

No. 777,301.

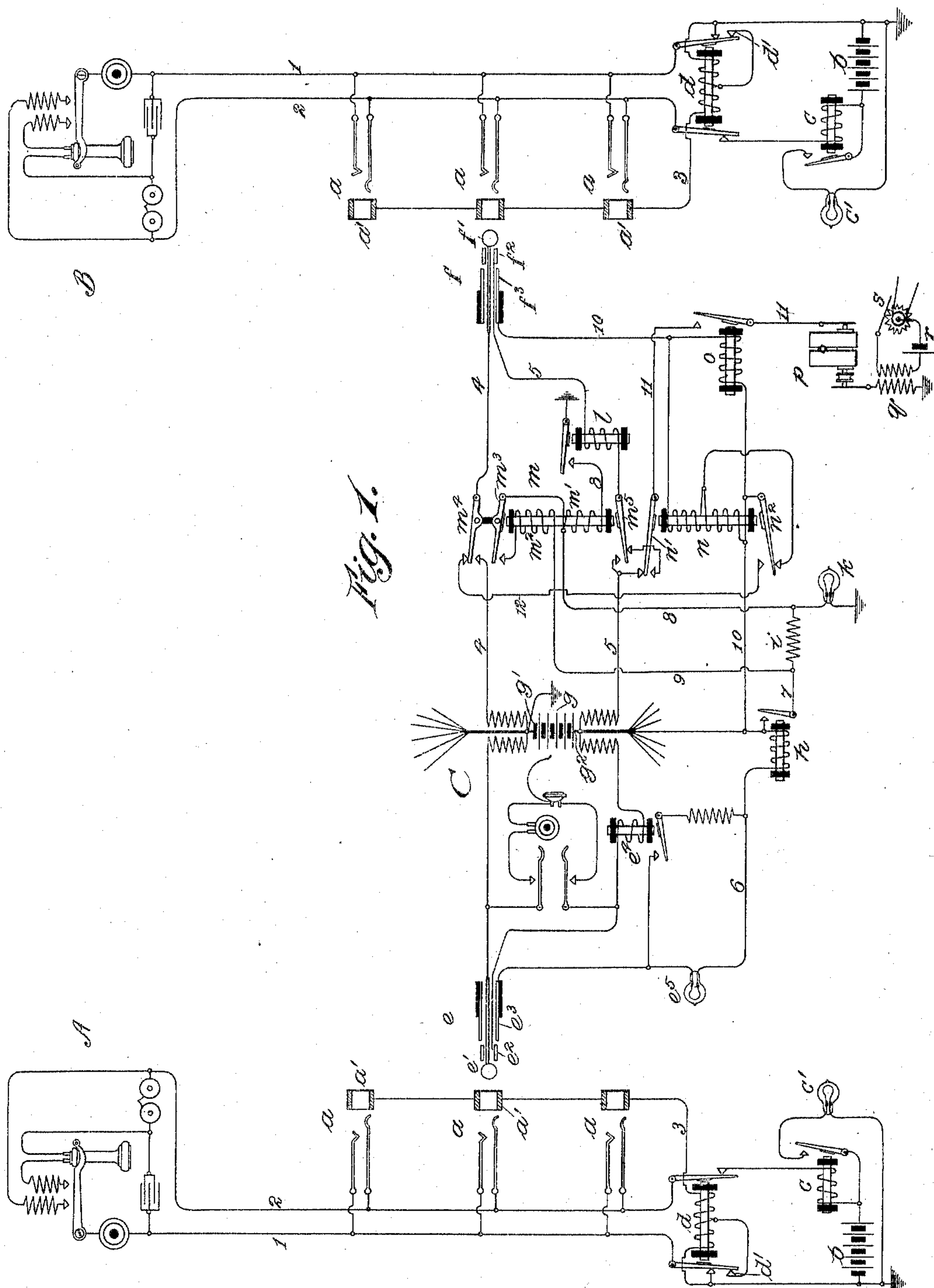
PATENTED DEC. 13, 1904.

J. L. McQUARRIE.
BUSY SIGNAL FOR TELEPHONE EXCHANGES.

APPLICATION FILED APR. 1, 1901.

NO MODEL.

2 SHEETS—SHEET 1.



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2 SHEETS—SHEET 2.

Fig. 3.

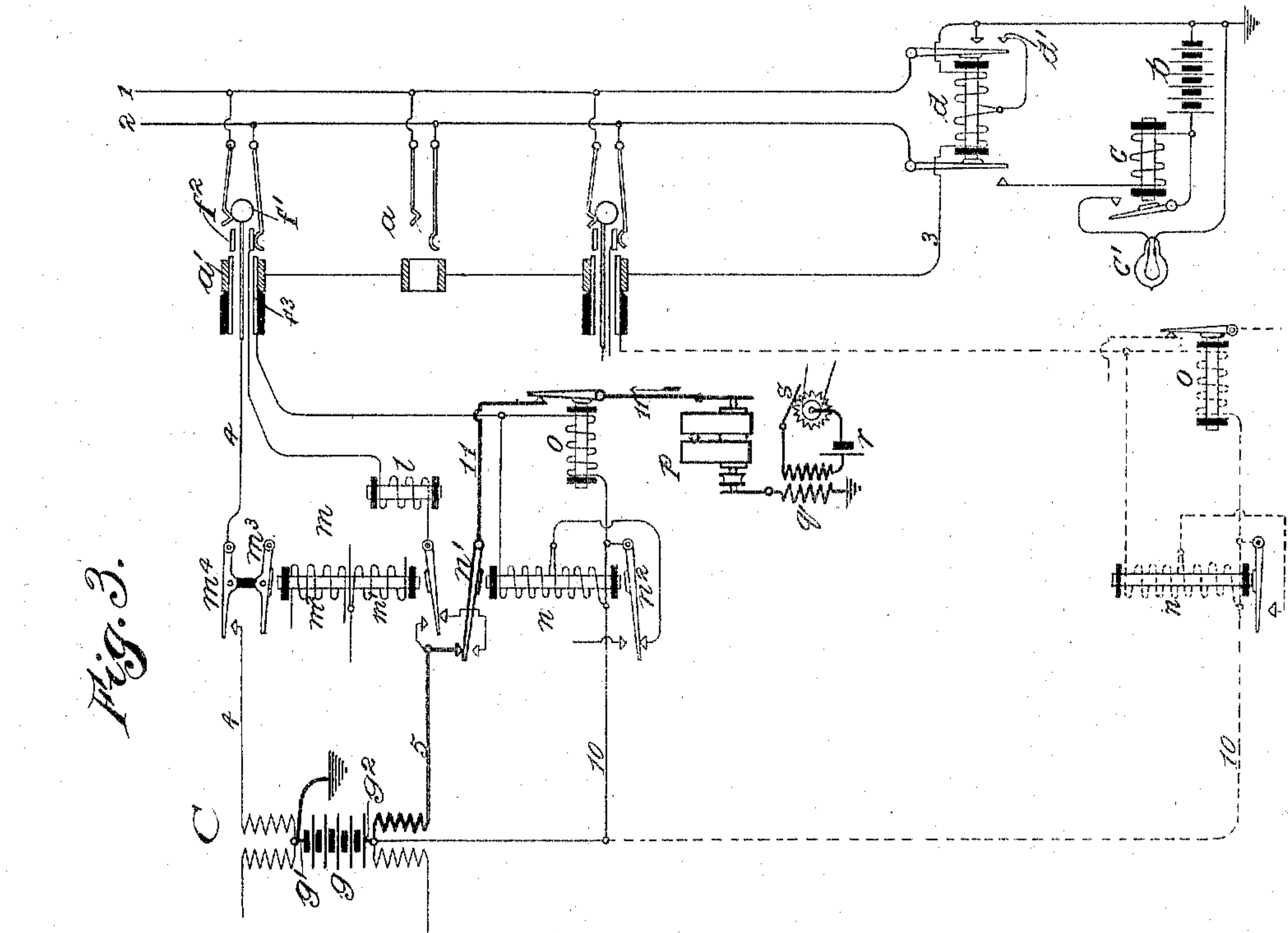
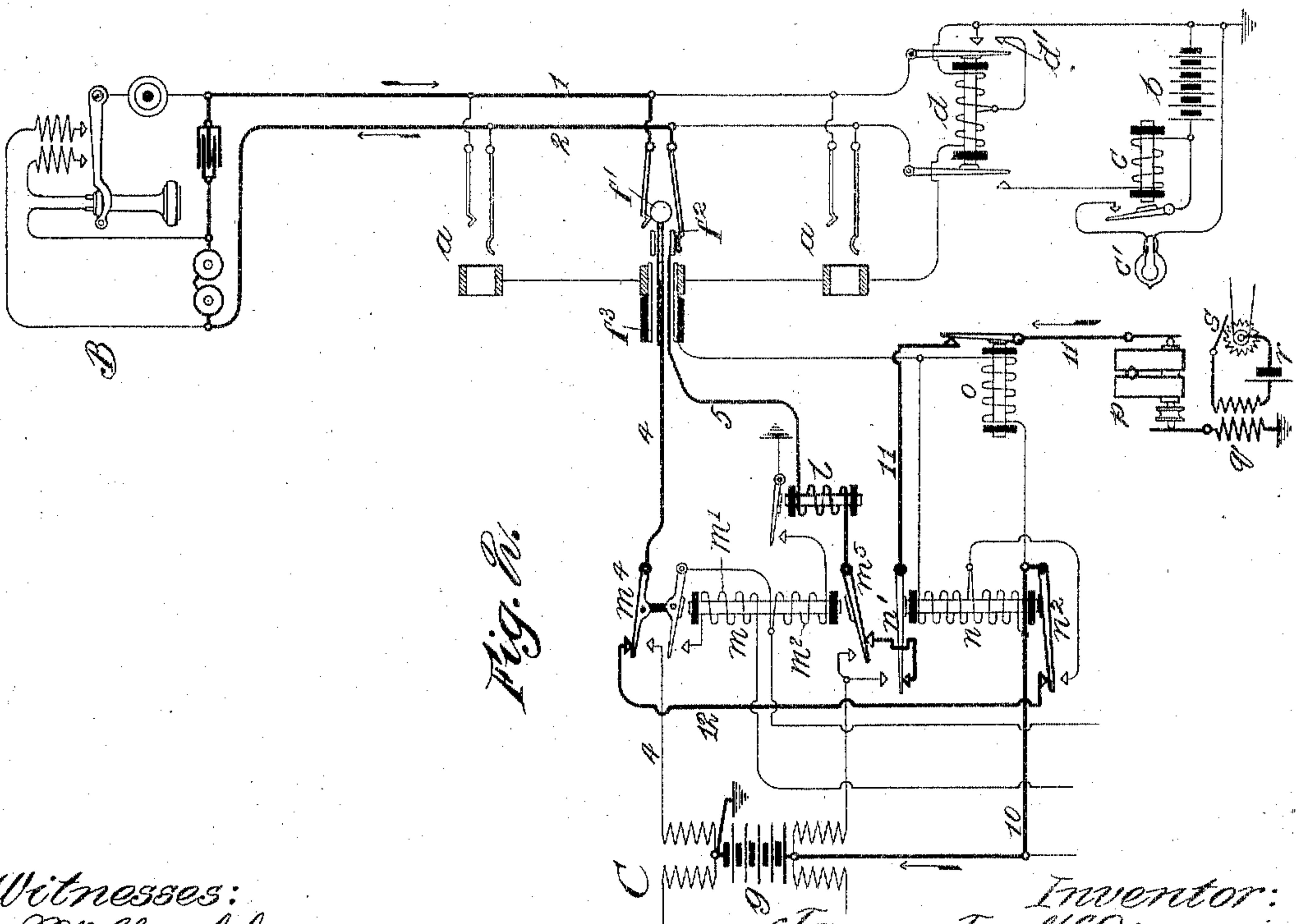


Fig. 2.



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UNITED STATES PATENT OFFICE.

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BUSY SIGNAL FOR TELEPHONE-EXCHANGES.

SPECIFICATION forming part of Letters Patent No. 777,301, dated December 13, 1904.

Application filed April 1, 1901. Serial No. 53,874. (No model.)

To all whom it may concern:

Be it known that I, JAMES L. McQUARRIE, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented a certain new and useful Improvement in Busy Signals for Telephone-Exchanges, of which the following is a full, clear, concise, and exact description.

My invention relates to a busy signal for telephone-exchanges, and has for its object to relieve the central-office operator from the duty of testing each called line to find out if it is free before making connection therewith.

At present in all large exchanges each line is provided with a number of multiple spring-jacks, one on each section of the switchboard, and it is necessary that each operator before making connection with any line at her section of the board should first make a test to ascertain whether or not a connection has already been made with the line at a spring-jack of some other section. Then if the line is engaged the operator must notify the calling subscriber of that fact and that he must wait until the line called for is disengaged before he can have the desired connection. The usual "busy-test" system comprises means brought into action by connection with any spring-jack of a line for establishing a peculiar electrical condition at all the other spring-jacks of that line, which condition may be perceived by an operator at any section upon touching the tip of her connecting-plug with a contact-terminal or "test-ring" of the jack and listening in her telephone-receiver. This test by the operator occupies a considerable portion of the time required to complete a connection from one line to another, and it is evident that if it could be eliminated the burden upon the operator would be greatly lessened and the efficiency of telephone service materially increased.

I have devised a system wherein the operator may immediately make connection with the line called for without testing, and if the line is already engaged a signal will automatically be transmitted to the calling subscriber which will apprise him of the fact. If the

called line is busy, the mere act of making connection with another spring-jack of the line will not complete the circuit; neither will ringing-current be applied to that line, but instead a peculiar signal would automatically be transmitted over the calling-line, which will be perceived by the calling party and understood by him to mean that the called line is busy. This signal may be produced by inducing in the circuit of the calling-line a rapidly-varying current, which will cause a hum or tone in the subscriber's telephone, or a phonograph may be used to transmit spoken words, or any other desired signal may be employed.

My invention consists in certain combinations of apparatus and circuits hereinafter to be described, and particularly defined in the appended claims.

The accompanying drawings illustrate diagrammatically a telephone-exchange system embodying my invention, and I will proceed to describe said invention particularly by reference to the drawings.

Figure 1 is a diagram showing two subscriber's telephone-lines extending from substations to multiple spring-jacks at a central office and an operator's pair of plugs and plug-circuit for uniting the lines. The system is equipped and arranged in accordance with my invention. Fig. 2 is a skeleton diagram illustrating the condition of the apparatus and the path of the ringing-current when a calling-plug is inserted in the jack of a free line, and Fig 3 is a similar diagram showing the condition of the apparatus when the operator's calling-plug is inserted in a jack of a line already connected at another section of the switchboard. This figure shows how the busy-signal current is applied to the calling-line.

Similar letters and figures of reference are used to designate the same parts wherever shown.

The subscriber's apparatus at each of the substations A B is of the usual type, comprising a transmitting and a receiving telephone, an induction-coil, a condenser, and a signal-bell, all associated together in a well-known

manner, and having a switch-hook for the telephone to cut the talking apparatus out of circuit when not in use. The signal-bell is included with the condenser in a bridge of the line.

Each telephone-line extends in two limbs 1 2 to the central-office switchboard and is provided with multiple spring-jack terminals a at the several sections of the board. A battery b is normally connected with a line-relay c in a bridge of the line by way of the armatures and back contacts of a cut-off relay d . The line-relay c controls a subsidiary signal-lamp c' . The magnet of the cut-off relay is of comparatively high resistance, and an extra back contact d' is provided for one of its armatures, said contact being connected with an intermediate point in the winding. Normally, then, a portion of the magnet-winding of the cut-off relay is short-circuited at contact d' ; but when the magnet draws up its armature the contact is broken and the resistance of the whole winding introduced into the circuit. The cut-off relay of each line is included in the circuit of a conductor 3, which extends from ground to all the test-rings a' of the spring-jacks of that line.

The operator at the central office C is provided with a number of pairs of plugs $e f$ for connecting any two lines together by plugging into the spring-jacks of the lines. Each plug has three contact-pieces adapted to register with the two contact-springs and the test-ring, respectively, of any spring-jack into which it may be inserted. Thus plug e , which is the answering-plug, has tip, ring, and sleeve contacts e' e'' e''' , and similarly plug f , which is the calling or connecting plug, has corresponding tip, ring, and sleeve contacts f' f'' f''' . The tip and ring contacts of each plug are connected, respectively, with the tip and ring contacts of its mate by the link conductors 4 5 of the plug-circuit, and a battery g is connected in a bridge of said conductors 4 5 between the windings of a repeating-coil in the usual manner. The pole g' of said battery is grounded. The answering-plug has the usual cord-circuit connections. A supervisory relay e^4 in the ring-strand 5 controls a shunt about the supervisory signal-lamp e^5 , which is connected in a conductor 6, leading from the pole g' of the central battery to the sleeve-contact e^3 of the plug. The conductor 6 also includes the magnet-winding of a relay h , which is adapted when excited to close a branch circuit 7 from the battery g to ground through a resistance i and supervisory signal-lamp h .

Four relays $l m n o$ are associated with the calling-plug f for controlling the automatic ringing and busy-signal circuits. The relay l is in the nature of a supervisory relay and is included in the ring-strand 5 of the calling-plug. The relay m controls the continuity of the cord-circuit and is in the nature of a ring-

ing-key. It has two windings m' m'' , of which the former is included in a branch conductor 8, leading to ground by way of the armature and front contact of relay l in shunt of the supervisory lamp h . The other winding, m'' , is included in a shunt-path about the resistance i , said shunt being made up of conductors 9 8 and being controlled by one of the armatures, m^3 , and its front contact of relay m . The relay l being included in one of the main conductors 5 of the plug-circuit is responsive to the flow of current in the line with which plug f may be connected. When said relay l is excited, it closes the ground branch 8 through the winding m' , shunting out the lamp h and exciting relay m . The latter relay then closes the circuit 8 9 through its "sticking-winding" m'' and thereupon becomes independent of relay l . The relay m has two armatures m^4 m^5 , which control the continuity of link conductors 4 5, respectively, of the plug-circuit. Said link conductors are normally broken, and the ends thereof which lead to the calling-plug are adapted to be connected by the switch-contacts of the other relays o and n with ground and with the grounded generator p , respectively, in a manner presently to be described. The relays o and n are both included in parallel paths of a conductor 10, leading from a connection with pole g' of battery g to the sleeve-contact f^3 of the calling-plug. The relay n has two armatures n' n'' , of which the former is connected with the front contact of relay o , whose single armature is connected with the grounded generator p by a conductor 11. The front contact of armature n' is connected to the back contact of armature m^5 , so that relay m being inert and relays n and o excited calling-current from said generator will find its way to the ring contact of the calling-plug.

The armature n'' of the relay n is connected to the conductor 10 and its front contact is connected by a conductor 12 with the back contact of armature m^4 . Relay m being inert then and relays n and o excited, ringing-current from generator p sent out from the ring contact of the calling-plug to limb 2 of the telephone-line after passing through the bridge at the substation will find a return-path over limb 1 of the line to the tip of the plug and conductor 4, to armature m^4 , conductor 12, armature n'' , conductor 10, to ground through the battery g . The back contact of armature n'' is connected with an intermediate point of the winding of relay n , so that normally a part of the winding is short-circuited.

The relays n and o are both excited whenever the calling-plug f is inserted in the spring-jack of a free line, current for exciting said relays passing from grounded battery g through conductor 10 to the sleeve f^3 of the plug and thence to the ground by way of the

test-ring of the jack and conductor 3 connected therewith, said conductor including the winding of the cut-off relay d ; but while relay o is extremely sensitive and always draws up its armature whenever the plug f is inserted in the jack of any line, whether free or not, the other relay, n , is not so sensitive and a part of its winding is normally short-circuited. If then the plug f be inserted in the jack of a line which already has a connection at another jack, the difference of potential at the relay n will not be high enough to cause the flow of sufficient current to excite said relay—that is to say, the relay-circuit of the plug already connected with conductor 3, leading to ground through the cut-off relay, shunts the relay-circuit of any plug afterward inserted in any jack of the line, so that the relay n of such last-mentioned plug is not excited. It will be remembered, too, that whenever a plug is inserted in any jack of a line the drawing up of the armatures of the cut-off relay of that line increases to a large extent the resistance of the conductor 3 by removing the short circuit about a portion of the cut-off-relay windings. Again, the relay n of each plug-circuit normally has a portion of its winding short-circuited, which makes it less sensitive, and when it is once excited sufficiently to draw up its armatures the short circuit is broken and the whole winding included in the circuit.

The back contact of armature n' is connected with the conductor 5 of the plug-circuit, from which a path to ground can be traced through the battery g and a winding of the repeating-coil. Therefore if relay o should be excited and relay n remain inert current from the ringing-generator p will find a path through said winding of the repeating-coil by way of conductors 11 and 5. This current passing through one winding of the repeating-coil will induce currents in the other windings, which find circuit through the line of the calling subscriber. I have shown a secondary winding of an induction-coil q included in the conductor 11, and the primary of said induction-coil is included in a local circuit with a source of current r and an interrupter s . By this means an alternating current of high frequency may be superimposed upon the ringing-current from the generator p . This high-frequency current being transferred by induction through the repeating-coil to the line of the calling subscriber will cause a hum or tone to be produced in his receiver, which he will recognize as a busy signal. Instead of the "tone" test it is evident that a phonograph or other signal device might be employed to send out the busy signal.

The operator is provided with the usual telephone set and is provided with a key for connecting the same in bridge of the cord-circuit, whereby she may communicate with subscribers.

The operation of the system may be reviewed as follows: Assume that subscriber A desires to communicate with subscriber B. The removal of his telephone from its switch-hook closes a bridge of the line, whereby current from the battery b finds circuit through the line-relay, excites the same, and causes the illumination of the line signal-lamp c' . The operator at that section of the multiple switchboard at which subscriber A's lamp is located perceiving the signal inserts her answering-plug into the spring-jack of A's line at her section of the board and upon "listening in" inquires the number of the line wanted. Having ascertained that the line to substation B is wanted, the operator, without making any test to ascertain whether or not B's line is busy, inserts the other or calling plug of the pair into the spring-jack of B's line, thus completing the connection. If B's line is not already engaged, the insertion of the calling-plug in his spring-jack will cause ringing-current to be automatically applied to his line. The condition of the operator's plug-circuit apparatus at this stage is shown in Fig. 2, and the path of the ringing-current is illustrated by heavy lines. Both relays n and o have been excited by current in conductor 10, as shown, upon completion of the circuit by the insertion of the plug in the jack of the called line. Relays l and m are as yet inert, because the resistance of the bell-bridge at the substation is so great that sufficient current does not pass through relay l to excite the same; but when the subscriber at the called station answers by removing his telephone from the switch-hook the closing of the low-resistance bridge of the line through the talking apparatus causes an increase in the current flowing through relay l , whereby said relay becomes excited and draws up its armature. Circuit is thus closed through winding m' of relay m to ground, shunting out the signal-lamp, which was lighted when the answering-plug was first inserted. Relay m in drawing up its armatures cuts off the ringing-current and establishes the complete circuit of the link conductors 4 5 from the calling to the answering plug, so that subscribers A and B are thus connected together for conversation. The drawing up of armature m^3 closes the circuit through the sticking-winding m^2 , so that relay m is now rendered independent of the switch at the called station and is maintained excited as long as the plugs remain in the spring-jacks. The relay l still acts as the supervisory relay of the called line and is maintained excited by current from battery g as long as subscriber B's telephone is off its hook. When the conversation is finished and the subscribers hang up their telephones, the shunts about supervisory lamps e^5 and k are broken by the deenergization of relays e^4 and l , respectively, whereby said lamps become illuminated to indicate a signal for disconnection.

In disconnecting the operator will first remove the calling-plug f and then the answering-plug e to avoid sending a false ringing-signal over the called line, which would otherwise result by reason of the deenergization of the relay m ; but assuming now that subscriber A has called for a connection with subscriber B, but subscriber B's line already has a connection at some other section of the multiple switch-board, the full resistance of the cut-off relay d is therefore included in the ground conductor 3 from the test-rings of the jacks of that line. The operator may plug in without making any test; but only the sensitive relay o will be excited, the path including relays n and o being shunted by the circuit already established. The condition of the apparatus and circuits at this time is illustrated in Fig. 3, and the path of the busy-tone current is shown in heavy lines. Relay o alone being excited, the current from generator p , upon which is superimposed the tone-producing current, finds path through one winding of the repeating-coil, and thus induces a similar current in the line to the calling-station. The calling subscriber, listening in his telephone for the response of the called party, hears instead the tone produced by the induced current, and, recognizing this as a notification that the line is busy, hangs up his telephone. His supervisory lamp is thus lighted, giving to the operator the signal for disconnection.

When a calling-plug of one cord-circuit has been connected with one of the jacks of a line and the line is afterward plugged into at another jack, it may be thought that the relay mechanism of the first plug would be disturbed by the establishment of the second parallel circuit. The answer to this objection is that the relay n of the plug first inserted in drawing up its armature n^2 has removed a short circuit about a portion of its winding, so that the entire winding receives current. The relay will thus hold up its armature under considerably less current than is required to draw up the armature in the first place.

If connection should be made with a line busy at the moment, but from which the first connection is removed while the second plug remains inserted, it is desirable that the busy signal should be maintained upon the second plug-circuit and that the substitution of the telephone-line should not be rung the instant the first connection is removed, since the called subscriber would not be apt to recognize this as indicating a different connection. This result is accomplished by means of the improved construction of the cut-off relay, whereby a connection with the line causes said relay to break a short circuit normally maintained about a portion of its winding, thus increasing the resistance of the conductor 3. This increase in resistance causes the potential to drop, so that the relay n of the last plug in-

serted will not respond, even though the plug first inserted should be removed.

Since in an average city exchange only about ten per cent. of the calls have to be abandoned because the line of the called party is busy, it is evident that the elimination of the operator's busy test from the other ninety per cent. effects a clear saving of a great amount of time, the burden on the operator being decreased and the efficiency of the telephone service correspondingly increased.

It is evident that many modifications may be made by those skilled in the art without departing from the spirit of my invention. I do not, therefore, wish to be understood as limiting myself closely to the particular apparatus and circuits, but claim broadly as my invention the following:

1. The combination with a telephone-line having a number of multiple spring-jack terminals, of a calling-plug and a plug-circuit therefor, a source of signaling-current adapted to be connected with the plug-circuit, an electromagnetic relay device controlling the application of the aforesaid signaling-current to the plug-circuit, a circuit for said relay device adapted to be established in registering contacts of the plug and a spring-jack of the telephone-line, whereby the operation of said relay device is affected by the electrical condition of the spring-jack into which the calling-plug is inserted, said relay device being sensitive to an abnormal electrical condition of such spring-jack, other plugs for making connection with the line, and means, brought into action by connection with any spring-jack of the telephone-line, for changing the electrical condition of the several multiple spring-jacks of that line, whereby said source of signaling-current is applied to the plug-circuit of the calling-plug upon its insertion into one spring-jack of the line when a connection already exists at another spring-jack thereof, to transmit a busy signal over said plug-circuit, substantially as set forth.

2. The combination with a telephone-line having a number of multiple spring-jack terminals, of a calling-plug and a plug-circuit therefor, a source of calling-current adapted to be connected with the calling-plug, electromagnetic relay mechanism controlling the application of said calling-current to the calling-plug, a circuit for said relay mechanism adapted to be established in registering contacts of the plug and any spring-jack of the telephone-line, said relay mechanism being sensitive to the electrical condition of the spring-jack into which the calling-plug is inserted, other plugs for making connection with the line, and means, brought into action by connection with any spring-jack of the telephone-line for changing the electrical condition of the several multiple spring-jacks of that line, and so for preventing the normal operation of said

relay mechanism when the calling-plug is inserted in a jack of the telephone-line while a connection exists at another spring-jack of said line, substantially as set forth.

5 3. The combination with telephone - lines each having a number of multiple spring-jack terminals, of plugs and their plug-circuits for making connection with the telephone-lines, a local circuit including a resistance \mathcal{A} , associated with each telephone-line, having parallel branches, one in each plug-circuit, each of said parallel branches being adapted to be closed in registering contacts of its plug and a spring-jack of the line, a magnet in each of
10 said parallel branches, and a source of current in the circuit, said source of current and the several magnets being proportioned or adjusted to one another so that each of said magnets is adapted to respond to the flow of current
15 in its branch when that branch alone is closed, but not to respond when the circuit of its branch is completed in shunt of a branch already established at another spring-jack of the line, substantially as set forth.

25 4. The combination with telephone - lines each having a number of multiple spring-jack terminals, of plugs and their plug-circuits for making connection with the telephone-lines, a local circuit including a resistance \mathcal{A} , associated with each telephone - line, having parallel branches, one in each plug-circuit, each of said parallel branches being adapted to be closed in registering contacts of its plug and a spring-jack of the line, a magnet in each of
30 said parallel branches, a source of current in the circuit, said source of current and the several magnets being proportioned or adjusted to one another so that each of said magnets is adapted to respond to the flow of current in
35 its branch when that branch alone is closed, but not to respond when the circuit of its branch is completed in shunt of a branch already established at another spring-jack of the line, and switching mechanism, operated by
40 said magnet, controlling the plug-circuit with which said magnet is associated, substantially as set forth.

5 5. The combination with telephone - lines each having a number of multiple spring-jack terminals, of plugs and their plug-circuits for making connection with the telephone-lines, a local circuit including a resistance \mathcal{A} , associated with each telephone - line, having parallel branches, one in each plug-circuit, each of said
50 parallel branches being adapted to be closed in registering contacts of its plug and a spring-jack of the line, a magnet in each of said parallel branches, a source of current in the circuit, said source of current and the several
55 magnets being proportioned or adjusted to one another so that each of said magnets is adapted to respond to the flow of current in its branch when that branch alone is closed, but not to respond when the circuit of its
60 branch is completed in shunt of a branch al-

ready established at another spring-jack of the line, a source of signaling-current, and switching mechanism, operated by said magnet, controlling the application of said signaling-current to the plug-circuit, whereby a
70 busy signal is transmitted over the plug-circuit when connection is made with a busy line, substantially as set forth.

6. The combination with two telephone-lines extending from substations to a central
75 office, of a pair of plugs and link conductors uniting them for connecting said telephone-lines together in response to a call from a substation of one of said lines, multiple spring-jack terminals for the called line, a source of
80 signaling-current, an instrument at the calling-station responsive to such signaling-current, a third plug adapted to be connected with one of the spring-jacks of the called line, relay mechanism for applying said source of
85 signaling-current to the calling - line, and means, controlled jointly by the insertion of both the calling-plug of the pair uniting said two lines, and the third plug, into multiple spring-jacks of the called line, for controlling said relay mechanism, substantially as set forth.

7. The combination with a called line having a number of multiple terminals, and a connection-switch temporarily applied to one of said
95 terminals, means controlled by said connection-switch for establishing a peculiar electrical condition to constitute a busy signal at the other multiple terminals, a calling-line and a connection-switch for uniting the same with
100 the called line at one of said terminals, a magnet associated with the last-mentioned connection-switch sensitive to the busy signal produced by the first - mentioned connection-switch, a source of signaling-current and a
105 switch for applying the same to the calling-line, controlled by said magnet.

8. The combination with a telephone-line and multiple - terminal spring-jacks thereof and a calling-line terminating in a plug for
110 connection with one of said multiple jacks, a signal-receiving instrument at the substation of said calling-line connected in the line-circuit, a source of busy-test current at the central office and a local circuit formed in part of
115 conductors terminating in the terminal plug of said calling-line and the spring jack or socket of the called line, and in part adapted for completion through registering contacts of another spring-jack and the plug uniting a
120 different line with said spring-jack, whereby the user of the calling-line receives a busy-signal, a switch at the substation of the calling-line and a clearing-out signal connected with the line at the central office controlled
125 by said switch, whereby the user of the telephone may call for disconnection after receiving the busy signal, as described.

9. The combination with a telephone-line having two or more terminals and link con-
130

ductors at each of said terminals for making connections therewith from other lines, means adapted to change the electrical condition of said line in making connection therewith by
 5 any of said link conductors, an electromagnet in connection with one of said link conductors sensitive to the electrical condition of the line, and a switch in the link conductor controlled through the agency of said magnet;
 10 whereby when the line is engaged by connection at one terminal, a connection made at another terminal is ineffective, as described.

10. The combination with a telephone-line having multiple connection-terminals and connection-switches with their respective link
 15 conductors for making connection with the line at any terminal, means controlled by applying a connection-switch to one terminal for establishing a changed electrical condition at
 20 the other terminals, an electromagnet *n* associated with one of said connection-switches sensitive to the electrical condition of the terminal to which said connection-switch is applied, a source of signaling-current adapted
 25 to be applied to the link conductor associated with said last-mentioned connection-switch, and switching mechanism governed by said magnet controlling a break in said link con-

ductor and also controlling the application of said signaling-current, whereby an attempted
 30 connection with a busy line is rendered ineffective and a warning signal given, as described.

11. The combination with a telephone-line having two or more terminals and link con-
 35 ductors at each of said terminals for making connections therewith from other lines, means adapted to change the electrical condition of said line in making connection therewith by
 40 any of said link conductors, an electromagnet *n* in connection with one of said link conductors sensitive to the electrical condition of the line, a switch operated through the agency of
 45 said magnet, controlling a break in the circuit of said link conductors, and a locking-winding for said magnet, the excitement of said locking-winding being dependent upon the
 50 connection of the corresponding link conductor with the said line, substantially as described.

In witness whereof I hereunto subscribe my name this 20th day of August, A. D. 1900.

JAMES L. McQUARRIE.

Witnesses:

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 DUNCAN E. WILLETT.