B. D. WILLIS.

SUBSTATION CIRCUIT.

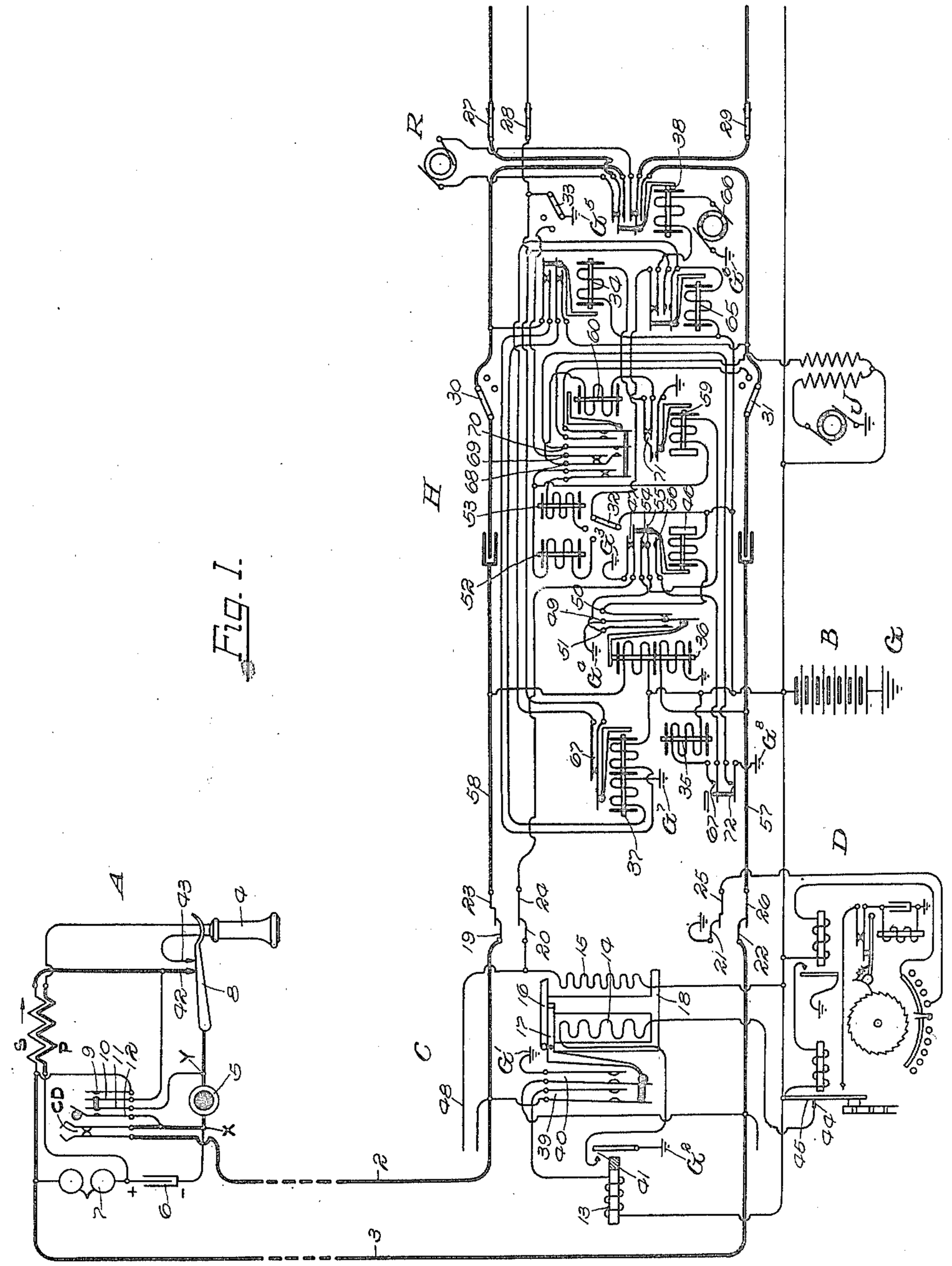
APPLICATION FILED AUG. 26, 1915.

1,238,705.

Patented Aug. 28, 1917.

2 SHEETS—SHEET 1.

Fig. 1.



Witnesses

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B. D. WELLS.

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2 SHEETS—SHEET 2.

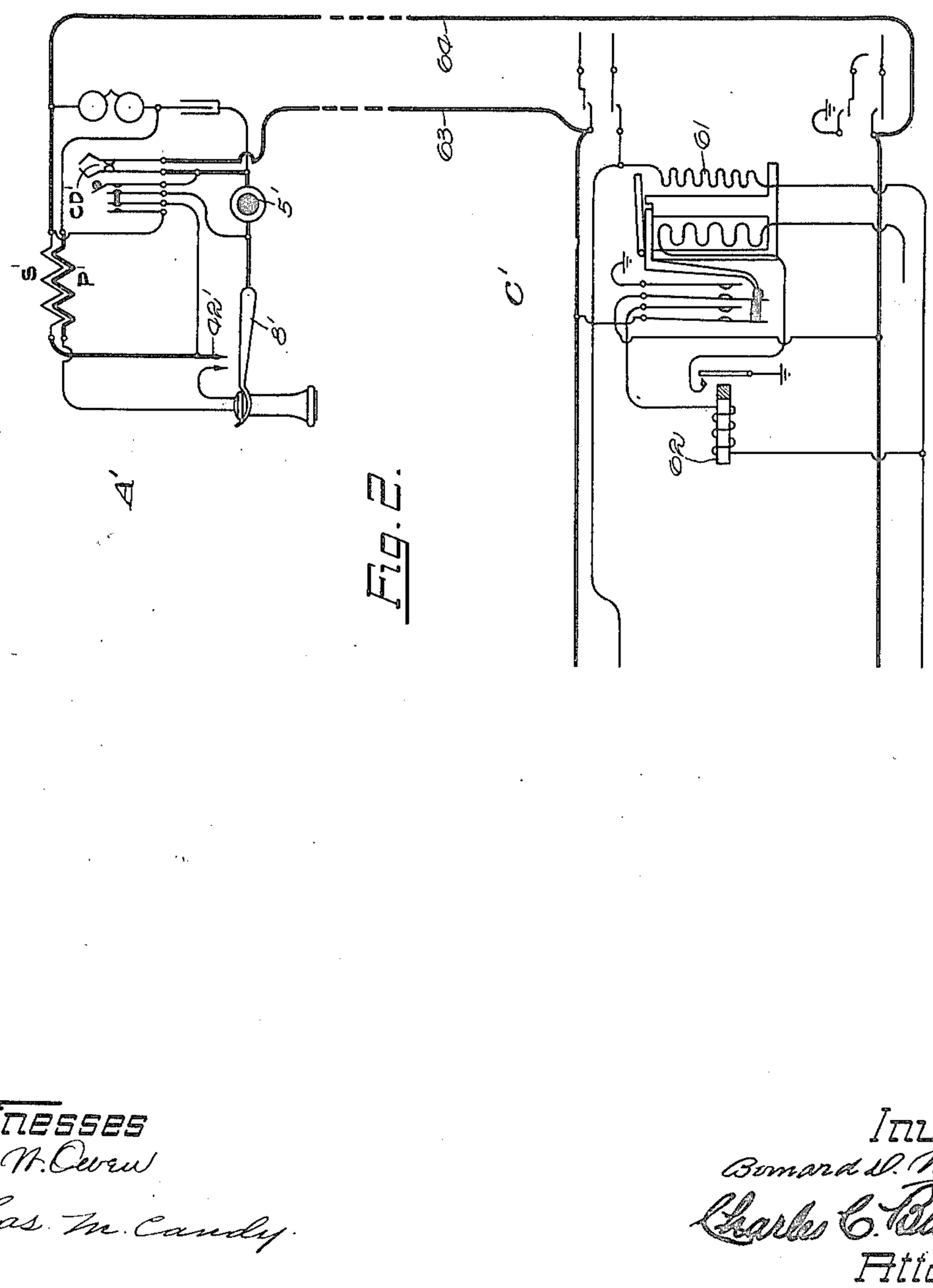

Fig. 2.

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UNITED STATES PATENT OFFICE.

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SUBSTATION-CIRCUIT.

1,238,705. Specification of Letters Patent. Patented Aug. 28, 1917.

Application filed August 26, 1915. Serial No. 47,445.

To all whom it may concern:

Be it known that I, BERNARD D. WILLIS, a citizen of the United States of America, and a resident of Chicago, Cook county, Illinois, have invented a certain new and useful Improvement in Substation-Circuits, of which the following is a specification.

My invention relates to substation circuits in general, but more particularly to automatic telephone substation circuits.

Generally stated the object of my invention is the provision of a substation circuit of efficient voice transmitting qualities adapted for use in conjunction with automatic central office apparatus.

Special objects of my invention are, the provision of means for enabling a calling subscriber to operate and control automatic central office apparatus in combination with a substation circuit for rendering very efficient talking qualities; the provision of a tuned substation circuit in combination with an impulse sending device for use with automatic apparatus, and the provision of certain other details and features of improvement tending to increase the general efficiency and service conditions of an automatic telephone system.

To accomplish the foregoing and other useful ends, my invention consists of matters hereinafter set forth and claimed.

In the accompanying drawings Figures 1 and 2 represent a complete connection between a calling substation A and a called substation A′ in a telephone system embodying the principles of my invention.

The system herein described is of a well known automatic type, known as a two-wire system, and is equipped with individual or line switches C divided into groups, each group controlled by a master switch, such as the master switch shown at D, and also with connectors H, but it will be readily understood by those versed in the art that selector switches may be inserted in the system thereby increasing the capacity of the exchange without departing from the principles of my invention.

The subscriber's station is connected with the central office through the conductors 2 and 3, which terminate in an individual or line switch C, said switch being one of a group of switches controlled by the master switch D. By means of the line switch C the line is extended to the connector H. The connector H responds to digits of the calling device CD to select the called station and complete the connection therewith.

The substation shown herein comprises a polarized receiver 4, transmitter 5, condenser 6, ringer 7, induction coil comprising the windings P and S and switch hook 8. Being an automatic substation it is also provided with an impulse transmitter or calling device which is similar to the type of calling device shown in British patent to S. G. S. Dicker, No. 29654 of 1910 and is herein represented by the impulse springs CD. The shunting springs 9 and 10, 11 and 12 have been added and arranged to short circuit the transmitter 5 and secondary winding S during the time impulses are being transmitted to operate the automatic switches. When the calling device returns to its normal position the said short circuits are removed.

The line switch C, which is associated with the line of the substation A, is of the general type of line switch shown in British patent to R. W. James, No. 26301 of 1906, and shown more particularly in British patent to T. G. Martin, No. 1419 of 1910, the circuits being slightly modified. The line switch comprises among other details a plunger (not shown) attached to the end of a so called plunger arm 16 which is controlled by the magnet 18. The magnet 18 comprises two windings namely, the pull-in winding 14 and the holding or cut-off winding 15. The winding 14 operates both the cut-off armature 17 and plunger arm 16, while the winding 15 is only strong enough to operate the armature 17 and to hold the plunger arm 16 in an operated position after it has been once operated by the pull-in winding 14. The circuit of the pull-in winding 14 is controlled by the line relay 13 which is slow acting, *i. e.*, slow to release its armature after its energizing circuit is broken. When the plunger arm 16 is operated, the plunger is forced into a bank of contact springs, forcing springs 19, 20, 21 and 22 into engagement with the springs 23, 24, 25 and 26 respectively. The switch C is controlled through the medium of the line relay 13, as will be described.

The master switch D is of the same general type as that disclosed in British patent to R. W. James, No. 26,301 of 1906, above referred to, being of the particular

type, however, disclosed in the above mentioned British Patent No. 1419 of 1910. The function of the master switch as is well known is to maintain the plungers of all the idle line switches in position to engage the terminals of an idle trunk.

The connector H is of the same general type of connector switch disclosed in United States Letters Patent No. 815,176 granted March 13, 1906, to Keith, Erickson and Erickson, the circuits, however, being modified to adapt the switch to operate in a system in which the central office apparatus is controlled by impulses delivered over the two sides of the line in series. The connector is provided with a shaft (not shown) carrying the wipers 27, 28 and 29. The usual side switch comprising the wipers 30, 31, 32 and 33 is controlled by the private magnet 34 in the usual and well known manner. The magnet 35 is the usual release magnet. The operations of the switch are controlled through the medium of the double wound line relay 36. The called subscriber receives talking current through the windings of the back bridge relay 37. The ringing relay 38 is the means by which ringing current is applied to the called line. For the purpose of supplying battery current for operating the apparatus and for talking purposes, there is shown the battery B having one terminal grounded at G.

Busy signaling current for the calling line is provided by the busy machine J which is shown associated with the connector H. This busy machine comprises an induction coil or transformer the primary winding of which is included in a local circuit with a battery and an interrupter. Through the medium of this interrupter an interrupted current is supplied to the primary winding, which induces an alternating current into the secondary winding, whereby when said winding is connected with the subscriber's line, a buzzing sound is heard in the receiver.

A general description of the apparatus involved having been given, and as the automatic switches herein disclosed are well known to those versed in the art, it is thought that a general description of setting up a connection between a calling and called subscriber will suffice.

Upon the removal of the receiver from the hook-switch at substation A preparatory to making a call, an energizing circuit is closed through the line relay 13 of the line switch C. This circuit extends from ground G^1 through contact of springs 40, line conductor 3, secondary winding S of induction coil, contact of spring 42 and hook 8, transmitter 5, impulse springs CD, line conductor 2, springs 39 and through the said line relay 13 to the battery B. The line relay 13, upon energizing, operates to close the circuit of pull-in winding 14. This circuit extends from ground G^2, through springs 41, winding 14 and the springs 44 and 45 to battery B. The pull-in winding 14 operates to cause the armature 17 to separate both springs 39 and 40 and also to draw the plunger on the plunger arm 16 into the bank of contacts 19 to 26 inclusive. The disengagement of the springs 39 and 40 opens the circuit of line relay 13. The line relay 13, being slow acting does not fall back immediately, however, but holds the plunger arm in an operated position until a holding ground is supplied to the holding winding 15 from the connector H. The engagement of springs 19 to 22 with 23 to 26 respectively, extends the subscriber's line to the line relay 36 of the connector switch H.

When the connection is thus extended to the connector H, the calling substation receives current through the line relay 36 of the connector H. The line relay 36, upon energizing, closes the circuit of the slow acting relay 46 which is as follows: from ground G^4, through contact of springs 49 and 50, said relay 46 to the battery B. The relay 46, upon energizing, closes a circuit for the holding winding 15 of the line switch C. This circuit extends from ground G^3 through contact of springs 47, springs 24 and 20 and through said holding winding 15 to the battery B. A guarding ground potential, to protect the substation from seizure, extends along the circuit as above traced to spring 20, thence along conductor 48 to the private contact of said substation.

A further result of the energization of relay 46 is the opening of the circuit of the release magnet 35 at springs 56 and 55 and the preparation of a circuit at springs 54 and 55 for the vertical magnet 52.

Assuming the number of the desired substation A′ to be 22, the calling subscriber now operates his calling device for the first digit 2, which momentarily separates the springs CD twice and at the same time causes springs 12 and 10 to engage 11 and 9 respectively until the sending of the impulses has been completed. When the dial returns to normal after the transmission of impulses the said springs 12 and 10, 11 and 9 disengage. Springs 12 and 11 on closing, short circuit the transmitter 5, while springs 10 and 9, on closing, short circuit the secondary winding S of the induction coil. The path of the impulses will be from ground through the lower winding of the line relay 36 of connector H, along conductor 57, line conductor 3, contact of springs 9 and 10, contact of springs 42 on hook 8, contact of springs 11 and 12, impulse springs CD which are being momentarily separated, line conductor 2, conductor 58 and through the upper winding of the line relay 36 to the battery B. The connector line relay 36 operates in response to first digit 2, to transmit

two impulses to the vertical magnet 52 to cause said magnet to raise the shaft wipers 27, 28 and 29 two steps to a position opposite the second level or row of bank contacts. The slow relay 59 maintains the private magnet 34 energized while the first digit of impulses is being transmitted, and allows said magnet 34 to deënergize immediately after the said impulses have been completed. The private magnet 34, upon deënergizing, permits the side switch to pass to second position.

The calling subscriber now operates his calling device for the last digit 2, in response to which the connector line relay 36 operates to transmit two impulses through the rotary magnet 53, whereby the shaft wipers are rotated onto the contacts of the desired line. The relay 59 operates in response to the impulses of this digit in the same manner as for the previous digit to cause the private magnet 34 to advance the side switch to third position.

The called subscriber is also provided with a line switch C′ which is similar in all respects to the line switch C. By the engagement of side switch wipers 30 and 31 with their third position contact points, the line connection is completed with the called line. Upon the engagement of side switch wiper 33 with its third position contact point a circuit is completed through the cut-off winding of the line switch C′, the said circuit extending from ground G^5 through wiper 33, private wiper 28 and cut-off winding 61 of switch C′. The cut-off winding upon energizing, operates to disconnect the line relay 62 from the called substation A′. The connection of ground G^5 with the connector private bank contact of the called line prevents the called line from being seized by some other connector switch. By the engagement of side switch wiper 32 with its third position contact point a circuit is closed through the ringer relay 38 and interrupter 66 to ground G^6. The ringer relay disconnects the calling line from the called line and bridges the ringing current generator R across the called line. The ringer relay 38 is energized only intermittently through the medium of the interrupter 66. Upon the response of the called subscriber his line is provided with talking current through the windings of the back bridge relay 37, which relay, upon energizing closes the circuit through the ringer cut-off relay 65. This circuit extends from ground G^5, through springs 67 of relay 37, thence through relay 65 to battery B. Relay 65 upon energizing, opens the circuit of ringer relay 38 and locks up through its make springs to ground G^5. The energizing circuit of the back bridge relay extends from ground G^7 through the left hand winding to wiper 29, line conductor 64, secondary winding S′ of the induction coil, contact 42′ on hook 8′, transmitter 5′ calling device springs CD′, line conductor 63, wiper 27 and the right hand winding of the back bridge relay 37 to the battery B.

The subscribers are now ready for conversation, and as the substations A and A′ are similar I will only describe the action that takes place at substation A. The transmitter being now at rest of course has a fixed resistance. Current will flow from ground through the lower winding of the line relay 36 along conductor 57, springs 26 and 22, line conductor 3, secondary S, spring 42, hook 8, transmitter 5, springs CD of calling device, line conductor 2, springs 19 and 23, conductor 58, and the upper winding of the line relay 36 to battery B. Between the points X and Y there will exist a certain difference of electrical potential, the condenser 6 will be charged to the same difference of potential that exists between said points and the direction of this charge will be with its negative potential nearest the point X. In speaking into the transmitter a sudden lowering of its resistance is caused. The difference of potential between the points X and Y will be reduced so that it will be lower than the charge existing in the condenser. A discharge will accordingly take place from the condenser 6, through primary P, receiver 4, contact 43, hook 8, transmitter 5, to the other side of said condenser. This flow of current through the primary winding P will cause a voltage to be induced in the secondary winding S; which assists the main line voltage. When the transmitter returns to normal the difference of potential will again be raised between the points X and Y.

Current will therefore flow into the condenser from the point Y, through the hook 8, contact 43, receiver 4, primary P in a direction opposed to its previous path and into the condenser to the point X.

An induced current will be generated in the secondary S in a direction opposed to the line current already flowing therein, but on account of the increase of resistance of the transmitter 5, the main line current is on the decrease and the last mentioned induced current will tend to decrease it still further. It is thus seen that the current changes are possessed of a wide range through the assistance of the condenser and induction coil. These current changes brought about by the action of the voice waves upon the transmitter diaphragm are carried to the called substation A′ and thereat act upon the receiver at said substation.

After the conversation is completed the connection is released by the hanging up of the receiver at the calling substation in the following manner: When the receiver is placed upon the switch hook, the separation

of spring 42 from hook 8 destroys the energizing circuit of line relay 36 of the connector H. The relay 36 upon deënergizing, opens the circuit of slow relay 46, which upon falling back, removes the ground G^3 from the holding winding 15 of the line switch C and also permits its springs 55 and 56 to engage. The release magnet circuit of the connector is thus closed by the following path: ground G^4, springs 49 and 51, springs 55 and 56, springs 67, said release magnet 35 to the battery B. The energization of the release magnet 35 causes the shaft wipers and side switch wipers to be returned to normal position, its own circuit being opened when the shaft has reached normal by means of the off normal springs 67.

The removal of ground G^3 from the holding winding 15 of the line switch C, causes said winding to deënergize, which allows the plunger arm 16 and cut off arm 17 to return to normal position.

It has been explained how one subscriber establishes a connection and releases the same. It will now be generally explained how connection is prevented from being made with a busy line. If the called line is busy there will be a guarding ground potential upon the connector private bank contact, just as explained in connection with the line switch C. The connector private wiper 28, upon engaging this guarded contact, and before the side switch leaves the second position completes a circuit through busy relay 60. This circuit extends from ground on the guarded contact, through the private wiper 28, side switch 33 (in second position) through springs 69 and 68 of relay 60, through said relay 60, springs 71 of relay 59, and the private magnet 34 to the battery B. Relay 60 and private magnet 34 both energize. Relay 60 upon energizing, locks up to ground G^8 through springs 72, springs 70 and 68 thence over the circuit as previously traced. A busy tone is supplied through the contacts of relay 60 to the calling subscriber from busy machine J. Private magnet 34 maintains the side switch in second position.

The subscriber upon receiving the busy tone replaces his receiver upon the switch hook which opens the circuit of line relay 36. The deënergization of line relay 36 permits the connector H and line switch C to be returned to normal position as hereinbefore described.

It is thus seen that I have devised a very efficient substation circuit in combination with an impulse-sending device which may be of any suitable type for operating and controlling automatic central office apparatus.

While I have illustrated and described one particular embodiment of my invention it is to be understood that I do not wish to be limited to the exact construction and arrangement of apparatus and circuits shown and described, but that various modifications can be made without departing from the scope of my invention.

What I claim as my invention is:

1. In a telephone system, a line, a substation for said line, a bridge across said line, a microphone in said bridge, a shunt around said microphone, an impulse sender for said substation, said sender connected in series with both sides of said line, a reactance coil and a condenser in said shunt, another coil inductively related to said first coil, means for maintaining said shunt during talking, and a receiver associated with said line, a switch hook for supporting said receiver, said means including said hook, said second coil located in said bridge.

2. The combination with a metallic telephone circuit and a source of current in a closed bridge thereof at the central office, of two bridges uniting the line conductors at a substation; one of said bridges comprising a condenser and a signal, the other of said bridges comprising a transmitter in serial relation with one winding of an induction coil, a shunt circuit for said transmitter and a shunt circuit for said winding, an impulse sender associated with said substation, said shunt circuits under the control of said impulse sender.

3. In a telephone system, a line, an impulse sender for said line, a bridge across said line, a switch hook in said bridge, a talking transmitter in said bridge, a shunt for said transmitter, a coil in said bridge, a shunt for said coil, both of said shunts controlled by said impulse sender, and a second bridge permanently connected across said line.

4. In a telephone system, a line, an impulse sender for said line, a bridge across said line, a switch hook in said bridge, a talking transmitter in said bridge, a shunt for said transmitter, a coil in said bridge, a shunt for said coil, both of said shunts controlled by said impulse sender, a second bridge permanently connected across said line, and a bridge across said two first bridges.

5. In a telephone system, a line, an impulse sender for said line, a bridge across said line, a switch hook in said bridge, a talking transmitter in said bridge, a shunt for said transmitter, a coil in said bridge, a shunt for said coil, both of said shunts controlled by said impulse sender, a second bridge permanently connected across said line, and a bridge across said two first bridges, some of said bridges controlled by said switch hook.

6. In a telephone system, a line, an impulse sender for said line, a bridge across said line, a switch hook in said bridge, a

talking transmitter in said bridge, a shunt for said transmitter, a coil in said bridge, a shunt for said coil, both of said shunts controlled by said impulse sender, a second bridge permanently connected across said line, a bridge across said two first bridges, said last bridge controlled by said switch hook, and a receiver in said last bridge.

7. In a telephone system, a line, an impulse sender for said line, a bridge across said line, a switch hook in said bridge, a talking transmitter in said bridge, a shunt for said transmitter, a coil in said bridge, a shunt for said coil, both of said shunts controlled by said impulse sender, a second bridge permanently connected across said line, a bridge across said two first bridges, said last bridge controlled by said switch hook, a receiver and a coil in said last bridge, said first mentioned coil inductively related with said last mentioned coil to form an induction coil.

8. In a telephone system, a line, an impulse sender for said line, a bridge across said line, a switch hook in said bridge, a talking transmitter in said bridge, a shunt for said transmitter, a coil in said bridge, a shunt for said coil, both of said shunts controlled by said impulse sender, a second bridge permanently connected across said line, a condenser and a signal in said permanent bridge.

9. In a telephone system, a line, an impulse sender for said line, a bridge across said line, a switch hook in said bridge, a talking transmitter in said bridge, a shunt for said transmitter, a coil in said bridge, a shunt for said coil, both of said shunts controlled by said impulse sender, a second bridge permanently connected across said line, a condenser and a signal in said permanent bridge, and a third bridge across said other bridges controlled by the switch hook.

10. In a telephone system, a line, an impulse sender for said line, a bridge across said line, a switch hook in said bridge, a talking transmitter in said bridge, a shunt for said transmitter, a coil in said bridge, a shunt for said coil, both of said shunts controlled by said impulse sender, a second bridge permanently connected across said line, a condenser and a signal in said permanent bridge, and a third bridge across said other bridges controlled by the switch hook, said third bridge terminating in said permanent bridge at a point between the condenser and the signal.

11. In a telephone system, a line, an impulse sender for said line, a bridge across said line, a switch hook in said bridge, a talking transmitter in said bridge, a shunt for said transmitter, a coil in said bridge, a shunt for said coil, both of said shunts controlled by said impulse sender, a second bridge permanently connected across said line, a condenser and a signal in said permanent bridge, and a third bridge across said other bridges controlled by the switch hook, said third bridge terminating in said permanent bridge at a point between the condenser and the signal, said third bridge having located therein a receiver and a coil inductively related to said first coil to form an induction coil.

12. In a telephone system, a line having two conductors, an impulse sender for said line for sending impulses over said conductors in series, a bridge across said line, a switch hook in said bridge for controlling the impulse sending circuit, impedance in said bridge, means for controlling said impedance, said means under the control of said impulse sender, a second bridge connected across said line, a third bridge between said other two bridges, said bridges being the only ones across the line, a receiver in said last bridge, and a signal in said second bridge.

13. In a telephone system, a line, a bridge across said line; switch hook springs, a talking transmitter and a coil in said bridge; an impulse sender for shunting said transmitter and coil, and a second bridge permanently connected across said line.

14. In a telephone system, a line, a bridge across said line; switch hook springs, a talking transmitter and a coil in said bridge; an impulse sender for shunting said transmitter and coil, a second bridge permanently connected across said line, and a bridge across said first two bridges.

15. In a telephone system, a line, a bridge across said line; switch hook springs, a talking transmitter and a coil in said bridge; an impulse sender for shunting said transmitter and coil, a second bridge permanently connected across said line, a condenser and a signal in said normally connected bridge.

Signed by me at Chicago, Cook county, Illinois, this 15th day of July, 1915.

BERNARD D. WILLIS.

Witnesses:
CHAS. M. CANDY,
W. W. OWEN.