April 6, 1926. 1,579,835

W. T. POWELL

AUTOMATIC TELEPHONE SYSTEM

Filed May 6, 1921 3 Sheets-Sheet 1

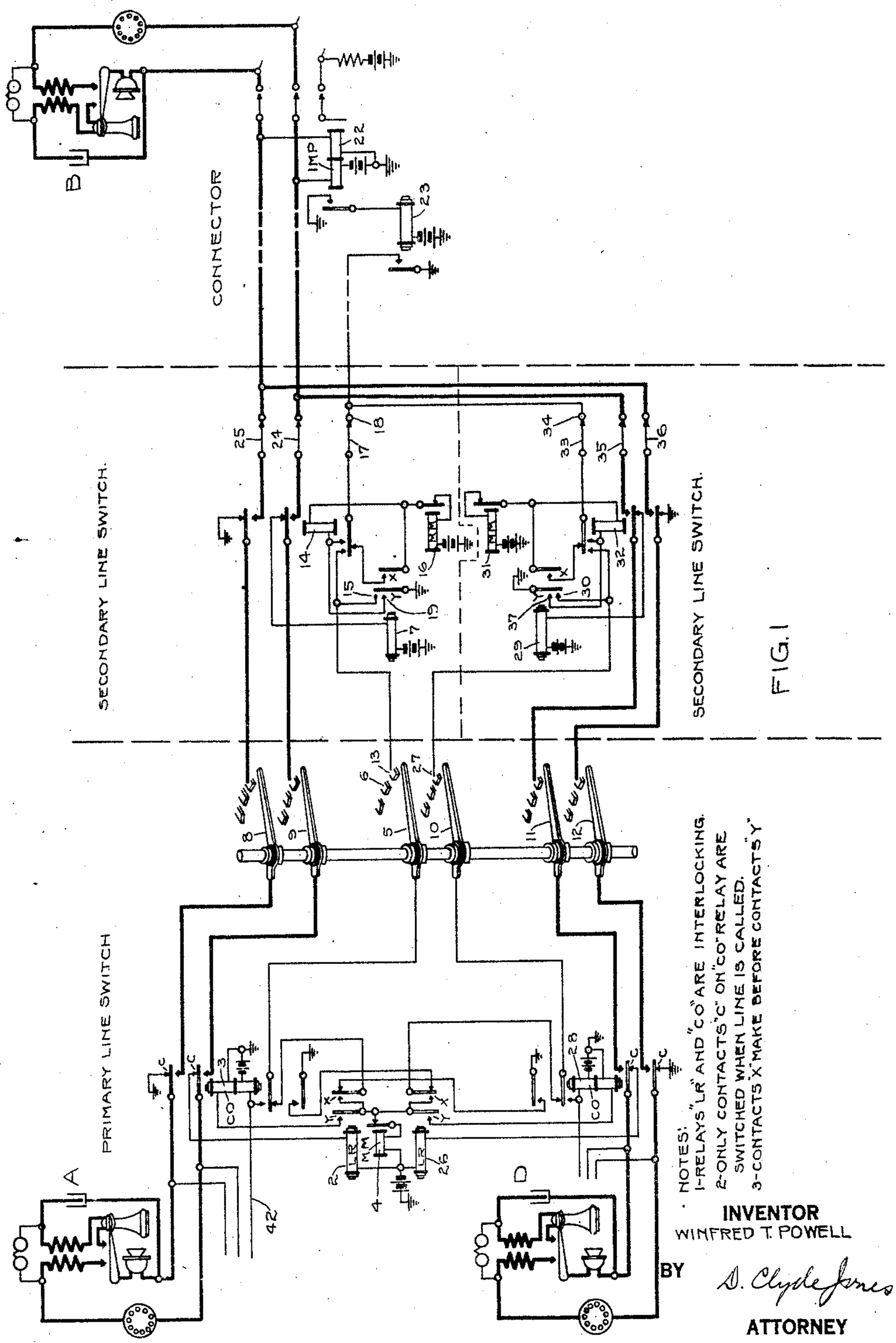

FIG. 1

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AUTOMATIC TELEPHONE SYSTEM

Filed May 6, 1921 3 Sheets-Sheet 2

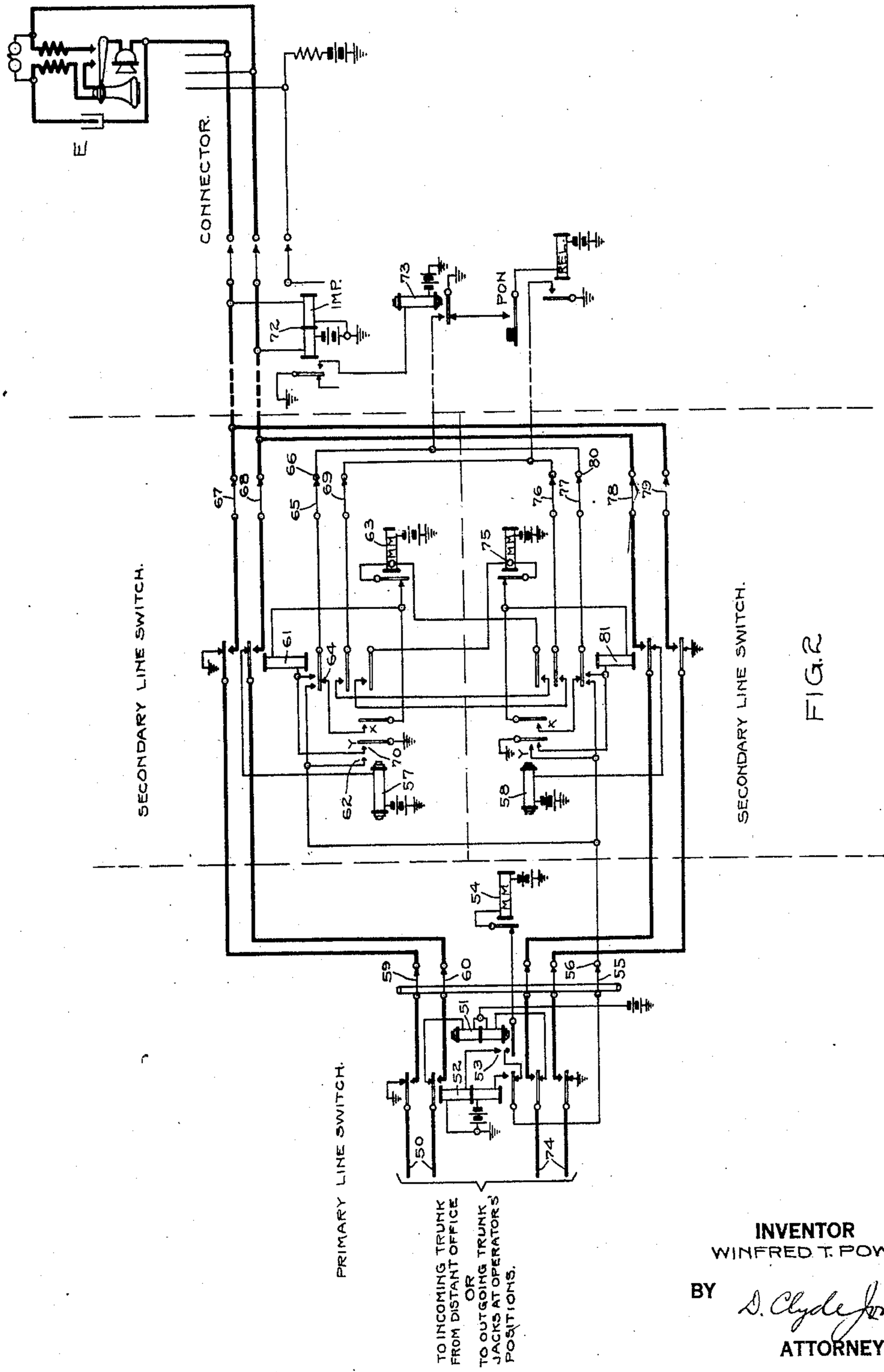

FIG.2

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Filed May 6, 1921 3 Sheets-Sheet 3

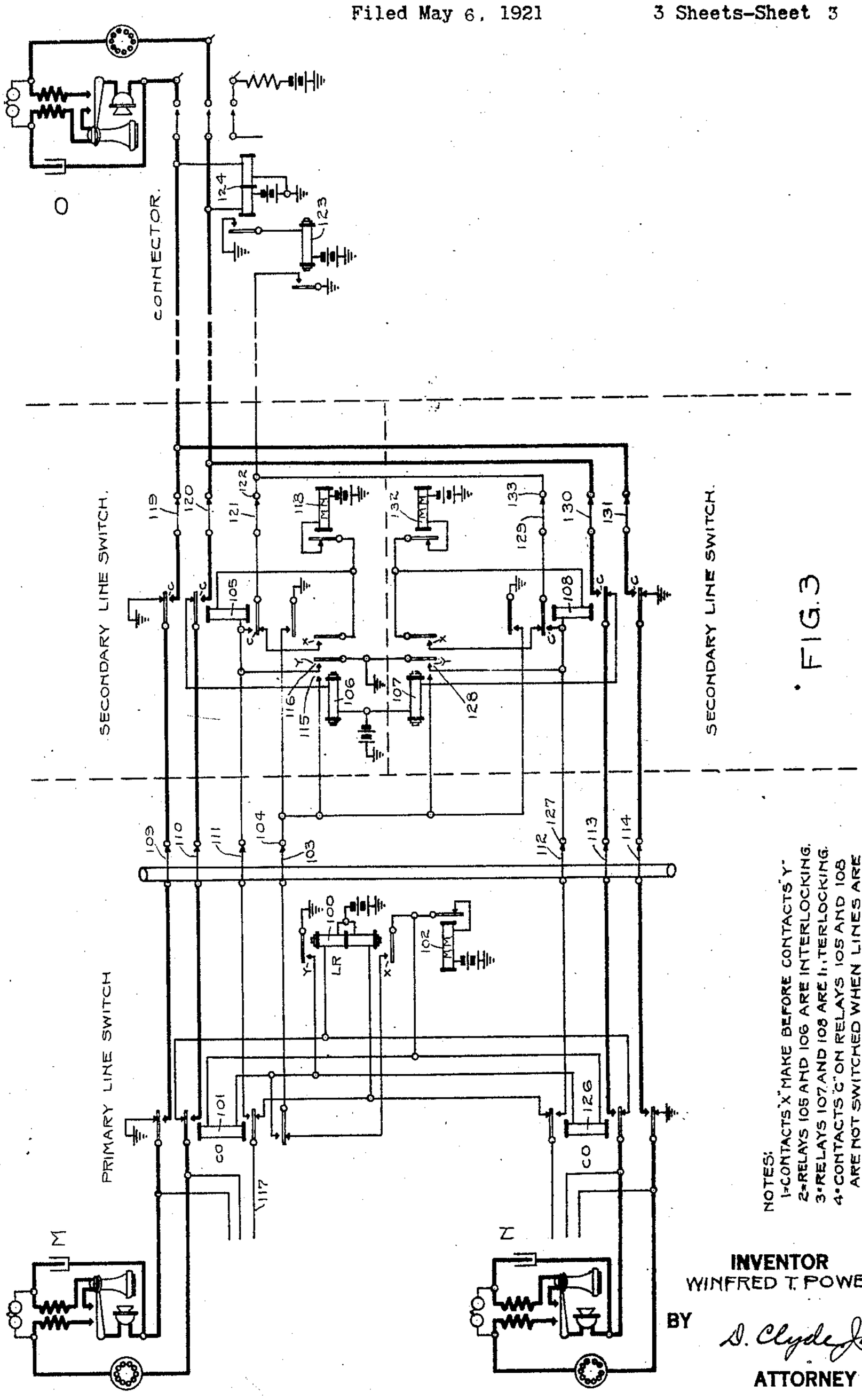

FIG. 3

NOTES:
1=CONTACTS "X" MAKE BEFORE CONTACTS "Y"
2=RELAYS 105 AND 106 ARE INTERLOCKING.
3=RELAYS 107 AND 108 ARE INTERLOCKING.
4=CONTACTS "C" ON RELAYS 105 AND 108 ARE NOT SWITCHED WHEN LINES ARE CALLED.

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UNITED STATES PATENT OFFICE.

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AUTOMATIC TELEPHONE SYSTEM.

Application filed May 6, 1921. Serial No. 467,476.

To all whom it may concern:

Be it known that I, WINFRED T. POWELL, a citizen of the United States, residing at Rochester, in the county of Monroe and State of New York, have invented certain new and useful Improvements in Automatic Telephone Systems, of which the following is a full, clear, concise, and exact description.

This invention relates to telephone systems and more particularly to telephone systems employing automatic switches in establishing telephone connections.

In former telephone systems where a non-numerical switch was employed to connect a line or trunk to a trunk, it was necessary to provide a separate switch for each of said lines or trunks. This arrangement, while efficient in operation, is necessarily expensive because of the number of switches employed.

In accordance with the present invention, it is proposed to employ a single non-numerical switch for connecting two more lines or trunks to idle trunk circuits.

In the drawings, Figure 1 diagrammatically represents the present invention employed for connecting telephone lines to idle trunks. At the left of the dotted line of Figure 1 there are represented two sub-stations connected by telephone lines to brushes of a single non-numerical or line switch. In the center portion of Figure 1 there are represented two separate line switches which are known as secondary line switches and function to further extend calling lines to idle numerical switches. At the extreme right of this figure, there is indicated a connector switch and a wanted sub-station.

In Figure 2 the invention is applied to what is commonly known as a call distributing system. At the left of the dotted line of Figure 2 there appears two incoming trunks which terminate at one end in the brushes of a single primary line switch. The other end of each of these trunks terminates at a distant office through which a calling line may be extended by automatic switches or by operators' cord circuits at operators' positions located thereat. In the center of Figure 2 there appears two secondary line switches which function to extend a trunk circuit selected by the primary line switch to an idle numerical switch which may be either a selector switch or a connector switch depending on the size of the system. At the extreme right of this figure there is indicated an automatic switch which may be a connector switch. At the extreme right of Figure 2 a wanted subscriber's line and sub-station circuits are shown.

Figure 3 represents a modified form of the invention shown in Fig. 1 and discloses primary and secondary line switches, while at the extreme right of this figure an abbreviated disclosure of the connector switch is indicated.

The line switches used in this system may be of a structure substantially similar to that disclosed in the patent to Clement 1,107,153 patented August 11, 1914, while the mentioned selector and connector switches may be substantially similar to those disclosed in Patents 815,321 and 815,176 granted to Keith, Erickson and Erickson on March 13, 1906. The line relay L. R. and the cut-off relays C. O. are arranged to be interlocking as disclosed in the patent to Lamb 1,193,160 granted August 1, 1916.

When this invention is used in a system of the character disclosed in Figure 1 that is a so-called full automatic telephone system, the subscribers' telephone lines may be arranged in groups of 100 lines each. Each group is further sub-divided into sub-groups having two lines each. For the use of each sub-group of telephone lines an individual line switch known as a primary line switch is provided and there will therefore be provided 50 primary line switches for each group of 100 lines. Each primary line switch will have access to 20 secondary line switches and these in turn will have access to 10 numerical switches. These numerical switches may be first selectors if the system is large in size or connector switches if the system is relatively small. It will be understood that the invention is not limited to this arrangement or to the number of lines or trunks individual to a primary line switch.

It is believed that the invention will best be understood by describing the method of establishing a telephone connection from a calling sub-station at A. to a wanted station indicated at B. When the calling subscriber at A. removes his receiver from its switch hook, a circuit is closed for the line relay 2 extending from grounded battery, wind-

ing of this line relay, inner, upper back contact and armature of the cut-off relay 3 over the lower side of the calling subscriber's line and through the sub-station circuits in series of the calling sub-station, over the upper side of the calling line, uppermost armature and back contact of the cut-off relay 3 to ground. The line relay 2 is energized in this circuit and closes an operating circuit for the motor magnet 4 of the line switch which circuit extends from grounded battery, winding of the motor magnet, its armature and back contact, outermost front contact and armature of the line relay 2 inner lower back contact and armature of the cut-off relay 3 through the test brush 5 and test terminals such as 6 of busy trunks to ground at the front contact and armature of slow releasing relays such as 7. The motor magnet 4 thus advances the brushes 5, 8, 9, 10, 11, and 12 in a rotary direction until the test brush 5 engages a test terminal which is characterized by the absence of potential which indicates that the trunk which is individual to this test terminal is idle.

Let it be assumed that the first idle trunk circuit tested by the primary line switch is that indicated in figure 1 at which time when the test brush 5 engages the test terminal 13 there will be no guarding potential on this test terminal due to the fact that relay 7 and relay 14 are not operated.

As a result of this condition, and since the line relay 2 has removed the obstruction from the path of the armature of the cut-off relay 3 it will be fully operated in a circuit extending from ground, through its upper winding, inner front contact and armature of the line relay 2 back contact, armature and winding of the motor magnet 4, to grounded battery. The cut-off relay 3 thus attracts its armature and at its upper armatures opens the operating circuit of the line relay 2, but this relay is of the type that is slow in releasing its armatures and therefore remains operated for a relatively short interval. At the upper armatures and front contacts of the cut-off relay 3, the calling line is extended through the brushes 8 and 9 of the primary line switch to the select trunk circuit by which a circuit is closed for energizing the slow releasing relay 7 from grounded battery which is completed through both sides in series of the extended connection including the calling line and trunk terminating at ground at the uppermost armature and back contact of the relay 14.

The relay 7 is operated in this circuit to attract its armature and through its inner armature and contact 15, it applies a guarding potential to the test terminal 13 of the trunk that has just been seized and also closes a circuit from ground through the armature of relay 7 and its contact 15, test terminal 13, test brush 5, inner lower armature and front contact of the cut-off relay 3, its lower winding to grounded battery. Under the control of this last described circuit the cut-off relay is held operated during the period that the connection is maintained.

With the relay 7 operated a circuit is closed for the motor magnet 16 of the secondary line switch which is now associated with the calling line. This circuit is traceable from grounded battery winding of the motor magnet 16, its back contact and armature, outer armature and front contact of the line relay 7, lower back contact and armature of relay 14, test brush 17, and test terminal such as 18 of busy trunks. This busy condition, as in the previous instance, is indicated by the presence of ground potential on the test terminals of busy trunk circuits. Let it be assumed that the first idle trunk circuit tested by the test brush 17 is that indicated in Figure 1, and when this test takes place the relay 14 which has been short circuited, by ground applied through the test terminal 18 and test brush 17 is now operated in a circuit completed from grounded battery, winding of the motor magnet 16 its armature, and back contact winding of the relay 14, front contact 19 and armature of the relay 7 to ground. The motor magnet 16 is not operated in this last described circuit, but the relay 14 is operated to attract its armatures and thereby interrupts the operating circuit of the slow releasing relay 7 and also functions to further extend the calling line to the brushes 24 and 25 of the selected secondary line switch and through the terminals of the selected trunk to an impulse relay such as 22 associated with the numerical switch of the trunk just seized. The impulse relay 22 of this last mentioned switch will be operated over the circuit indicated to attract its armature and close a circuit for actuating the slow releasing relay 23. This relay when operated will apply a holding ground and guarding potential to the test terminal 18 by which the relay 14 will now be locked operated in a circuit extending from grounded battery winding of the motor magnet 16, its back contact, and armature, winding of the relay 14 lower front contact and armature of this relay through the test brush 17 and the test terminal 18 to ground as mentioned.

The calling subscriber at A. will now operate his dial to transmit series of impulses to actuate the numerical switches such as the connector herein indicated to cause these switches to extend the connection to a called telephone line in the well known manner. It is not necessary in this description to outline the operation of these

numerical switches or to indicate how the called line is tested and if found idle signalled. This portion of the system may operate in the manner disclosed in the mentioned Lamb patent.

It will be noted that when the primary line switch seizes the secondary line switch the brushes of which are indicated at 17, 24 and 25, brushes 11 and 12 of the primary line switch extend the line whose sub-station is indicated at D, to the secondary line switch indicated at the lower portion of Figure 1. Thus whenever the subscriber at A. or D. initiates a call, the non-numerical switch individual to these two lines, extends them to idle secondary line switches.

Let it now be assumed that, after the calling line whose sub-station is indicated at A. has been extended through an idle secondary line switch to an idle numerical switch, the subscriber at D. now initiates a call. At the time when the receiver is removed from the switch hook at the sub-station at D the line relay 26 is energized over the two sides of the calling line in series in the manner that has been previously described in connection with the calling line A. With the line relay 26 energized a break point in the operating circuit of the motor magnet 4 is closed but since the test brush 10 is now in engagement with the test terminal 27 of a trunk leading to an idle secondary line switch, the motor magnet 4 will not be operated but the cut-off relay 28 will be energized in a circuit from grounded battery winding of the motor magnet 4, inner armature and front contact of line relay 26 lower winding of the cut-off relay 28 to ground. The cut-off relay 28 when thus energized attracts its armatures and thereby opens the energizing circuit of the line relay 26 and extends the calling line D. to the brushes 11 and 12 of the primary line switch and thence through these brushes to the selected trunk leading to the idle secondary line switch. The extension of this circuit completes an energizing circuit for the relay 29 which attracts its armatures and closes a holding circuit for the cut-off relay 28. This circuit is traceable from grounded battery upper winding of this relay, its front contact and armature through the test brush 10, test terminal 27, contact 30 and armature of the relay 29 to ground. Under the control of this circuit, the cut-off relay 28 is maintained operated during the connection. With relay 29 actuated a circuit is completed for the motor magnet 31 of the secondary line switch closed from grounded battery winding of this motor magnet, its back contact and armature outer armature and front contact of the slow releasing relay 29, upper back contact and armature of relay 32 test brush 33 of the secondary line switch and through test terminals such as 34 to ground at engaged trunk circuits leading to numerical switches. Under the control of this circuit the motor magnet 31 advances the brushes 33, 35 and 36 of the secondary line switch until an idle trunk is located which will be indicated by the absence of ground potential on its test terminal 34. When such a trunk is located, the relay 32 will be operated in a circuit extending from grounded battery winding of the motor magnet 31, its back contact and armature, winding of the relay 32, front contact 37 and armature of relay 29 to ground. It will be noted that previous to the location of this idle trunk the relay 32 was short circuited by ground on the test terminals of busy trunks so that it remained inactive. At this time, however, the relay 32 is operated and extends the primary trunk circuit to the seized secondary trunk circuit at which time an impulse relay similar to 22 is energized and this in turn actuates a slow releasing relay similar to 23 which applies ground potential to the holding trunk. The closure of this holding circuit locks the relay 32 in its actuated condition. The operating of relay 32 of course interrupts the energizing circuit of the relay 29 causing this relay to deenergize and remove the holding ground which has been applied to the test terminal 27, but at this time a substitute holding ground is applied to the test terminal 27 through the test brush 33 and the test terminal such as 34 of the trunk that has been seized.

The apparatus and circuits are now in condition to receive the impulses from the dial of the calling sub-station at D. and in response to these impulses numerical switches are operated in the well known manner to extend the calling line to the wanted station. The testing and the release operations at these numerical switches will take place in the manner now well known.

At the termination of the conversation when the calling subscriber at station A. replaces his receiver on its switch hook the impulse relay 22 of the final numerical switch will deenergize and shortly afterwards this will effect the deenergization of the slow releasing relay 23. This relay when it retracts its armature removes the holding ground which has been applied to the test terminal 18 as a result of which the relay 14 and cut-off relay 3 will de-energize and since the non-numerical switches of this system are of the "stay-put" type they will remain in engagement with the trunk circuits last used. The apparatus is now in condition to care for succeeding calls.

Let it be supposed that it is desired to call station A. When a connector switch such as that shown at the right of Figure 1, tests the line leading to station A, it engages a test terminal connected to conductor 42. If this

wanted line is engaged as a calling line, ground potential is applied through the innermost front contact and armature of the cut-off relay 3 and test brush 5. If this line is idle it will be seized and the cut-off relay energized in a circuit including its lower winding and conductor 42. At this time the line relay 2 has not been operated so that its armature will prevent the complete attraction of the armatures of cut-off relay 3 and thus only its contacts *c* are opened.

Let it be assumed that when the subscriber at substation A initiates a call, the trunk terminating in the secondary line switch brushes 35 and 36 has been seized by another telephone line terminating at a substation similar to D. Under this condition when the test brush 5 engages the test terminal 13 corresponding to the pair of trunks terminating in secondary line switch brushes 24, 25, 35 and 36, the line switch of Fig. 1 is prevented from seizing this pair of trunks one of which has already been seized. The guarding condition on test terminal 13 is applied as follows:—Since it is assumed that the line corresponding to that terminating at substation D has seized a trunk while the line corresponding to that terminating in substation A is idle, then ground is applied through the upper armature and front contact of a relay similar to 28, outer armature and back contact of a relay similar to 2, inner, lower back contact and armature of a relay similar to 3 and through a test brush similar to 5 at the primary line switch which has seized one of this pair of trunks to test terminal 13. In this manner the primary line switch of Fig. 1 is prevented from seizing a pair of trunks one of which has already been seized.

Figure 2 shows the same principle applied to the distribution of calls from the incoming trunks to the other trunk circuits. In this arrangement the incoming trunks may terminate at a distant automatic office or may terminate at jacks in operators' positions at distant offices. In this arrangement two incoming trunks terminate in the brushes of a primary line switch and this switch functions as soon as one of these incoming trunks is seized to select an idle secondary line switch.

It is believed that the operation of the system disclosed in Figure 2 will best be understood by describing the method of extending an incoming trunk circuit to a wanted station, such as that indicated at "E".

Let it be assumed that a calling line (not shown) has been extended, either manually or automatically to the incoming trunk circuit whose conductors are designated by the numeral 50. As soon as this portion of the connection has been extended a circuit is completed for the slow release relay 51 extending from grounded battery, its upper winding, inner upper back contact and armature of the relay 52, over the lower side of the incoming trunk 50 to the distant office and over the upper side of this trunk 50 to ground at the uppermost armature and back contact of relay 52. The relay 51 is energized in this circuit to attract its armature and thereby completes an operating circuit for the motor magnet 54. This circuit may be described as extending from grounded battery, winding, armature and back contact of this magnet armature and front contact of relay 51, innermost lower back contact and armature of the relay 52, test brush 55 of the primary line switch and test terminal 56 which is common to a pair of trunk circuits leading to secondary line switches and thence to ground as will be described. It will be pointed out further in this description that whenever a trunk circuit is seized, a relay such as 57 or 58 is energized to apply ground potential to its terminal, such as 56 individual to this pair of trunk circuits.

Let it be assumed that the first pair of idle trunks tested by the primary line switch are those shown in Figure 2. As a result of this idle condition, guarding potential will be absent from the test terminal 56. As a result of which the operating circuit of the motor magnet 54 is incomplete and this magnet will stop the brushes of the switch in engagement with the terminals of the pair of trunks here shown.

At this time the relay 52 which has been short circuited is now operated in a circuit completed from ground, upper winding of the relay 52, contact 53 and armature of relay 51; back contact armature and winding of the motor magnet 54 to grounded battery.

The relay 52 is operated in this circuit but the marginal motor magnet will not be energized in series with this last named relay. As soon as the relay 52 is operated it interrupts the operating circuit of the slow releasing relay 51 but this relay remains energized for a short period to maintain the original operating circuit of the relay 52. At the upper armatures and front contacts of the relay 52, a circuit is completed through the brushes 59 and 60 of the primary line switch and through the upper armatures and back contacts of the relay 61 to ground and through the winding of slow releasing relay 57 to grounded battery. The relay 57 is operated in this circuit and at its inner armature and contact 62 it applies ground potential to the test terminal 56 of the selected pair of trunks to prevent them from being seized by other primary line switches. Also this ground potential is extended through the test brush 55 and the innermost armature and front contact of relay 52, lower winding of this

relay to grounded battery. This last described circuit locks the relay 52 operated as long as the connection is maintained.

As soon as the relay 57 is operated it completes an energizing circuit for the motor magnet 63, this circuit being completed from grounded battery, winding of this magnet, its armature and back contact, outermost armature and front contact of relay 57, contact 64 and armatuure of relay 61, test brush 65 to ground at test terminals, such as 66 of busy trunks terminating at the secondary line switch. It will be noted at this time that the relay 61 is short circuited by this last described circuit. The motor magnet, however, is operated and advances its brushes 65, 67, 68 and 69 until the test brush 65 engages a test terminal 66 characterized by the absence of potential which condition indicates that this trunk is idle. When such an idle trunk is reached the operating circuit of the motor magnet 63 is no longer completed and the short circuit about the relay 61 is no longer effective so that this relay is now energized in a circuit closed from grounded battery, winding, armature and back contact of the magnet 63, winding of relay 61, contact 70 and armature of relay 57 to ground. When the relay 61 is thus operated to attract its armatures, the energizing circuit of the relay 57 is interrupted and since this relay is slow releasing in its characteristics it will remain operated for a short interval to maintain the energizing circuit of the relay 61. At the uppermost armatures and front contacts of relay 61, the connection is further extended to the brushes 67 and 68 and through both windings in series of impulse relay 72 associated with the first numerical switch to ground and battery. This relay is energized in this circuit and effects the operation of the slow releasing relay 73 which operates in the well known manner to apply a holding ground to the trunk circuit just seized and further to prevent the release of the selected numerical switch.

As soon as the relay 73 is operated, the holding circuit for the secondary line switch is completed from ground at the armature and front contact of the relay 73 through the test terminal 66 test brush 65, innermost lower armature, front contact and winding of relay 61, back contact armature and winding of the motor magnet 63 to grounded battery. It will also be noted that this circuit serves to apply ground potential to the test terminal 66 to insure that the connection will not be disturbed at this point.

The apparatus disclosed in Figure 2 is now in condition to be directively operated in response to directive impulses transmitted from the distant office over the incoming circuit. In response to these impulses the numerical switches such as selectors and connectors will be directively operated to extend the connection to the wanted telephone line, the sub-station of which is indicated at E. The arrangement and operation of these numerical switches may be similar to that disclosed in the mentioned patent to Lamb, and for this reason it is not necessary to describe the operation or the manner in which the wanted line is tested and, if idle, signalled. It is sufficient to state that at the termination of the conversation when the incoming trunk circuit is opened either by the removal of the operator's calling plug at the distant office (not shown) in the manual system or by the operation of the repeater (not shown) in a full automatic system, relays such as 72 and 73 associated with the final numerical switch are released to remove the holding ground from the test terminal 66 so that the relay 61 will de-energize. Similarly the holding circuit of the relay 52 which was extended through the test terminal 56 is also opened so that the relay 52 also de-energizes. Since the primary line switches and the secondary line switches in this arrangement are also of the "stay-put" type, they remain in engagement with the trunks last used.

It will thus be seen that whenever a call is extended over the incoming trunk circuit 50 or the incoming trunk circuit 74 the primary line switch individual to these two trunk circuits is operated to extend these circuits to an idle pair of trunk circuits leading to secondary line switches.

If the call originates over the incoming trunk 74 instead of over trunk 50, the relay 51 is energized in a circuit completed through its lower winding and over both sides of the incoming trunk circuit in series to ground. With relay 51 operated the motor magnet 54 advances the brushes of the primary line switch as in the manner already described.

Let it be assumed that the incoming trunk circuit 50 has been extended to the secondary line switch shown in the upper portion of Figure 2 and that a call is then extended over the incoming trunk circuit 74. The relay 51 will not be energized since its operating circuit is open at the innermost lower contact and armature of relay 52 and therefore the motor magnet 54 will not be actuated so that the primary line switch is not moved from the pair of trunks already seized. The relay 58 will then be operated to close an energizing circuit for the motor magnet 75 of the secondary line switch shown in the lower portion of Figure 2. This motor magnet will then be operated in the manner described in connection with the other secondary line switch of this disclosure to advance its brushes 76, 77, 78 and 79 until its test brush 77 encounters a test terminal similar to 80 which is characterized by the absence of a guarding potential at which time the

motor magnet 75 will cease to operate and the relay 81 will attract its armatures to extend the incoming trunk 74 to the trunk circuit that has just been seized.

The operation of releasing the connection over the incoming trunk circuit 50 will be ineffective to disturb the connection over the incoming trunk circuit 74 since the holding circuit for the primary line switch is controlled over parallel holding circuits independently controlled at the numerical switches in succession of the extended connections.

In the event that both the secondary line switches of Figure 2 are in use simultaneously and if one of these line switches is to be released before the other, a different releasing arrangement is provided from that previously described. It will be noted that when the relays 61 and 81 of the secondary line switches of Figure 2 are energized, indicating that these switches are in use, a circuit is completed from ground, at the armature and front contact of relay 73, test terminal 66, test brush 65, innermost armature and front contacts of relay 61 and through the innermost, upper, front contacts and armature of relay 81, winding of this relay, back contact, armature and winding of the motor magnet 75 to grounded battery. It will thus be seen that if it is desired to release the secondary line switch at the lower portion of Figure 2 while the relay 61 of the upper secondary line switch is operated, some means must be provided to release the relay 81. This is accomplished in the following manner. When the release magnet R. E. L. associated with one of the numerical switches such as the connector switch, is operated, it completes a circuit from ground, its armature and front contact, test brush 76, middle upper armature and front contact of relay 81, lowermost front contact and armature of relay 61 winding of the motor magnet 75 to grounded battery. This last described circuit is effective to short circuit the relay 81 causing it to deenergize and release the secondary line switch. Similarly if the secondary line switch at the lower part of Figure 2 is in use when it is desired to release the secondary line switch at the upper portion of this figure, a similar circuit is completed to the brush 69 of that line switch to effect the deenergization of relay 61.

In the modified form of the invention shown in Figure 3 this principle is applied to a full automatic system in which one line relay is provided for each pair of telephone lines, likewise also, the interlocking line and cut off relays such as L. R. and C. O. of Figure 1 have been associated with secondary line switches, so that their number is greatly reduced. With this brief outline of the system of Figure 3 it is believed that the operation of the same will be best understood by describing the method of establishing a telephone connection from the sub-station such as M to a wanted substation such as that indicated at O. When the subscriber removes his receiver from its switch hook a circuit is completed for the line relay 100, extending from grounded battery upper winding of this relay, innermost back contact and upper armature of the cut off relay 101, over the lower side of the calling line, and through the sub-station circuits in series and over the upper side of the calling line to ground at the uppermost armature and back contact of the cut-off relay. The line relay is thus energized and at its lower armature and front contact closes a break-point in the operating circuit of the motor magnet 102. In the event that the brushes of the line switch are in engagement with busy trunk circuits the test brush 103 of the line switch will be in engagement with the test terminal such as 104 common to a pair of trunk circuits which is characterized by the presence of ground potential. When the line relay 100 is thus energized to close the mentioned break point and with the test brush 103 in engagement with a busy test terminal, an operating circuit is closed for the motor magnet 102 from grounded battery winding of this magnet, its back contact and armature, lower armature and front contact of the line relay 100 lowermost back contact and armature of the cut-off relay 101, test brush 103, test terminal 104 to ground, at the front contacts and armatures of some one of the relays 105, 106, 107 or 108. Under the control of this circuit the motor magnet 102 advances its brushes 109, 110, 111, 103, 112, 113 and 114 until the test brush 103 encounters a test terminal, 104 which is characterized by the absence of ground potential indicating that its associated trunks are idle. When such test terminal is reached the operating circuit of the motor magnet 102 will no longer be completed and the primary line switch will be stopped with its brushes in engagement with the selected trunk circuits. At this time a circuit is completed from grounded battery winding of the motor magnet 102 its back contact and armature, winding of the cut off relay 101, upper front contact and armature of the line relay 100 to ground. The cut off relay is energized in this circuit and at its upper armatures and back contacts it interrupts the operating circuit of the line relay 100, but this relay is of the slow releasing type and therefore holds its armatures operated for a relatively short interval to maintain the initial energizing circuit of the cut off relay 101. At the uppermost armatures and front contacts of the cut off relay, the conductors of the calling line are extended to the brushes 109 and 110 of the

primary line switch and through the terminals with which these brushes are in engagement to the two sides of the selected trunk and thence to ground at the uppermost armature and back contact of relay 105 and to grounded battery through the inner upper armature and back contact of relay 105 and the winding of slow releasing relay 106. The relay 106 is energized in this circuit to attract its armatures and at its inner armature and contact 115 it closes a holding circuit for the primary line switch extending from ground through contact 104, test wiper 103, lower armature and front contact of the cut off relay 101, winding of this relay, armature, back contact and winding of the motor magnet 102 to grounded battery. The closing of the inner armature and contact 116 of relay 106 applies a guarding potential to the line switch brush 111 and through the front contact and inner lower armature of the cut off relay 101 to the conductor 117 leading to the multiple contacts of the calling line at the various connector switches through which it may be reached as a called line. At the outer armature and front contact of relay 106 a break point is closed in the operating circuit of the motor magnet 118 of the selected line switch and in the event that the brushes 119, 120, and 121 of this line switch are in engagement with a busy trunk leading to an engaged numerical switch the test terminal such as 122 of this trunk will be characterized by the presence of ground potential applied from the armature and front contact of a relay similar to 123 at some one of the numerical switches in the connection. As long as the test brush 121 is testing busy trunks an operating circuit is closed for the motor magnet 118 from grounded battery winding of this magnet, its back contact and armature, outer armature and front contact of relay 106, back contact and armature of relay 105, test brush 121 and test terminal such as 122 of the busy trunk to ground at the front contact and armature of a relay similar to 123. Under the control of such operating circuits the motor magnet 118 advances its brushes 119, 120 and 121 of the secondary line switch until an idle trunk is located.

Let is be assumed that the first idle secondary trunk tested is that appearing in Figure 3, under which assumption when the test brush 121 engages the test terminal 122 due to the absence of the ground potential on test terminal 122 the operating circuit of the motor magnet 118 will no longer be completed so that it will stop the line switch with its brushes in engagement with this selected trunk.

It will be noted that as soon as the relay 106 is actuated a circuit is closed from grounded battery through the winding of the motor magnet 118, its back contact and armature, winding of the relay 105, front contact 116 and armature of relay 106 to ground, but this last described circuit is ineffective to operate relay 105 because of the short circuit completed through the test brush 121 as long as the secondary line switch is testing busy trunks. When, however an idle trunk is located this short circuit is no longer complete and the relay 105 attracts its armatures. At its upper armatures and back contacts it opens the initial energizing circuit of the relay 106 but since this relay is slow releasing it holds its armatures attracted for a relatively short interval after its operating circuit is broken. At the uppermost armatures and front contacts of relay 105 the connection from the calling line previously established, is now extended through the secondary line switch brushes 119 and 120, over the two sides of the selected trunk and the winding of the impulse relay such as 124 of the succeeding numerical switch to ground and battery. Relay 124 is energized in this circuit and effects the operation of slow releasing relay 123 which attracts its armature to apply ground potential to the test terminal 122 of the selected trunk and also completes a holding circuit through its brush 121, inner lower armature and front contact of relay 105 winding of relay 105 armature back contact and winding of the motor magnet 118 to grounded battery.

It will be noted that the holding circuit for the primary line switch is now completed to ground through the front contact and armature of the relay 105. The apparatus is now in condition to receive directive impulses from the dial sender at the calling substation but it is not necessary to describe the operation of the numerical switches such as the connector herein shown to establish the wanted connection, since such operation is now well known in the art and may be similar to that outlined in the mentioned patent to Lamb.

Let it be assumed that the subscriber at substation N. desires to establish a telephone connection during the time that substation M is calling.

Under the conditions assumed the cut off relay 126 of the calling line N is in operated condition since it was energized in multiple with the cut off relay 101, as soon as that relay was operated. Also the brushes 113 and 114 of the primary line switch will be in engagement with the terminals of the selected primary trunks since the previously mentioned operation of the primary line switch was effective to select a pair of idle trunks. When the subscriber at N removes his receiver from its switch hook the slow releasing relay 107 of the secondary line switch will be immediately energized in a circuit closed from grounded

battery, winding of this relay, inner lower armature and back contact of relay 108 and through the two lines of the selected primary trunk and calling line in series to ground at the lowermost armature and back contact of relay 108. Relay 107 at its inner armature and contact 128 applies a guarding potential through terminal 127, brush 112 upper front contact and armature of the cut off relay 126 through the multiple terminals (not shown) of the calling line at a group of connector switches. Also at this time the motor magnet 132 of the secondary line switch is operated in a circuit completed from grounded battery, winding of the motor magnet 132, its back contact and armature, outer armature and front contact of relay 107, inner upper back contact and armature of relay 108, test brush 129 and test terminals such as 133 of busy trunks to ground at the front contact and armature of a relay such as 123 at the succeeding numerical switch. When such an idle secondary trunk is located it will be characterized by the absence of ground potential at its test terminal and the operating circuit of the motor magnet 132 will no longer be complete so that the secondary line switch will stop its brushes 129, 130 and 131 in engagement with the terminals of an idle secondary trunk. The relay 108 which has been short circuited during the operation of the secondary line switch is now energized from grounded battery winding of the motor magnet 132 its back contact and armature winding of relay 108 contact 128 and armature of relay 107 to ground. As soon as the relay 108 is energized in this circuit it is locked operated through its innermost upper front contact and armature, test brush 129 and test terminal similar to 133 to ground at the front contact and armature of the relay similar to 123 at the selected numerical switch.

When a calling subscriber such as M decides to terminate the connection, he replaces his receiver on its switch hook at which time a relay such as 124 of the final numerical switch has its operating circuit interrupted and deenergizes to effect the release of a relay such as 123 which has been holding the connection. The relay 123 on deenergization removes the holding ground from the test terminal such as 122 which causes the relay 105 of the secondary line switch to retract its armatures. When relay 105 releases, it removes the holding ground which has been applied through its lowermost armature and front contact, over the holding terminal 104 to deenergize the cut off relay 101. Since the line switches of this modification are also of the so-called "stay-put" type their brushes remain in engagement with the terminals of the trunks last used.

Let it be assumed that it is desired to call the line terminating at substation M. When a connector switch (not shown) seizes this line, ground at the connector will be applied to the conductor 117 so that a circuit is completed through the lower winding of the line relay 100 to grounded battery. The line relay 100 is energized in this circuit and if the two sets of brushes of the primary line switch are in engagement with busy trunk terminals the motor magnet 102 will advance the brushes of the primary line switch until idle trunks are located by the test brush 103 at which time the cut off relay 101 of the called line will be operated in the manner already described. As soon as the contacts of relay 101 are thus operated the test conductor 117 is extended through its inner lower armature and front contact, line switch brush 111, winding of relay 105, armature, back contact and winding of the motor magnet 118 to grounded battery, and since the relay 106 has not been operated prior to the operation of relay 105, this last named relay although energized will operate all its contacts except these marked *c*. It will thus be seen that the relay 106 will not be operated when the called party removes his receiver from its switch hook and likewise the brushes 119 and 120 of the secondary line switch are not connected to the called line. The cut off relay 101, however, is locked operated through the test brush 103 to ground at the lowermost front contact and armature of relay 105.

At the termination of the call to the line M. when the calling subscriber releases the connector, ground potential will be removed from conductor 117 so that the relay 105 will release and at its lowermost armature and front contact open the holding circuit of the cut off relay 101.

It will be understood that the arrangements disclosed in this application are merely typical of applicant's invention and the same may be widely varied within the scope of the appended claims without departing from the spirit of the present invention.

What is claimed is:—

1. In a telephone system, an automatic switch provided with sets of brushes and fixed terminals, a plurality of independent incoming circuits, one incoming circuit terminating in each set of brushes, a plurality of trunks terminating in said fixed terminals, means for rendering trunks busy, and means for operating a switch to extend its incoming circuits to idle trunk circuits in response to the initation of a call over one of said incoming circuits.

2. The method of extending circuits which

consists in arranging circuits into groups and sub-groups, arranging trunks into groups, extending all the circuits of a sub-group to seize idle trunks of a group on the imitation of a call over one of said circuits of said sub-group, and providing outlets through which said seized trunks may be extended.

3. In an automatic telephone system, a plurality of incoming circuits, a plurality of trunks, a trunk hunting switch in which several incoming circuits terminate, means responsive to a call over any of said incoming circuits for operating a trunk hunting switch to extend them to idle trunks, and means to extend said trunks separately and contemporaneously.

4. In a telephone system, a plurality of incoming circuits, a plurality of trunk circuits, a trunk hunting switch in which several incoming circuits and trunk circuits terminate, means controlled over the two sides of an incoming circuit in series for operating said trunk hunting switch to extend the incoming circuits to idle trunk circuits, and means to extend said last mentioned trunks separately and contemporaneously.

5. In a telephone system, a plurality of independent incoming circuits, a plurality of trunk circuits, means including primary and secondary line switches for interconnecting incoming circuits and trunk circuits, each primary line switch being connected to a group of incoming circuits, and means responsive to the initiation of a call over any of said incoming circuits of a group for extending all of the incoming circuits of this group to idle secondary line switches.

6. In a telephone system, a plurality of independent incoming circuits, a plurality of out going circuits, a trunk-hunting non-numerical switch in which said incoming circuits terminate and means including said non-numerical switch responsive to a call over any of said incoming circuits for extending all of said incoming circuits to idle outgoing circuits.

7. In a telephone system, a non-numerical switch provided with brushes and fixed terminals, a pair of incoming circuits terminating in said brushes, trunk circuits terminating in said fixed terminals, means responsive to the initiation of a call over either of said pair of incoming circuits for operating said switch, a single test brush for said switch, and means controlled through the same for stopping said switch in engagement with idle trunks.

8. In a telephone system, a pair of incoming circuits, a plurality of trunk circuits, a non-numerical switch individual to said pair of incoming circuits, means for advancing said switch on the initiation of a call over either of said incoming circuits for extending the same to idle trunk circuits, and holding circuits for said switch controlled at any one of said selected trunk circuits.

9. In a telephone system, a plurality of incoming circuits, a plurality of outgoing circuits, a non-numerical switch in which said incoming circuits terminate, said non-numerical switch functioning to extend said incoming circuits to idle outgoing circuits, a motor magnet for controlling the various operations of said non-numerical switch, a relay controlled over any of said incoming circuits for initiating the operation of said motor magnet, and a relay controlled over any of said outgoing circuits and held operated during a connection for disconnecting said first relay from control of said incoming circuits.

10. In a telephone system, an automatic switch provided with sets of brushes and passive terminals, a plurality of primary circuits, a primary circuit terminating in each set of said brushes, a plurality of secondary circuit terminating in said passive terminals, means for rendering said circuits busy, and means for operating a switch to extend its primary circuits to idle secondary circuits when a call is initiated over one of said circuits.

11. In a telephone system, a plurality of incoming circuits, a plurality of outgoing circuits, a non-numerical switch in which several incoming circuits and several outgoing circuits terminate, and means including a relay controllable over the two sides of any one of a plurality of said incoming circuits in series for operating said non-numerical switch to extend each of its incoming circuits to a separate idle outgoing circuit.

12. In a telephone system, a plurality of incoming circuits, a plurality of outgoing circuits, a non-numerical switch in which several incoming circuits and several outgoing circuits terminate, means including a relay controllable over the two sides of any one of a plurality of said incoming circuit in series, and a motor magnet governed by said relay for operating said non-numerical switch to extend each of its incoming circuits to a separate idle outgoing circuit.

13. In a telephone system, a plurality of incoming circuits, a plurality of outgoing circuits, a non-numerical switch in which several incoming circuits and several outgoing circuits terminate, means including a relay controllable over the two sides of any one of a plurality of said incoming circuits in series, a motor magnet governed by said relay for operating said non-numerical switch to extend all of its incoming circuits, to idle outgoing circuits and a cut-off

relay operated responsive to the extension of said incoming circuits to disable said first relay.

14. In a telephone system, a plurality of independent incoming circuits, a plurality of trunk circuits, means including primary and secondary line switches for interconnecting incoming circuits and trunk circuits, said primary and said secondary line switches being of the type that remain in the position last used, each primary line switch being connected to a group of incoming circuits, and means responsive to the initiation of a call over any of said incoming circuits of a group for extending all of the incoming circuits of this group to idle secondary line switches.

15. In a telephone system, a primary line switch having two sets of brushes and sets of fixed terminals, a telephone line terminating in each of said sets of brushes, a plurality of trunks each terminating at one end in a set of fixed terminals, a secondary line switch for the other end of each trunk, means for seizing one of said telephone lines as a called line, means responsive to such seizure for extending said called telephone lines to a secondary line switch, and a trunk release arrangement for controlling the release of operated switches.

In witness whereof, I hereunto subscribe my name this 5th day of May A. D. 1921.

WINFRED T. POWELL.