C. S. WINSTON.

AUTOMATIC TELEPHONE SYSTEM.

APPLICATION FILED FEB. 19, 1913.

1,216,641.

Patented Feb. 20, 1917.

3 SHEETS—SHEET 1.

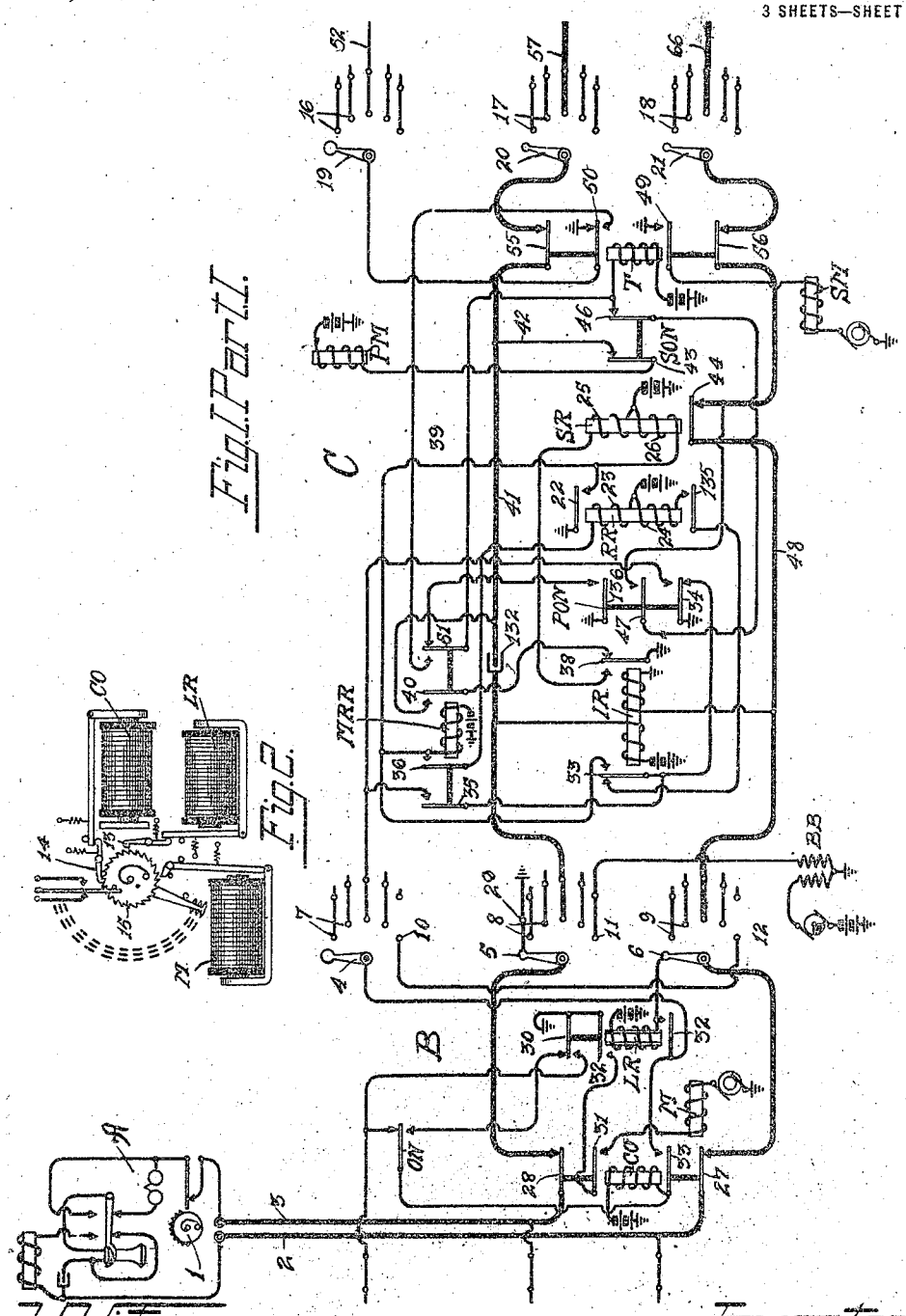

Fig. 1.

Fig. 2.

Witnesses:

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Wm. Berghahn

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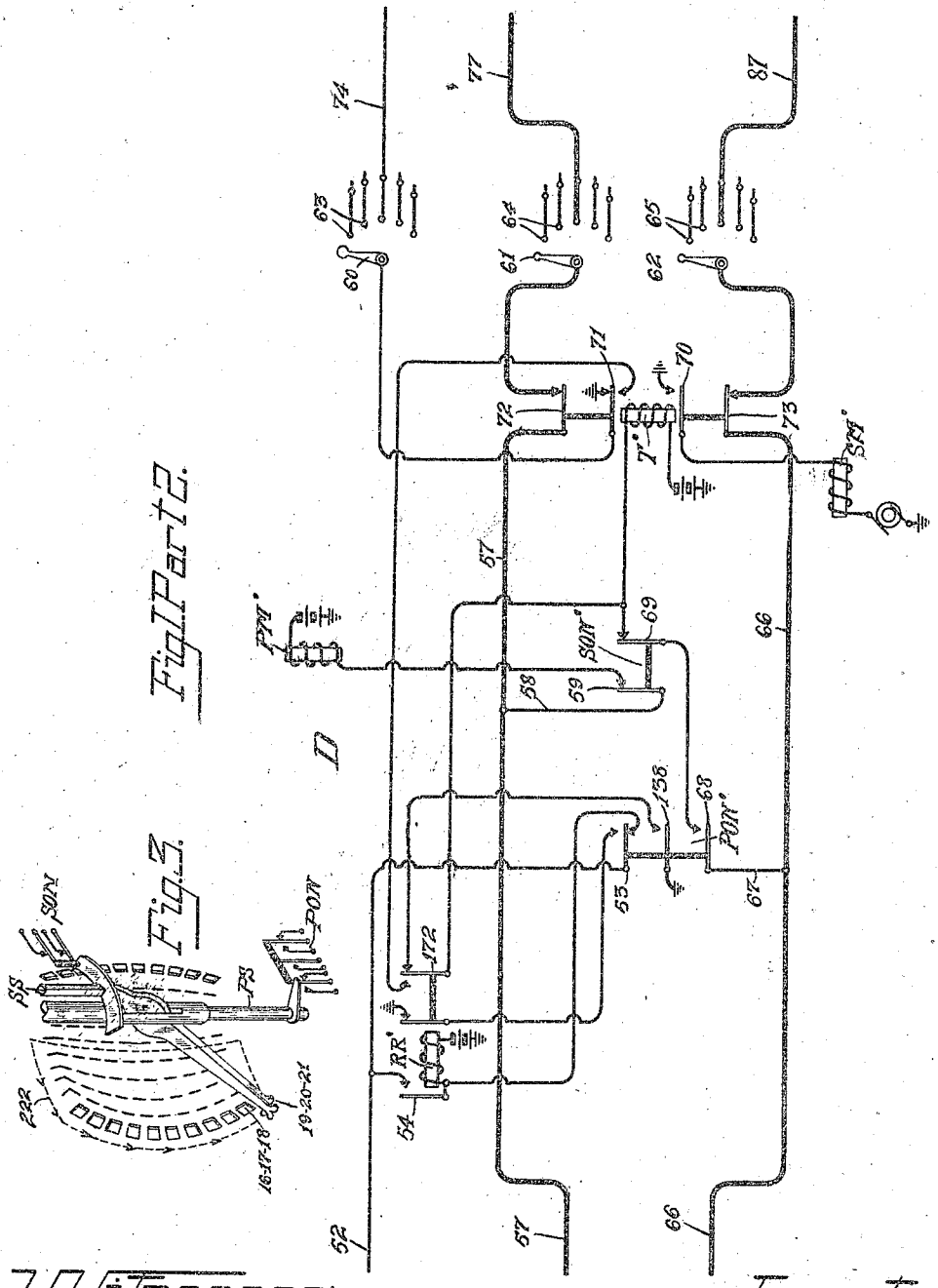

Fig. 1 Part 2.

Fig. 3.

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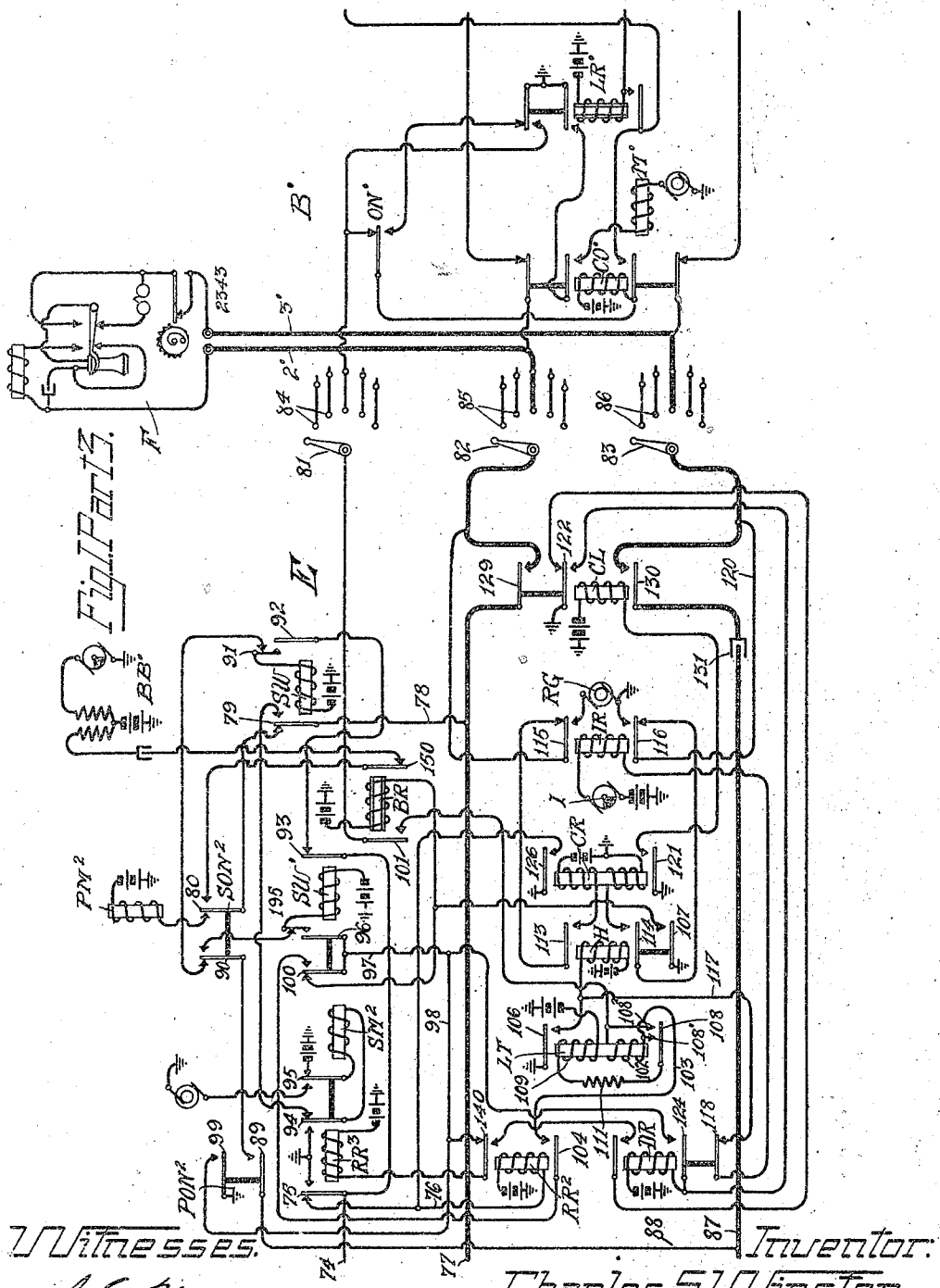

Witnesses.

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UNITED STATES PATENT OFFICE.

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AUTOMATIC TELEPHONE SYSTEM.

1,216,641. Specification of Letters Patent. **Patented Feb. 20, 1917.**

Application filed February 19, 1913. Serial No. 749,324.

To all whom it may concern:

Be it known that I, CHARLES S. WINSTON, a citizen of the United States of America, residing in Chicago, county of Cook, and State of Illinois, have invented certain new and useful Improvements in Automatic Telephone Systems, of which the following is a specification.

My invention relates to telephone systems and has to do more particularly with metallic line or two-wire control circuits for controlling the operation of selective switches. In the so-called metallic circuit automatic telephone systems, wherein two-dimension switches are employed, and in which primary and secondary circuit changes are effected, means must be provided which effect a secondary circuit change after the transmission of the primary impulses, such means remaining in a certain condition during the transmission of the primary impulses and thereafter automatically operated to effect this secondary circuit change. In systems of this character a release controlling device as a release relay must also be provided which is not affected by the transmission of the primary impulses at a predetermined period, but when the metallic circuit is interrupted for any appreciable period this release relay must operate to effect the restoration of the switch. To this end I have provided differential secondary and release relays which do not respond to short periodic current variations of a predetermined period, such as the transmission of the primary impulses, but will respond only to a longer current variation to bring about the so-called secondary and release circuit changes.

In the accompanying drawings I have illustrated a preferred embodiment of my invention the like parts of these drawings being indicated by like reference characters and in which—

Figure 1, comprising Parts 1, 2, and 3, illustrates an automatic telephone system embodying my invention;

Fig. 2 illustrates diagrammatically a switch construction adapted for use with the individual line switch of the system shown;

Fig. 3 is a diagrammatic view of the contact bank and wiper arrangement of the selector and connector switches.

In illustrating my invention I have shown sufficient apparatus for one connection. A calling substation A is shown connected to a line switch B which is adapted to automatically select an idle first selector C upon initiation of a call and which first selector may be directively controlled to select an idle second selector D which in turn may be operated to pick out an idle connector E which has access to the line of a called substation F. A line switch B^1 is also shown associated with the called substation F. By placing Fig. 1, Part 2 between Fig. 1, Part 1, and Fig. 1, Part 3, the description of the system may be more readily followed. I preferably employ hundred point selector and connector switches, and also provide ten per cent. trunking in accordance with the common practice of the present day, and in a 10,000 line system as illustrated, on the percentage of trunking referred to there would of course be 1000 first selectors C, 1000 second selectors D and 1000 connectors E. A line switch B is of course provided for each line and I preferably divide the lines into groups of 100 and for each such group 10 first selectors C are provided. Therefore the line switches B are preferably 10 point switches, each group of 100 such switches being multiply connected to 10 corresponding first selectors C although in the illustration but two such multiple connections are shown. The second selectors D and connectors E are distributed in accordance with the ten per cent. trunking outlined and it is thought that this distribution of these switches is so well known that further reference thereto is unnecessary.

Referring now more in general to the apparatus of my preferred arrangement, substations as A of any well-known common battery type may be provided and a calling device 1 is also provided for each substation, such calling device being of the metallic line type which when operated will interrupt the metallic circuit of the line from one to ten times as desired. Substation A is connected by line conductors 2, 3, to the line switch B at the central office said switch comprising a line relay LR which is energized upon initiation of a call to energize a cut-off relay CO. A motor magnet

M is also provided which has its circuit closed through the line and cut-off relays and is adapted to advance the wipers 4, 5, 6 in a step by step movement over the associated ten sets of contacts 7, 8, 9. An extra set of contacts 10, 11, 12 are preferably provided for the line switch B so that if all of the trunks extending from the contacts 7, 8, 9, are busy the switch will step to the last set of contacts and transmit a busy signal to the calling substation, in which case the receiver may be replaced upon the switch-hook thereat to effect the restoration of the line switch. An off-normal contact ON is also provided which is adapted to move to an alternate position upon the first step of the wipers and remain in its alternate position until the wipers are again restored to normal.

In Fig. 2, I have illustrated diagrammatically a mechanical structure adapted for operation with the line switch circuit B, the like parts being indicated by like reference characters. In this construction, holding pawls 13, 14 are provided for the line and cut-off relays, the pawl 13 being normally free of engagement with the driving ratchet 15 while pawl 14 is normally in engagement with said ratchet. During the selecting operation of the line switch both of the relays CO and LR are energized so that the pawl 13 is in engagement with the ratchet 15 while the pawl 14 is out of engagement therewith. As soon as an idle trunk is selected, the cut-off relay CO deënergizes and the line relay LR remains energized so that both of the pawls 13, 14 are engaging the ratchet wheel. Now when a release of the switch is desired, the cut-off relay CO is again energized and the line relay LR maintained energized so that both of the holding pawls are disengaged and therefore the wipers are free to be restored to normal by spring tension.

The selector and connector switches preferably employed are of the two-dimension type, that is the type in which the bank contacts are divided into groups and in which a primary adjustment of the switch is effective to select a group and thereafter a secondary adjustment produced to select a contact of the selected group. On a basis of ten per cent. trunking this means that the contacts are preferably divided into ten groups of ten contact sets each as is diagrammatically illustrated in Fig. 3. As all of the selector and connector switches are of the same type it might be well to describe in general the construction and operation of these switches before proceeding with a description of the circuits.

In Fig. 3, I have illustrated diagrammatically the preferred contact bank and wiper arrangement of the selector and connector switches each set of three contacts 16, 17, 18 as of the first selector C being indicated by a single piece marked 16, 17, 18. These contact pieces are divided into ten arcuate radially disposed rows and a set of three wipers 19, 20, 21, as shown at first selector C are adapted for coöperation with the bank contacts. In order to give the wipers their primary adjustment, a primary shaft PS is provided which is adapted to be rotated by a primary magnet (PM of the circuit drawing) and thereafter the secondary shaft SS is moved downward by a secondary magnet (SM of the circuit drawing) to give a secondary adjustment of the wipers to select a set of contacts of the selected row. A primary off-normal switch PON is also provided which is moved to its alternate position upon the first primary step of the switch and a secondary off-normal switch SON is also provided which is adapted to be moved to its alternate position upon the first secondary step of the switch. The primary and secondary adjustment of the switch is against the tension of a pair of spring members and therefore holding pawls are also provided.

In the preferred switch construction I do not depend upon a release magnet for withdrawing the retaining pawls but preferably employ a releasing arrangement in which the secondary magnet is again brought into play to advance the wipers in a continued secondary adjustment over the contacts of the selected row until they have passed beyond the last contact of the group. Upon reaching this point the wipers are automatically restored by spring tension over a path indicated by the dotted line 222 of Fig. 3 and in the direction of the arrows indicated thereon. Thus in a complete cycle of operation of the wipers the contact ends follow a path as illustrated by this dotted line 222 but of course in accordance with the selected row. In the restoring operation of the switch the primary and secondary off-normal switches are also restored in a manner as will be clear from Fig. 3. It is thought that from the above description the operation of the preferred selector and connector switch construction will be readily understood but for a more complete understanding of this switch reference may be had to an application of Wm. Kaisling for automatic switches, Serial No. 600,664, filed January 3rd, 1911.

First selector C.

Each first selector C is provided with 100 sets of contacts 16, 17, 18, and coöperating wipers 19, 20, 21, test wiper 19 having its contacting end so arranged that it will make one contact 16 before leaving the preceding contacts while the line wipers 20, 21, are arranged to break before make. A primary magnet PM is provided for giving

the primary adjustment to the wipers and a secondary magnet SM provided for giving the secondary adjustment to these wipers, the secondary magnet being preferably operated by alternating current from an alternating current generator as shown although other forms of operating current may be employed. An impulse relay IR is bridged across the line conductors at first selector C and is adapted to be energized by current flowing over the calling line when the selector C is connected with. A main release relay MRR is also provided which is preferably energized responsive to the initial energization of IR, and upon the energization of MRR, a differential release relay RR is energized by current through its upper winding so that its alternate contact 22 closes. This establishes a locking circuit for RR and also for relay MRR. Now when the impulse relay IR is rapidly operated for transmitting primary impulses, a circuit is closed through the lower winding 24 of the release relay, the flow of current through this lower winding 24 being opposite to that of the upper winding 23, this action tending to neutralize the magnetism of the core of RR but these impulses through the lower winding 24 are of too short a duration to sufficiently neutralize the relay to cause the falling back of its armature. That is, as long as relay IR is rapidly vibrating at a predetermined rate, these impulses do not effect a retraction of the armature of RR, but as soon as relay IR is deënergized for a predetermined longer period than when operated for sending primary impulses, the neutralizing effect of the winding 24 is sufficient to cause a retraction of the armature of RR and thereby a release of the main release relay MRR which brings about the restoration of switch C. As relay IR is not deënergized for such a releasing period except when the receiver is replaced, it is apparent that both of the relays MRR and RR maintain their armatures attracted until a release is desired.

Now as to the secondary circuit changes which follow each series of primary impulses, I have provided a differential secondary relay SR which has a circuit closed through its two windings 25, 26, when relays IR and RR initially attract their armatures. Therefore the secondary relay SR does not attract its armature because the flow of current through its two windings 25, 26, has a differential effect upon the magnet thereof, but as soon as the relay IR starts to vibrate in response to the operation of the calling device at the substation, the circuit through one of the windings, in this instance winding 25, is interrupted each time relay IR vibrates and upon the first vibration of relay IR the flow of current through winding 25 is interrupted for a sufficient period to remove the neutralizing effect of this winding 25, and as the other winding 26 is still in a closed circuit the armature of relay SR is attracted and remains attracted as long as the circuit through the winding 25 is being rapidly interrupted. As soon as relay SR stops vibrating, which is at the termination of the calling device operation, the circuit through the winding 25 of relay SR remains closed long enough to effect a neutralization of the magnet of relay SR so that the armature of this relay retracts and brings about the secondary operation of the switch through a test relay T which energizes at this time.

I also provide primary and secondary off-normal switches PON and SON respectively which operate in a manner as already described.

I also preferably arrange the impulse and secondary relays to act as repeating relays, that is these relays are also adapted for transmitting primary and secondary impulses to the other selector and connector switches for causing their operation as will be more particularly described.

Now as to the second selector switches D preferably employed, they also comprise primary and secondary magnets PM^1, SM^1, a test relay T^1 and a release relay RR^1, which relay RR^1 energizes upon the selection of the switch D and remains energized until restoration is desired. The primary and secondary off-normal switches PON^1, SON^1 of the second selectors operate in a manner as already described. The preferred switch construction of these second selectors is the same as referred to in connection with Fig. 3.

Various types of connector switches may be employed in connection with my invention but for the purpose of illustration I employ a connector switch E of a type of switch mechanism similar to that outlined in Fig. 3. Therefore primary and secondary magnets PM^2, and SM^2 are provided for operating the switch. A release relay RR^2 is also provided which is energized upon connection made with the connector E. Another release relay RR^3 is also provided which is brought into play when a release of the connector is effected. In order to disconnect the primary magnet and connect the secondary magnet in operative relation with the line following the transmission of the first set of primary impulses to the connector, a switching relay SW is provided which energizes responsive to the first secondary circuit change transmitted to the connector. After the primary operation of the switch the secondary magnet is operated to drive the switch into connection with the terminal of the called line

after which another switching relay SW¹ is operated responsive to the last secondary circuit change. If the called line is busy the busy relay BR which had previously been energized, restores to connect the busy back device BB¹ in circuit with the calling substation. If the called line is idle the line test relay LT is energized to bring about the operation of the interrupter relay IR which connects the ringing generator RG in circuit with the called line. Upon a response being received from the called substation, a control relay CR is energized as is also the closing relay CL and disconnect relay DR whereby the ringing current is disconnected from the called line.

I have preferably arranged the release of the switches used in establishing a connection so that if a call is completed, the line switch B first selector C and second selector D are restored by the act of the calling subscriber replacing his receiver and the release of the connector E brought about by the restoration of the receiver at the called substation. If the connection is extended to the called line and the called subscriber fails to respond, all of the switches used in establishing the connection are brought to normal by the replacing of the receiver at the calling substation. Also should the calling subscriber fail to extend the connection to the terminals of the called line, any switches which may have been operated may be brought to normal by the restoration of the receiver at the calling substation.

Operation.

Having described in general the apparatus employed in the preferred embodiment of my invention the operation of the system illustrated in extending a connection will now be described more in detail. Assuming now that a connection is to be made between calling substation A and the called substation F, the number of whose line we will assume is 2343 the calling subscriber removes the receiver at substation A. A circuit for the line relay LR is thus established from battery through the winding thereof, wiper 6, normal contact 27, line conductor 2, substation A, line conductor 3, normal contact 28, wiper 5, to grounded contact 29. Relay LR therefore energizes closing its alternate contact 30 to establish an energizing circuit for the cut-off relay CO traced from ground at said alternate contact 30, normal contact ON, the winding of CO to battery. Relays LR and CO being energized, a circuit for motor magnet M is of course established from the alternating current generator connected to the winding of M, the alternate contact 31 to ground at alternate contact 32. Magnet M therefore advances the wipers 4, 5, 6 into engagement with the first set of contacts 7, 8, 9, which if busy have a ground potential connected to their test contact 7 in a manner as will be presently described. Therefore due to the closing of alternate contacts 32, 33, of relays CO and LR, a locking circuit for these relays is established through the test wiper 4 so that the motor magnet M advances the wipers a step and into engagement with the next set of contacts and in fact continues this operation as long as the wiper 4 is engaging busy contacts 7. Upon reaching the third set of contacts, which we will assume is the first idle one, and which contacts lead to the first selector C shown, there being no ground or busy potential upon the test contact of this set, the locking circuit for relays CO and LR is interrupted and relay CO being a quick relay immediately retracts its armature while the line relay LR which is a slow acting relay momentarily maintains its armature attracted. As soon as the relay CO retracts and closes its normal contacts 27, 28, the impulse relay IR energizes by current over the calling line and immediately closes a locking circuit to maintain the armature of the relay LR attracted. This energizing circuit for the impulse relay IR may be traced from battery through the left hand winding thereof, contact 8, wiper 5, normal contact 28, line conductor 3, substation A, line conductor 2, normal contact 27, wiper 6 and contact 9 and then through the right hand winding of IR to ground. Relay IR therefore energizes closing its alternate contact 33 which connects ground from the normal contact 34 of PON, alternate contact 33 and the winding of MRR to battery which immediately energizes and closes its alternate contact 35 to apply this said ground through test contact 7 and wiper 4, alternate contact 32 and winding of LR to battery. Thus relay LR being maintained energized, the wipers of the line switch B are held in their operated position.

The initial energization of the impulse relay IR through the assistance of the main release relay MRR closes a circuit through the winding 23 of release relay RR due to the closing of alternate contact 36 of MRR. This circuit through the winding 23 of RR causes the energization thereof and the attraction of its armature whereby its alternate contact 22 is closed establishing a locking circuit for both of the release relays MRR and RR. These relays now maintain their armatures attracted until a releasing deënergization of the impulse relay, which deënergization is only brought about when a release is desired and the receiver replaced upon the switch-hook.

Also responsive to the operation of the three relays IR, MRR, and RR, a circuit is closed through each of the windings 25, 26, of

the differential secondary relay SR, but the circuits through these windings 25, 26 have a differential effect upon the magnet of SR so that the armature thereof is not attracted. The circuit through the upper winding 25 may be traced from battery through said winding to ground at alternate contact 38, while the circuit through the winding 26 may be traced from battery through said winding 26, conductor 39, alternate contact 33, to ground at normal contact 34, and after the operation of RR the circuit through winding 26 may be traced also to ground at alternate contact 22. Thus the secondary relay SR does not attract its armature at this time.

The circuit of the calling line having been extended to an idle first selector C, operation of this selector in extending the call will now be described. The number of the called substation being 2343, the calling device 1 at substation A is operated to effect two interruptions of the impulse contacts thereof whereby the circuit through the impulse relay IR is interrupted two times causing two operations of its armature. Responsive to each such operation of IR, its normal contact 38 is closed to transmit a primary impulse through the primary magnet PM, this circuit being traced from said grounded normal contact 38, alternate contact 40, primary conductor 41, conductor 42, normal contact 43 and the winding of PM to battery, these two operations of the primary magnet effecting two primary steps of the wipers 19, 20, 21 to select the second group of contacts 16, 17, 18. These contacts in accordance with the well-known practice lead to second selectors having access to connector switches associated with lines in the second thousand group.

Also responsive to the two primary operations of relay IR its normal contact 33 is closed, each such closure effecting a short impulse through the winding 24 of the release relay, but it is to be understood that these impulses are not of sufficient duration to bring about a neutralizing effect of this winding 24 sufficient to cause a retraction of the armature thereof.

Now as to the secondary relay SR, it will be remembered that its winding 26 is maintained in a closed circuit through the alternate contacts 22 of relay RR, but upon the first primary operation of relay IR the circuit through the winding 25 of SR is interrupted for a sufficient period of time so that it loses its neutralizing effect enough to allow the winding 26 to cause the attraction of the armature of SR and thereby the interruption of its normal contact 44. Although this winding 25 of SR is closed in circuit each time the alternate contact 38 of relay IR operates during the primary operations, these impulses through winding 25 are not sufficient to bring about a neutralizing effect to cause a retraction of the armature of SR. But as soon as the primary operations of the relay IR cease, its alternate contact 38 remains closed for a sufficient period of time to render the neutralizing effect of the winding 25 of SR sufficient to cause a retraction of its armature to bring about this secondary circuit change and thereby the energization of the test relay T. This energizing circuit for T may be traced from battery through the winding thereof, normal contact 46, alternate contact 47 (which closes upon the first primary step of the switch,) normal contact 44, secondary conductor 48 and the right end winding of IR to ground. The closing of this circuit causes the energization of test relay T whereby its alternate contact 49 is closed establishing a circuit through the secondary magnet SM. Magnet SM therefore operates to advance the wipers 19, 20, 21 into engagement with the first set of contacts 16, 17, 18 of the selected group and assuming this first set leads to a busy second selector, its test contact 16 has a busy potential connected thereto, preferably ground, and a maintaining circuit for the test relay is established. This circuit may be traced from said grounded contact 16, wiper 19, alternate contact 50, alternate contact 51 and the winding of T to battery. Therefore magnet SM advances the wipers another step and continues this advance as long as the test wiper 19 is engaging busy test contacts 16. As soon as an idle set of contacts is reached, (such idle set having no ground or busy potential connected thereto) the circuit for the test relay T is interrupted whereby it restores interrupting the circuit for SM and rendering the wipers inert. As soon as relay T restores, its normal contact 50 closes placing a ground or busy potential upon the test contact 16 of the selected set. This ground connection to the test terminal 16 also establishes an energizing circuit for the release relay RR^1 of the selected second selector D this circuit being traced over the conductor 52, normal contact 53, winding of RR^1 to battery energizing said relay which closes its locking contact 54 whereby relay RR^1 is maintained energized until a release is to be effected. During the secondary adjustment of switch C its line wipers 20, 21, are on open circuit due to the interruption of normal contact 55, 56, of test relay T.

The circuit of the calling line has thus been extended to an idle second selector D, and the operation of this switch will now be described. The second operation of the calling device 1 at substation A interrupts the calling line circuit three times, corresponding to the second digit of the called substation number and therefore the impulse relay IR receives three primary op-

erations. As before the secondary relay SR attracts its armature on the first one of this last set of primary operations of IR and said relay SR maintains its armature attracted until the cessation of these primary operations. Also responsive to the three primary operations of IR three impulses are transmitted to the primary magnet PM^1 of second selector D, traced from ground at normal contact 38 of IR, alternate contact 40, primary conductor 41, contact 55, wiper 20 and contact 17, conductors 57, 58, normal contact 59 and the winding of PM^1 to battery. Magnet PM^1 therefore advances wipers 60, 61, 62, three primary steps to select the third group of contacts 63, 64, 65, which set of contacts leads to connector switches in the hundreds group which includes the called line. Upon cessation of the primary operations of IR, secondary relay SR restores its armature in a manner as before described whereby its normal contact 44 is closed to bring about the secondary operation of the second selector D through the energization of its test relay T^1. This circuit for T^1 is traced from ground through the right end winding of IR, secondary conductor 48, normal contacts 44, 56, wiper 21 and contact 18, secondary conductor 66, conductor 67, alternate contact 68 (which closed upon the first primary step of switch D), normal contact 69 and the winding of T^1 to battery. Test relay T^1 therefore is energized closing its alternate contact 70 to establish an operating circuit for the secondary magnet SM^1 whereby the wipers 60, 61, 62, receive a secondary adjustment and are thus advanced by the first step into engagement with the first set of contacts 63, 64, 65 of the selected group. If this set is busy its test contact 63 has a busy potential connected thereto, preferably ground, as will hereinafter appear. Therefore a maintaining circuit for the test relay T^1 is provided being traced from grounded test contact 63, wiper 60, alternate contact 71, alternate contact 172, and the winding of T^1 to battery so that the test relay is maintained energized over this circuit due to the fact that the initial energizing circuit is interrupted at SON^1 upon the first secondary step of the switch. The wipers of switch D are thus continued in their secondary adjustment until an idle set of contacts are reached, and due to the fact that the test contact 63 of an idle set has no busy potential the maintaining circuit for relay T^1 is interrupted causing said relay to deënergize and render the wipers inert. Upon the closing of normal contact 71 of T^1 upon its said deënergization, a busy potential, preferably ground is connected through the wiper 60 to the selected test contact 63 rendering all of the multiple contacts connected therewith non-selectable. During the secondary travel of switch D the line wipers 61, 62 are held disconnected due to the interruption of normal contacts 72, 73, of relay T^1. This ground connection to the selected test contact 63 also causes the energization of release relay RR^2 of the selected connector switch E this circuit being traced over the test conductor 74, normal contact 75, conductor 76, and the winding of RR^2 to battery. Relay RR^2 therefore energizes and is maintained energized until a release of the connector is effected.

The calling line circuit has now been extended to an idle connector E which has access to the terminals of the called line and the operation of this connector will now be described.

The subscriber at A now operates his dial 1 for the third time causing four interruptions of its impulse springs, corresponding in number to the third digit of the called line number and the impulse relay IR therefore receives four primary operations. Responsive to these primary operations the secondary relay SR attracts its armature in a manner as before described maintains it attracted until the cessation of said four primary operations. Also responsive to these four operations of IR four primary impulses are transmitted to the primary magnet PM^2 of connector E, the path of these impulses being traced from ground at normal contact 38 and IR, alternate contact 40, conductor 41, normal contact 55, wiper 20 and contact 17, conductor 57, contact 72, wiper 61 and contact 64, primary conductor 77, conductor 78, normal contacts 79, 80, and the winding of PM^2 to battery. Responsive to these four impulses the primary magnet advances wipers 31, 82, 83 to the fourth group of contacts 84, 85, 86 which is the group including the terminals of the called line.

Upon cessation of these primary operations of IR, secondary relay SR retracts its armature in a manner as before described whereby its normal contact 44 is closed and a secondary circuit change is effected to cause the operation of switching relay SW of connector E, the circuit therefor being traced from ground through the right end winding of IR over the previously described path through the secondary conductor 66 of switch D, normal contact 73, wiper 62, contact 65, secondary conductor 87, conductor 88, alternate contact 89 which closed upon the first primary step of the connector, normal contact 90 and normal contact 91 of SW through the winding thereof to battery. The switching relay SW therefore energizes closing its alternate contact 92, establishing a locking circuit for itself through normal contact 93 to the grounded test conductor 74. Due to the in-

terruption of normal contact 79 of SW and the closing of its alternate contact 79, the primary magnet PM^2 is disconnected and secondary magnet SM^2 connected in circuit with the primary conductor 77.

Now when the calling device 1 at substation A is operated for the last time to cause three primary operations of the impulse relay IR, secondary relay SR attracts its armature as before and three impulses are also transmitted over the primary conductor along the previously described path to alternate contact 79 of SW, normal contact 94, the winding of SM^2 to battery at normal contact 95. Responsive to these three primary impulses the secondary magnet SM^2 advances the wipers 81, 82, 83, in a secondary direction to select the third set of contacts 84, 85, 86, which are the terminals of the wanted line. Following the transmission of the last set of primary impulses, the secondary relay SR retracts its armature in a manner as before described whereby a secondary circuit change is effected to bring about the operation of switching relay SW^1, this secondary operating circuit being traced over the previously described path to secondary conductor 87, conductor 88, alternate contact 90 which closed upon the first secondary step of the switch, normal contact 195 and the winding of SW^1 to battery. Relay SW^1 therefore closes its locking contact 96 establishing a locking circuit for itself over conductors 97, 98, to the grounded off-normal contact 99.

It will be noted that upon the first primary step of the switch and the closing of its primary off-normal contact 99, a circuit for busy relay BR is established, traced from ground at said alternate contact 99, conductors 98, 97, normal contact 100 and the winding of BR to battery so that relay BR remains energized until its circuit is interrupted at the normal contact 100 by the energization of the switching relay SW^1 as just described. Relay BR being a sluggish relay maintains its armature momentarily attracted and if the line connected with is busy, said relay BR is maintained energized over a circuit as will be described, but if the line connected with is idle no maintaining circuit for BR is established so that it retracts its armature to transmit a busy signal to the calling substation.

Called line idle.

Assuming now that the line connected with is idle, upon the said energization of SW^1 the line test relay LT is connected in circuit with the test terminal 84 of the called line which is connected through the corresponding cut-off relay CO^1 to battery. Line test relay LT and cut-off relay CO^1 are therefore connected in a series energizing circuit which may be traced from battery through the winding of CO^1, normal contact ON^1, contact 84 and wiper 81, alternate contact 101 (which is still being maintained closed due to the sluggishness of BR) winding 102, conductor 103, alternate contacts 104, conductors 97, 98 to ground at alternate contact 99. Both of the relays LT and CO^1 are therefore energized the energization of LT causing the closure of its alternate contact 106 whereby the relay H is energized to close its alternate contact 107, which thereby closes another energizing circuit through the winding of BR before it has had a chance to retract its armature. Upon the closing of alternate contacts 108, of line test relay LT, the lower winding 102 is short circuited but the upper winding 109 is connected in a locking circuit which may be traced from battery through said winding 109, resistance 111, alternate contacts 108, 108^1, conductor 103, alternate contact 104, 100, conductors 97, 98 to ground at alternate contact 99, this circuit being effective to maintain the relay LT energized until the switch is restored. This shunting of winding 102 is also effective to connect the grounded conductor 103 through alternate contact 108^2 and alternate contact 100 to the connected test contact 84 and its multiples, this action rendering these contacts un-selectable by any other switch and also maintaining the cut-off relay CO^1 energized. Upon said energization of relay H, the control relay CR is connected in bridge of the terminals of the called line through alternate contacts 113, 114 of relay H and normal contacts 115, 116, of interrupter relay IR. Due to the interposition of the condenser at the called substation, this bridge circuit including the control relay CR does not effect an operation of CR until the receiver at the called substation is removed as will be more particularly described.

Now as to the application of the ringing current to the called line, this is brought about by the closing of alternate contact 106 of relay LT which connects ground through conductor 117 and normal contact 118 through the winding of interrupter relay IR, and interrupter I to battery. Due to the operation of the interrupter I, the interrupter relay IR alternately bridges the control relay CR and ringing generator RG across the terminals 85, 86, of the called line. Each time the ringing generator RG is connected in such bridge through the alternate contacts 115, 116, ringing current is projected over the calling line and through the call bell at substation F and when the subscriber thereat removes the receiver in response to this call and upon the succeeding closure of normal contacts 115, 116, of IR, an operating circuit for the control relay CR is established. This circuit

may be traced from battery through the upper winding of CR, alternate contact 113, normal contact 115, wiper 82, terminal 85, line conductor 2^1, substation F, returning over line conductor 3^1, terminal 86 and wiper 83, conductor 120, normal contact 116, alternate contact 114 and the lower winding of CR to ground. This circuit causes the relay CR to attract its armature whereby its alternate contact 121 is closed establishing an energization of closing relay CL which in turn causes its alternate contact 122 to effect the energization of the disconnect relay DR. Relay DR therefore interrupts its normal contact 118 rendering the interrupter relay inert and thus preventing any further application of ringing current to the called line. Upon the energization of DR its alternate contact 124 is closed establishing a locking circuit for itself to the grounded alternate contact 99.

Now returning to the control relay CR, also upon its energization its alternate contact 126 is closed thereby also placing release relay RR^2 under control of the called substation because this relay RR^2 cannot now restore as long as the control relay CR is energized and its alternate contact 126 closed.

Referring again to closing relay CL upon its said energization, its alternate contacts 129, 130 are closed thereby establishing the continuity of the talking circuit between the two substations A and F this circuit being traced over the heavily marked conductors in which condensers are interposed, the condenser 131 being connected in the secondary conductor at connector E while a condenser 132 is connected in the primary conductor at first selector C these condensers preventing interference between the battery supply and control relays energized over the calling and called lines. The substations are now connected for conversation, the talking battery for the calling substation being supplied through the windings of relay IR while the talking battery for the called substation is supplied through the windings of control relay CR, these relays of course having a sufficient impedance to prevent cross talk in accordance with well known practice.

Disconnection.

After the subscribers have finished conversation, by replacing their receivers upon their respective switch hooks they may effect the restoration of the switches, the restoration of the receiver at the called substation effecting the restoration of connector E, and the restoration of the receiver at substation A effecting the restoration of switches B, and C and D.

Assuming now that the subscriber at A is the first to replace the receiver upon its switch-hook, the circuit for relay IR is interrupted whereby said relay restores. Such restoration of IR of course causes the secondary relay SR to again attract its armature but such attraction is only incidental and has no effect upon the successful operation of the system.

It will be remembered that differential release relay RR and main release relay MRR have been maintained energized through the locking contact 22 of RR but upon a release deënergization of relay IR a circuit through the lower winding 24 of release relay RR is established for a sufficient length of time to bring about the neutralization of the magnet of RR, this neutralizing circuit being traced from battery through winding 24, alternate contact 135, 33, 35 and alternate contact 34 to ground. Therefore relay RR retracts its armature causing the interruption of this locking contact 22 and also of its contact 135 so that the holding circuit for both of the relays MRR and RR is interrupted rendering the relay RR inert, and causing the retraction of MRR.

Upon said deënergization of MRR, a release energization of relay T is effected, this energization being over a circuit traced from battery through the winding of T, normal contact 51 to ground at alternate contact 136. Relay T therefore closes its alternate contact 49 to establish a release operating circuit for the secondary magnet SM whereby the wipers are advanced in a secondary direction until they have passed beyond the last contact of the row where they are automatically restored to normal by spring tension in a manner already described. During restoration of the wipers, the off-normal switches are restored so that upon restoration of PON, the circuit for relay T is interrupted causing its restoration and the interruption of the circuit of SM. Switch C is now at normal.

Now as to the restoration of the line switch B, it will be remembered that the relay LR thereof has been held energized over the test conductor and through alternate contact 34 to ground so that when the switch PON restored, due to the interruption of alternate contact 34 this holding circuit for relay LR is interrupted causing its restoration. Normal contact 30 of LR is therefore closed establishing an energizing circuit for the cut-off relay CO, and relay CO being energized, and LR deënergized both of the pawls 13 and 14 are clear of the ratchet 15 and the wipers are free to be restored by spring tension. Upon said wipers reaching normal the switch ON is restored and the circuit for cut-off relay CO interrupted causing its restoration. Line switch B being at normal is available for use in extending other connections.

Referring now to the second selector D,

the release of this switch is brought about when the test relay T of first selector C is energized for release as previously described. That is when the normal contact 50 of relay T is interrupted during the release operation, the holding circuit for release relay RR^1 of second selector D is interrupted so that this relay restores to establish a release circuit for the relay T^1, traced from battery through the winding of T^1, normal contact 172, to ground at alternate contact 138. Relay T^1 therefore is energized to close an operating circuit for magnet SM^1 which advances the wipers of switch D in a secondary direction and brings about a restoration of the switch in a manner as before described. Upon restoration of PON^1, and due to the interruption of its alternate contact 138, the circuit for T^1 is interrupted, causing its restoration whereby the magnet SM^1 is rendered inert. Switch D being at normal is available for use in establishing other connections.

The restoration of connector E is brought about when the receiver is replaced at the called substation F this act interrupting the circuit for control relay CR and causing its deënergization. Upon the restoration of CR its alternate contact 121 is interrupted to allow restoration of relay CL and by the interruption of alternate contact 126 of CR the circuit of release relay RR^2 is interrupted causing its restoration. Upon restoration of RR^2 and due to the interruption of its alternate contact 104, the holding circuit for relay LT is interrupted causing this relay LT and also the relay H to restore. Now when relay RR^2 restores and closes its normal contact 140, a circuit for release relay RR^3 is established from ground at alternate contact 99 of PON^2, normal contact 140 and the winding of RR^3 to battery. Therefore relay RR^3 energizes and closes its alternate contacts 94, 95 whereby the secondary magnet SM^2 is connected in circuit with the alternating generator and thus the wipers are operated in a secondary direction and restored to normal in a manner as previously described.

Upon the restoration of switch E, the primary off-normal contact 99 is interrupted causing relay RR^3 to restore and also causing the restoration of DR. The interruption of this circuit at contact 99 also effects the restoration of relay SW^1. Switch E being at normal is available for use in establishing other connections.

Called line busy.

In the previous description it was assumed that the called line was idle when connection was made therewith and I will now describe the operation of the system when the connector switch connects with a busy called line.

As already referred to, when a line is busy its test contact 84 has a ground busy potential connected thereto as distinguishing from a battery potential when the line is idle. In the operation of the connector, the apparatus therefor operates the same up to the transmission of the last secondary impulse whether the wipers have connected to an idle or busy line, and it will be remembered that up to this period, that is, the transmission of the last secondary impulse, that relays RR^2, BR and SW^1 are energized, the energization of SW^1 having been effected by the last secondary impulse. Also due to the closing of alternate contact 100 of relay SW^1, the line test relay LT was connected in circuit with the test contact 84 of the called line. This contact now having a ground potential, the line test relay LT is not energized due to the fact that there is a ground potential at each of the terminals of its initial energizing winding 102. Therefore relay LT does not energize and consequently its associated relay H does not energize so that no maintaining circuit for busy relay BR is provided and said relay BR retracts its armature. Upon retraction of the armature of BR the test connection to LT is interrupted by the interruption of contact 101 and due to the closing of normal contact 150 of BR, the busy back device BB^1 is connected in circuit with the primary conductor to indicate to the calling subscriber that the called line is busy. This busy circuit may be traced from device BB^1, contact 150, alternate contact 80, normal contact 79 to primary conductor 77 following the path back over this conductor and through the right end winding of IR to ground. The calling subscriber in response to this signal replaces the receiver upon its switch-hook thereby restoring relay IR and effecting the restoration of the switches C, B and D as before. In the present instance the connector switch E is also brought to normal at the time the test relay T^1 of second selector D energizes for release. That is when this relay T^1 energizes to effect the release of switch D, its normal contact 7^1 is interrupted to remove the ground connection which maintained the release relay RR^2 of connector E energized. It will be noted that due to the fact that no response was secured from a called substation, the control of the release relay RR^2 remains with the calling subscriber, as the additional locking circuit through contact 126 of CR was not closed. Therefore when relay RR^2 deënergizes and its normal contact 140 is closed, a circuit for RR^3 is established from battery through the winding of RR^3, normal contact 140 to ground at alternate contact 99. RR^3 therefore closes its alternate contacts 94, 95, whereby the secondary magnet SM^2 is operated to restore the switch E.

Upon the switch E reaching normal the primary off-normal contact 99 is interrupted to allow the deënergization of RR^3 and SW^1.

All of the switches used in establishing this last attempted connection being at normal, are available for use in establishing other connections.

Although I have embodied my invention in preferred circuit arrangements and particular switch constructions, I contemplate using it in other ways than herein described and it is also to be understood that my invention is not limited to the use of line switches, as other means of interconnecting the calling line and the control circuits of the first selector may be employed and therefore I do not desire to be limited to the exact structure as shown and described but aim to cover all those embodiments as come within the spirit and scope of the appended claims.

What I claim as new and desire to secure by United States Letters Patent is:

1. A metallic-line control circuit for automatic switches comprising an impulse relay, a two conductor operating circuit for said relay and having a call transmitter connected in circuit, means for rapidly operating the impulse relay by said call transmitter for transmitting primary impulses, a differential release relay operated responsive to said impulse relay to attract its armature, a locking circuit for said release relay effective upon its operation, and a neutralizing winding for said release relay effective to cause a retraction of its armature only responsive to an extended deënergization of the impulse relay.

2. A metallic-line control circuit for automatic switches comprising an impulse relay, a two-conductor operating circuit for said relay having a call transmitter connected therewith, means for rapidly operating the impulse relay responsive to said call transmitter for transmitting primary impulses, a differential release relay having an initial operating winding responsive to the initial energization of the impulse relay to attract its armature, means for holding said armature attracted during the primary operations of the impulse relay, and a neutralizing winding for said release relay effective to cause a retraction of its armature only responsive to an extended deënergization of the impulse relay.

3. A metallic-line control circuit for automatic switches comprising a bridged impulse relay, a metallic operating circuit therefor, a call transmitter in said metallic circuit for operating said impulse relay to transmit primary impulses, a differential release relay having an initial operating winding closed upon the initial energization of the impulse relay, a locking circuit including said winding for holding the release relay operated during the primary operations of the impulse relay, a neutralizing winding for said release relay adapted to be included in an energizing circuit responsive to each primary operation of the impulse relay but not effective to cause a retraction of the armature of the release relay during such primary operations, said neutralizing circuit being rendered effective upon a release or extended period of deënergization of the impulse relay to cause a restoration of the armature of the release relay.

4. A metallic-line control circuit for automatic switches comprising an impulse relay, a two-conductor operating circuit therefor, a call transmitter connected in said circuit, a differential release relay having one of its windings closed responsive to operation of the impulse relay, means for closing a locking circuit through said relay to hold it operated during the primary operations of said impulse relay by the called transmitter, a neutralizing winding for said release relay included in an energizing circuit responsive to each primary operation of the impulse relay but not effective to cause a retraction of the armature of the release relay during such primary operations, said neutralizing circuit being rendered effective to cause a restoration of the armature of the release relay only upon a release deënergization of the impulse relay.

5. A metallic-line control circuit for two dimension automatic switches comprising an impulse relay, a two conductor operating circuit for said relay having a call transmitter connected therewith, means for rapidly operating the impulse relay responsive to said call transmitter for transmitting the primary impulses, a differential secondary relay operated over one of its windings to attract its armature responsive to the first primary operation of the impulse relay, and a neutralizing winding for said secondary relay effective upon cessation of the primary operations of the impulse relay to cause a secondary circuit change following the primary impulses.

6. A metallic line control circuit for two-dimension automatic switches comprising an impulse relay, a two-conductor operating circuit for said relay having a call transmitter connected therewith, means for rapidly operating the impulse relay responsive to said call transmitter for transmitting the primary impulses, a differential secondary relay operated to attract its armature responsive to said impulse relay and maintain its armature attracted during the primary operations of the impulse relay, and means for neutralizing the magnetizing effect of the winding of said secondary relay upon cessation of the primary operations to cause a retraction of the secondary armature and bring about a secondary circuit change.

7. A metallic-line control circuit for two-dimension automatic switches comprising an impulse relay, a two-conductor operating circuit for said relay, means for rapidly operating the impulse relay for transmitting primary impulses, a differential secondary relay operated to attract its armature responsive to the first primary operation of the impulse relay, means for maintaining said armature attracted during the primary operations of the impulse relay and a neutralizing winding for said secondary relay effective upon cessation of the primary operations of the impulse relay to cause a retraction of the secondary armature to effect a secondary circuit change.

8. A metallic-line control circuit for two-dimension automatic switches comprising an impulse relay, a two-conductor operating circuit for said relay, means for rapidly operating the impulse relay for transmitting primary impulses, a differential secondary relay, means for operating said differential relay to attract its armature and for maintaining said armature attracted during the primary operations of the impulse relay, and a neutralizing winding for said secondary relay effective upon cessation of the primary operations of the impulse relay to cause a retraction of the secondary armature to effect a secondary circuit change.

9. A metallic-line control circuit for two-dimension automatic switches comprising an impulse relay, a two-conductor operating circuit for said relay, means for rapidly operating the impulse relay for transmitting primary impulses, a differential secondary relay, means for operating said differential relay to attract its armature and for maintaining said armature attracted during the primary operations of the impulse relay, a neutralizing winding for said secondary relay effective upon cessation of the primary operations of the impulse relay to cause a retraction of the secondary armature to effect a secondary circuit change, a differential release relay, means for operating said impulse relay to attract its armature and hold said armature attracted during the primary operation of the impulse relay and a neutralizing winding for said release relay effective to cause a retraction of its armature only responsive to an extended deënergization of the impulse relay.

10. A metallic line control circuit for two-dimension switches comprising an impulse relay, a two-conductor operating circuit for said relay, means for rapidly operating the impulse relay for transmitting primary impulses, a differential secondary relay, means for operating said differential relay by the neutralization of its windings upon cessation of the primary operations of the impulse relay to effect a secondary circuit change, a differential release relay, means for operating said differential release relay by the neutralization of its windings responsive to an extended deënergization of the impulse relay, and a release circuit operative responsive to such operation of the release relay.

11. A two-conductor control circuit for automatic switches including primary, differential secondary and release relays, and means for controlling said relays over the two sides of a metallic line circuit in series.

12. A control circuit for automatic switches comprising an impulse relay, means for rapidly operating the impulse relay for transmitting primary impulses, a differential secondary relay, means for operating said differential relay to attract its armature and for maintaining said armature attracted during the primary operations of the impulse relay, and a neutralizing winding for said secondary relay effective upon cessation of the primary operations of the impulse relay to cause a retraction of the secondary armature to effect a secondary circuit change.

13. A control circuit for two-dimension automatic switches comprising an impulse relay, means for rapidly operating the impulse relay for transmitting primary impulses, a differential secondary relay, means for operating said differential relay by the neutralization of its windings upon cessation of the primary operations of the impulse relay to effect a secondary circuit change, a differential release relay, means for operating said differential release relay by the neutralization of its windings responsive to an extended deënergization of the impulse relay, and a release circuit operative responsive to such operation of the release relay.

14. A telephone system comprising a subscriber's telephone line, a two-dimension switch for extending a connection from said line having one motion for electing groups of trunk lines and a second motion for selecting an idle trunk in an elected group of trunk lines, a differential secondary relay for controlling the second of said motions, and a differential release relay for controlling the release of said switch.

15. A metallic line control circuit for a two-dimension switch comprising an impulse relay, means for operating said impulse relay for transmitting primary impulses, a differential secondary relay, means for operating said secondary relay upon the cessation of primary impulses to effect a secondary circuit change, a differential release relay, and means for operating said release relay responsive to a prolonged deenergization of said impulse relay for closing a release circuit.

16. An automatic switch of the character described for extending connections, an im-

pulse relay for said switch controlled over the two sides of a calling subscriber's line in series, a differential secondary relay responsive to the operations of said impulse relay for effecting a secondary circuit change, and a differentially wound release relay responsive to a prolonged deënergization of said impulse relay for closing a release circuit.

17. A metallic line control circuit for an automatic switch comprising an impulse relay, means for operating said impulse relay to transmit primary impulses, a differential secondary relay adapted to maintain its armature attracted during the primary operations of said impulse relay, and a neutralizing winding affective upon cessation of said primary operations of said impulse relay to cause a deënergization of said secondary relay to affect a secondary circuit change.

18. A telephone system comprising a telephone line, an automatic switch for extending a connection from said telephone line in the direction of a called subscriber's line, an impulse relay for said switch responsive to circuit changes in said telephone line, a differential secondary relay responsive to said impulse relay for controlling a secondary circuit, and a differential release relay responsive to a prolonged deënergization of said impulse relay for effecting the closure of a release circuit.

19. An automatic telephone exchange system comprising a subscriber's telephone line, an automatic selector switch for extending a call from said line, an impulse relay responsive to circuit changes in said telephone line, a differential secondary relay for said switch, means for operating said differential relay to attract its armature and for maintaining said armature in its attracted position during the primary operations of said impulse relay, a second winding for said differential relay affective upon cessation of said primary operation to cause a retraction of the secondary armature of said secondary relay, and a circuit controlled by said retraction.

20. A telephone system comprising a subscriber's line circuit, a two-wire automatic switch adapted to be connected to said line circuit, an impulse relay for said switch responsive to circuit changes in said telephone line, a differential relay for said switch operated to attract its armature responsive to the first primary operation of said impulse relay, and a neutralizing winding for said second relay effective upon a prolonged deënergization of said impulse relay to cause a retraction of its armature thereby effecting circuit changes.

21. A telephone system including a subscriber's line circuit, a two-wire automatic switch, automatic means for connecting said subscriber's line circuit to said automatic switch, an impulse relay for said switch, a transmitter connected in said line circuit for interrupting the circuit of said impulse relay, thereby causing said relay to be rapidly intermittently operated, and a differential relay controllable by said impulse relay for controlling a switching circuit.

22. An automatic telephone exchange system including a subscriber's telephone line, an automatic selector switch for extending a call from said line, an impulse relay responsive to interruptions of said telephone line, and a differential release relay responsive to a prolonged deënergization of said impulse relay for controlling a release circuit for said automatic selector.

23. An automatic telephone exchange system including a subscriber's telephone line, an automatic selector switch for extending a call from said line, an impulse relay responsive to interruptions in said telephone line, and a differential secondary relay controllable by said impulse relay for controlling a secondary switching circuit.

Signed by me at Chicago, county of Cook and State of Illinois, in the presence of two witnesses.

CHARLES S. WINSTON.

Witnesses:
G. E. MUELLER,
B. O'BRIEN.