that the trunk is disconnected at station C. The operator at station M thereupon withdraws the plug P from the jack j^3 of the called line. The withdrawal of plug *p* from plug j^2 disconnects the battery B from the trunk circuit H, as has been stated, and but for the presence of battery B^3 the armature 20 would fall away and cause the busy signals *s* to be reset, but the battery B^3 acts instantly by a current which flows in an opposite direction to that which emanated from battery B, and re-energizes the helices of the electro-magnet E, and so the busy signals are continued to be displayed, and because the current flows in an opposite direction, it fails to affect the helix of the polarized signal *u* and it becomes reset. After the plug P has been withdrawn from the jack j^3 it is replaced in its seat *w*, which act restores the trunk circuit to the condition shown in and described by Fig. 2. The conductor b^2 is opened at *x*, thus disconnecting the battery B^3 therefrom and resetting the busy signals *s*, and the leg 23 is closed to ground by the springs *l*, l^2.

For connecting two substations in the common battery exchange system, the induction coil I when wound with about two thousand turns of silk insulated copper wire .0179 of an inch in diameter in each helix gives good results.

Fig. 7 shows a method of displaying clearing out signals different from anything heretofore shown. Its object is to more sharply define to the operator's eye the disconnecting signal.

The signals *o'* and o^2 are normally actuated, and when the plugs *p* and *p'* are inserted in an answering or connecting jack continue to be displayed, but when the substation telephone is hung up or the plug P is replaced in its seat the signal is reset to show a disconnection. In this case the induction coil is divided and the battery B is bridged in between the divisions. The plugs *p* and *p'* rest in spring sockets *z* from which extend branches 50, 51 to the shunt 12, 15 which includes the signals *o'* and o^2. Resistances *r r* are placed in the branches 50. A metal ring on the base of the plugs is connected with the sleeve cord 10. By these means a sufficient amount of current from the battery B passes through the short circuiting resistance *r* to cause a fall of potential at the terminal of the helices of the induction coil to operate the signals *o' o²*.

The modification of the operator's looping or linking connections shown in Fig. 8 is especially designed to be used in connection with a common dynamo system in all respects identical with the common battery exchange system hereinbefore described. J^2 is a dynamo, and R, R' are retardation or impedance coils, in a bridge 56 between the tip and sleeve sides of the loop, and r^a, *r*, are non-inductive resistances in the tip side of the loop, one on each side of the point of connection therewith of the bridge wire 56. The double automatic visual signals D are in a shunt around the resistances *r r'*, with a connection between their helices to a point between the said resistances and each signal is operated by the fall of potential through the non inductive resistance about which it is bridged.

Having now fully described my invention, I claim—

1. The combination in a telephone circuit, of the two conductors of a link connection; a source of current in a bridge between them; and an induction coil having its two windings interposed in one of the said conductors on different sides of the junction of said bridge; with an automatic annunciator or other visual signal in a shunt circuit round one of the said induction coil helices.

2. The combination with an induction coil having its two helices serially connected in one of the two conductors of a telephone circuit connection cord; and a source of current in a bridge extending from a point on said conductor between the said helices to the other of the said two conductors; of a double automatic annunciator or like visual signal adapted to give two independent signals, the electrical connections of the said two independent signals being included in shunt circuits round the helices of the said induction coil respectively, substantially as described.

3. The combination in a switchboard apparatus of a trunk circuit having branch terminals in plug sockets at a number of switchboard sections; a visual busy signal device associated with each such socket, the said signal devices being contained in a single local circuit; and a relay bridged between the two main conductors of said trunk circuit, and controlling the said local circuit; with a loop circuit formed of the two conductors of a connection cord; a battery or like source of current included in the said loop; and a terminal plug for said loop adapted to be inserted in any of the said plug sockets, and thereby to connect the said battery with the said trunk circuit, and relay, and to actuate the said busy signals, substantially as described.

4. A double conductor trunk circuit extend-

ing between two switching stations, provided at the first station with open branch terminals and busy signals at each switchboard section and an electro magnetic device bridged in between the said conductors; and means whereby upon the insertion of a loop plug into one of the open branch terminals the said electro-magnetic device may be actuated and the busy signals thereby set.

5. A double conductor trunk circuit, extending between two switching stations, provided at the first station with open branch terminals mounted in plug sockets and busy signals at each switchboard section, and an electro-magnetic device controlling the said signals bridged in between the said conductors; and provided at the second station with a loop plug and an automatic switch controlled thereby; and means whereby upon the insertion of a loop plug into one of the said branch terminals, the busy signals are set, and other means enabling them to continue set until the reverse operation of the said automatic switch, as set forth.

6. The combination in a switchboard apparatus of a double conductor trunk circuit provided at one end with branch terminals in plug sockets at a number of switchboard sections; a series of associated busy signals in a local circuit, one for each socket; a relay controlling said local circuit and signals bridged between the said trunk connectors; a source of current and a plug conductor adapted for insertion in any of the said plug sockets and thereupon to close the said trunk circuit through said source to energize the said relay and operate the said busy signals; with an auxiliary source of current at the other end of said trunk arranged to be connected in the main circuit thereof, and to oppose the current of the first source in the said main circuit, but to strengthen the same in the relay bridge; and a circuit changer controlling the continuity of said trunk circuit, and the connection therewith of the said auxiliary source of current; whereby the busy signals at the plug sockets may be set by the current of the first source of current and maintained after the withdrawal thereof by the current of the auxiliary source, substantially as described.

7. The combination of a looping or linking apparatus and a trunk circuit; the said apparatus being provided with double connecting plugs, and having a bridge between its cord conductors which includes a battery; the said trunk circuit having normally open branch terminals, and automatic busy signals at each switchboard section, and an electro magnet in a bridge between the two sides of the said circuit, the armature of which is grounded through the said busy signals, and whose front stop is the terminal of a normally open grounded branch which includes a battery, as set forth.

8. In a telephonic trunk line system, the combination of a looping or linking apparatus provided with double conductor plugs, and a bridge between the said conductors which includes a battery, one pole of which is grounded; a trunk circuit and an automatic electro-magnetic signal as set forth in a shunt of one of said conductors around an induction coil helix; the said trunk circuit having normally open branch terminals in plug sockets, and automatic busy signals, one associated with each socket, and an electro-magnet in a bridge between the two sides of the said circuit, and an automatic attention signal in a normally closed earth branch from that side of the said trunk circuit which is connected with the ungrounded battery pole; whereby upon the insertion of a connecting plug into a branch terminal of the said trunk circuit the said battery energizes the said electro-magnet, and sets the busy signals at each switchboard section, and also sets the attention signal at the distant end of the said circuit.

9. In a telephonic trunk line system, the combination of two substation lines extending from substations and terminating at separate switching stations, of a looping or linking apparatus at the first switching station, the said looping apparatus being provided with double conductor plugs; and a trunk circuit extending therefrom to the second switching station and terminating there with a double connecting plug; a main battery in a bridge between the cords of the said link apparatus plugs, an induction coil having its helices in one of said cords, and a double automatic electro-magnetic signal as set forth in a shunt from one of the said cord conductors around the two induction coil helices respectively; the said trunk circuit having normally open branch terminals in plug sockets, and automatic busy signals at each switchboard section; an electro magnet in a bridge between the two sides of the said circuit, an automatic attention signal in a normally closed earth branch from the tip side conductor of the said circuit, a second automatic signal in a bridge between the two sides of the said circuit, an automatic switch in the sleeve side conductor of said circuit operated by the substance of the said terminal connecting plug, and a normally open auxiliary battery in the sleeve side of said circuit; whereby, upon the insertion of a loop plug into a terminal of the said trunk circuit, the said main battery energizes the said electro-magnet and sets the busy signals at each switchboard section, and also sets the attention signal at the distant end of the said circuit; and whereby, upon the withdrawal of the trunk circuit connecting plug from the said automatic switch the said attention signal is reset, the said second signal is set, and one side of the automatic signal at the first switching station is also set.

10. In a telephonic trunk line system, the combination of two substation lines extending from separate substations and terminating at separate switching stations in normally open line terminals; of a looping or

linking apparatus at the first switching station, and a trunk circuit extending therefrom to the second switching station and terminating therewith a double connecting plug; the said looping apparatus being provided with double conductor plugs and a main battery in a bridge between the cords of the said plugs, and a double automatic magneto-electric signal as set forth in a shunt from one of the said cord conductors around a pole of said battery; the said trunk circuit having normally open branch terminals and automatic busy signals at each switchboard section, an electro magnet in a bridge between the two sides of the said circuit, an automatic attention signal in a normally closed earthed branch from the tip side conductor of the said circuit, a second automatic signal in a bridge between the two sides of the said circuit, an automatic switch in the sleeve side conductor of said circuit operated by the substance of the said terminal connecting plug, and a normally open auxiliary battery in the sleeve side of said circuit; whereby upon the insertion of a loop plug at the first switching station into a substation terminal, one side of the automatic signal is set; and whereby upon the insertion of the other loop plug into a terminal of the said trunk circuit, the said main battery energizes the said electro-magnet, and sets the busy signals at each switchboard section, and also sets the attention signal at the distant end of the said circuit; and whereby upon the withdrawal of the trunk circuit connecting plug from the said automatic switch the said attention signal is reset, the said second signal is set, and the second side of the automatic signal at the first switching station is also set.

11. The combination in a double conductor connection cord, of double conductor terminal plugs with a battery in a bridge between the conductors of said cord; an induction coil having its windings in one of said conductors; and automatic electro-magnetic disconnecting signals and shunts around the induction coil windings respectively; and means as set forth whereby the said signal is normally set, as set forth.

12. The combination in an operator's looping or linking apparatus of double conductor plugs with an electric generator bridged between the said conductors, and coils of high impedance on each side thereof, and an automatic electric magnetic disconnecting signal in a shunt or derivation of the said source of electric current, with non-inductive resistances looped or shunted by the said helices of the said signals, as set forth.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 10th day of November, 1893.

THEODORE SPENCER.

Witnesses:
GEO. WILLIS PIERCE,
JOSEPH A. GATELY.

Corrections in Letters Patent No. 528,040.

It is hereby certified that in Letters Patent No. 528,040, granted October 23, 1894, upon the application of Theodore Spencer, of Cambridge, Massachusetts, for an improvement in "Telephone Circuits and Signals," errors appear in the printed specification requiring correction as follows: In line 32, page 5, the word "connectors" should read *conductors;* and in line 33, same page, the word "conductor" should read *connector;* and that the Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed, countersigned, and sealed this 6th day of November, A. D. 1894.

[SEAL.]

JNO. M. REYNOLDS,
Assistant Secretary of the Interior.

Countersigned:

JOHN S. SEYMOUR,
Commissioner of Patents.