B. G. DUNHAM.

AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

APPLICATION FILED OCT. 5, 1904.

901,698. Patented Oct. 20, 1908.

7 SHEETS—SHEET 1.

Fig. 1.

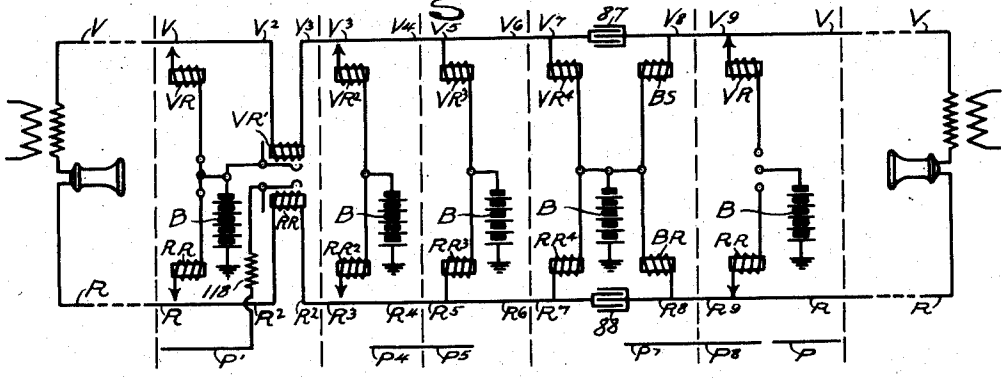
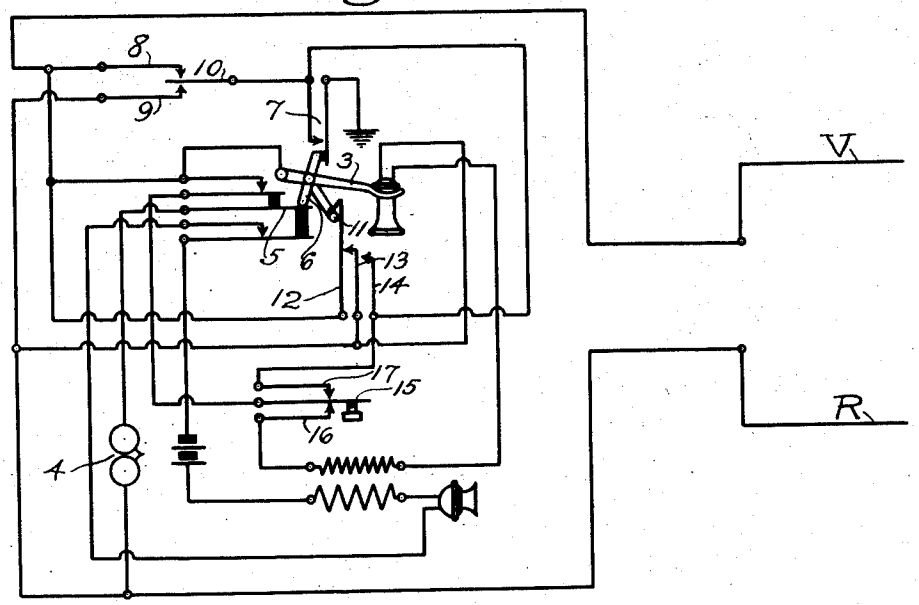


Fig. 2.



WITNESSES:

Harael C. Prado.

L. L. McMeen

B. G. Dunham,

INVENTOR.

BY Kempster B. Miller

ATTORNEY.

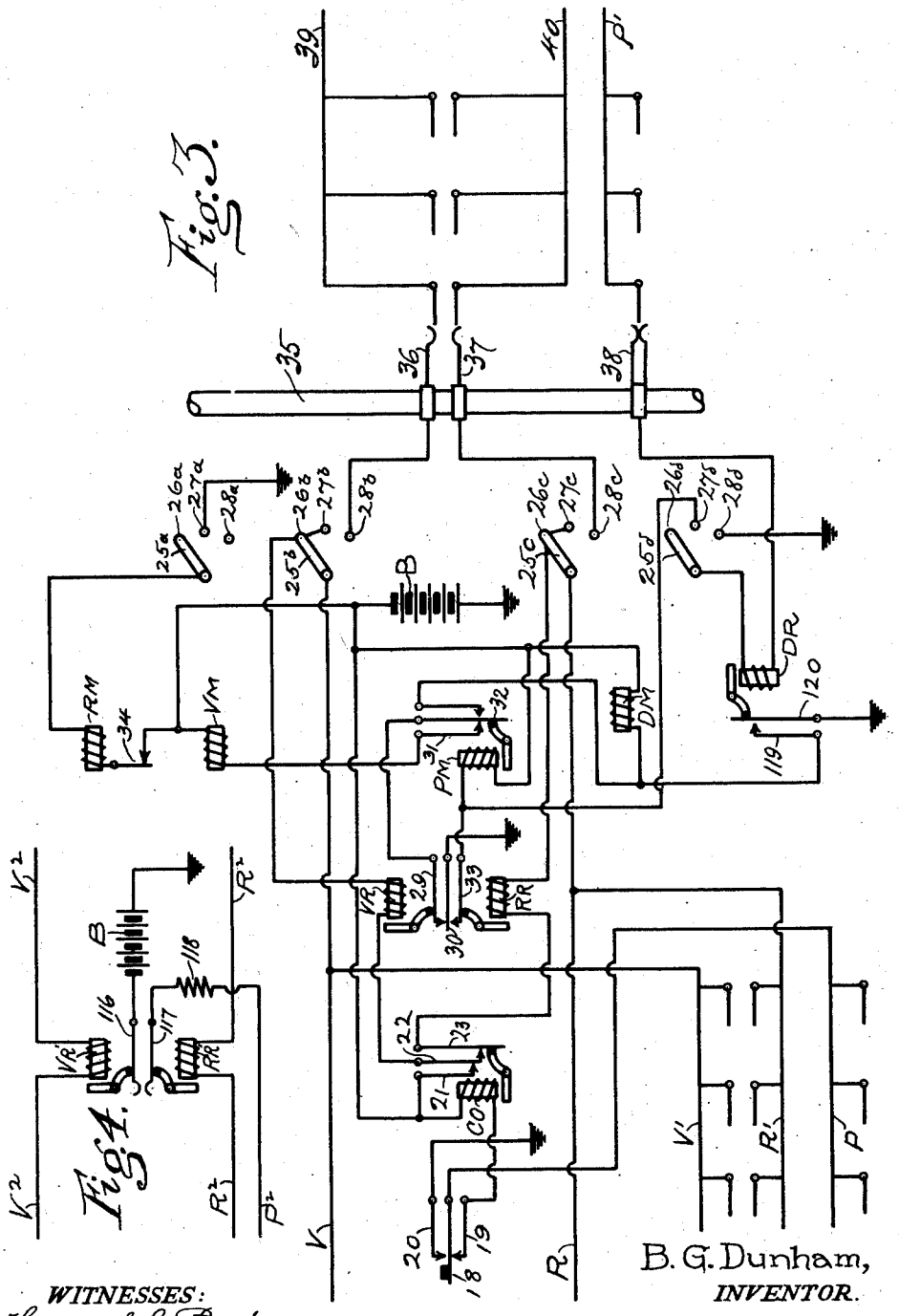
B. G. DUNHAM.

AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

APPLICATION FILED OCT. 5, 1904.

901,698. Patented Oct. 20, 1908.

7 SHEETS—SHEET 2.



WITNESSES:

Harael C. Prado

S. G. McMeen

B. G. Dunham,

INVENTOR.

BY Kempster B. Miller

ATTORNEY.

B. G. DUNHAM.

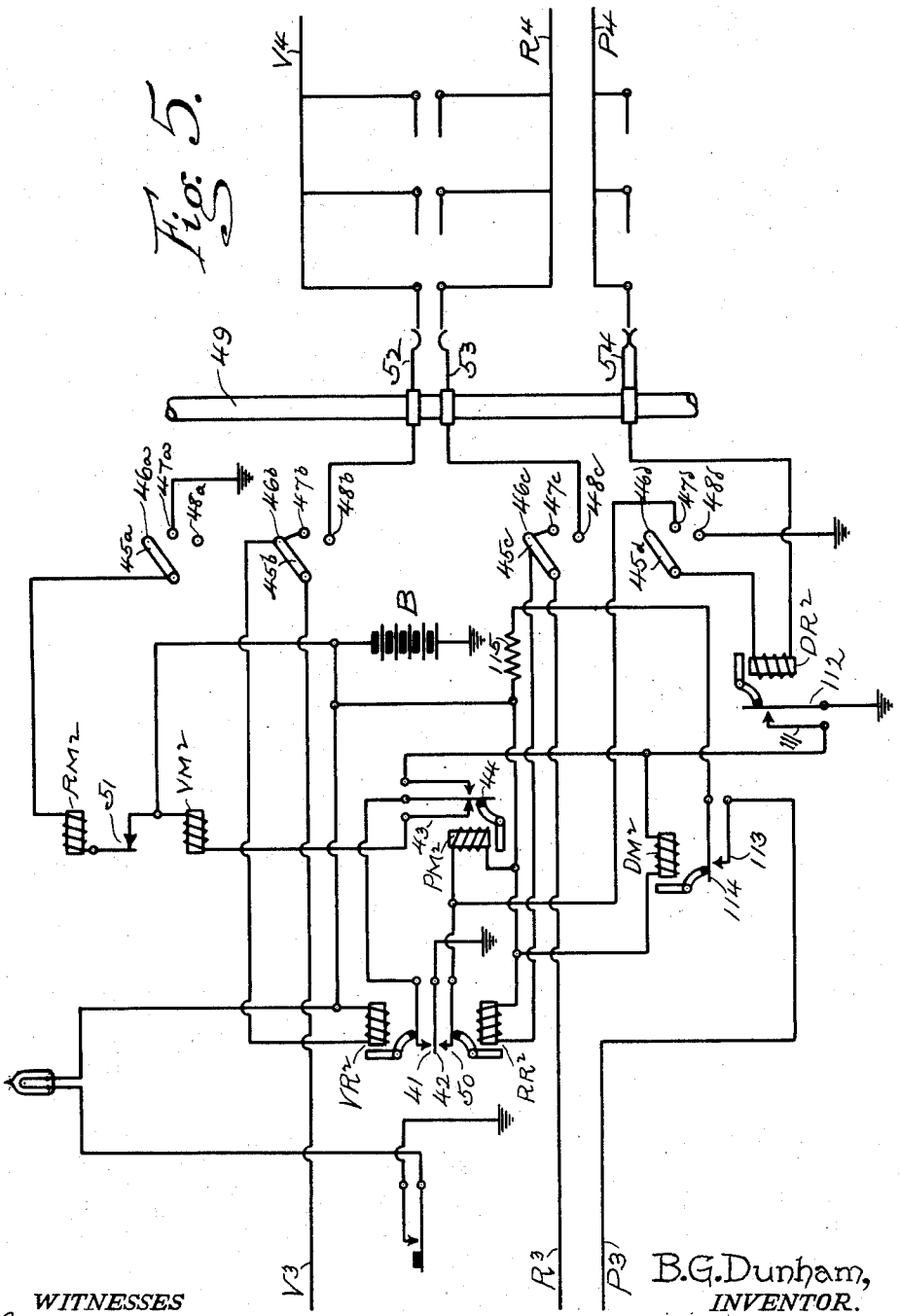
AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

APPLICATION FILED OCT. 5, 1904.

901,698. Patented Oct. 20, 1908.

7 SHEETS—SHEET 3.

Fig. 5.



B.G.Dunham,
INVENTOR.

WITNESSES
Haxael E. Prado
L. L. McMeen

BY Kempster B. Miller
ATTORNEY.

B. G. DUNHAM.

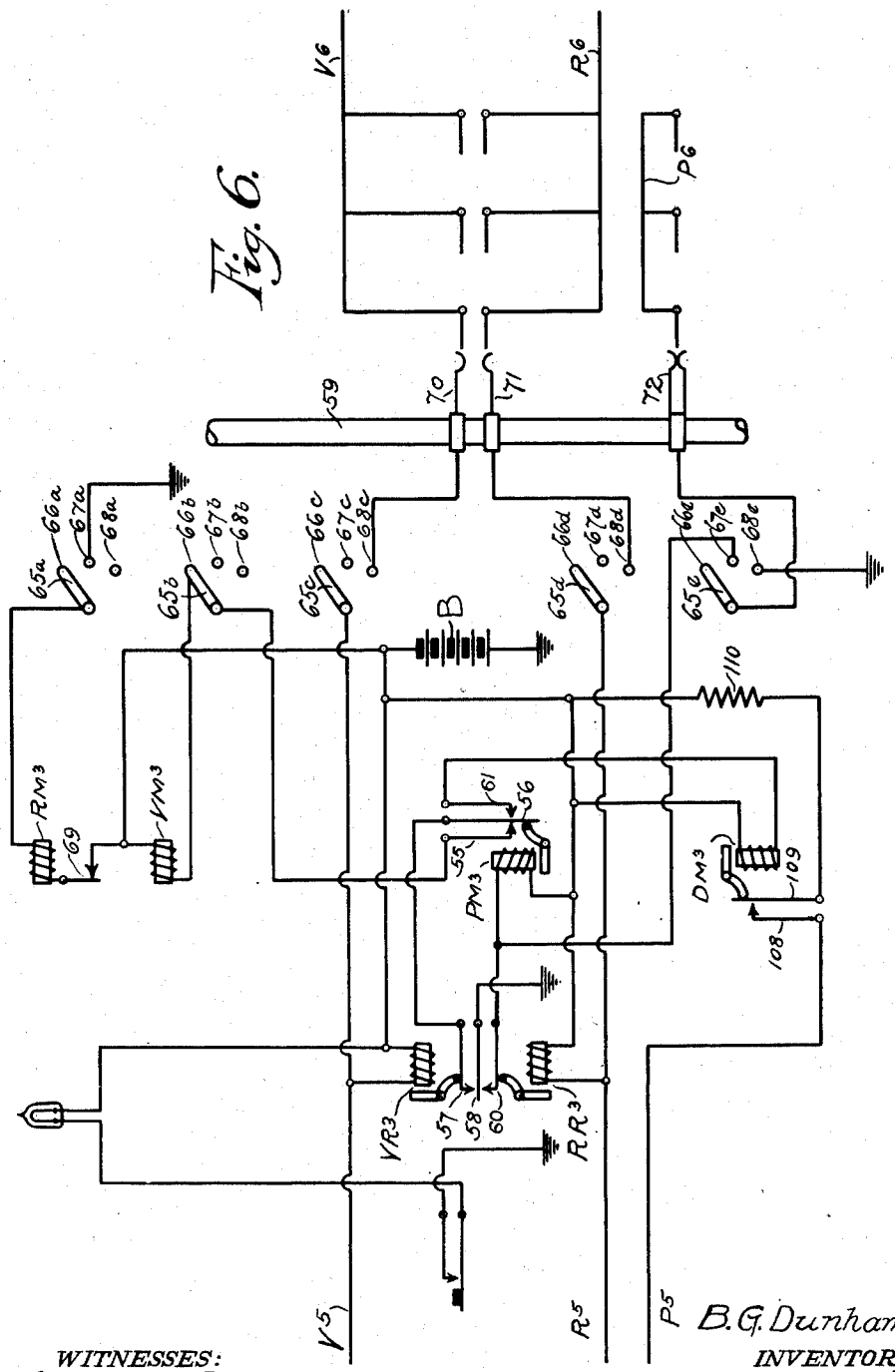
AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

APPLICATION FILED OCT. 5, 1904.

901,698. Patented Oct. 20, 1908.

7 SHEETS—SHEET 4.

Fig. 6.



WITNESSES:

Hazael C. Prado.

S. G. McMeen

B. G. Dunham,
INVENTOR.

BY Kempster B. Miller
ATTORNEY.

B. G. DUNHAM.

AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

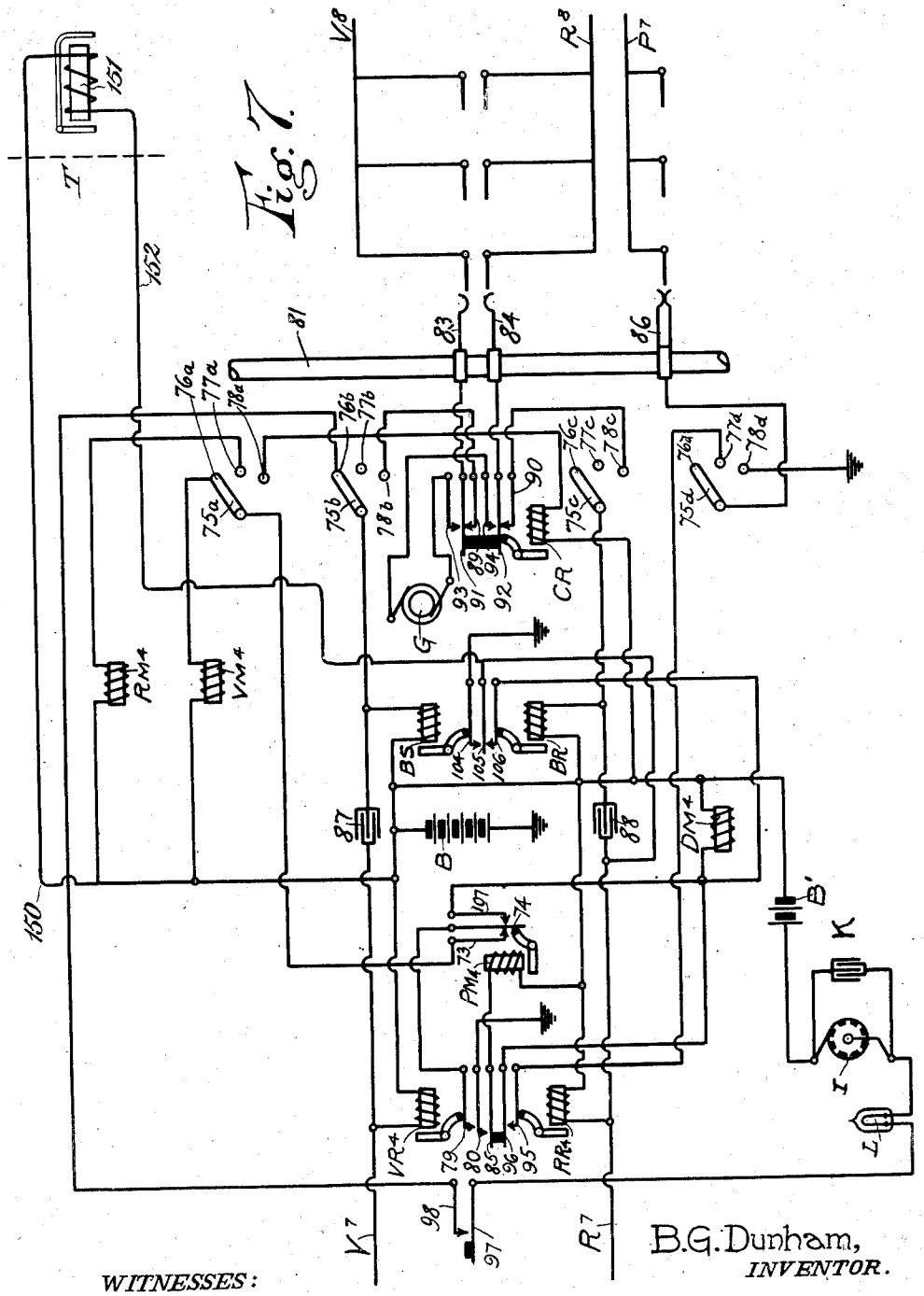
APPLICATION FILED OCT. 5, 1904.

901,698.

Patented Oct. 20, 1908.

7 SHEETS—SHEET 5.

Fig. 1.



B.G. Dunham,
INVENTOR.

WITNESSES:
Harael C. Prado
L. G. McNeer

BY Kemp Bicker
ATTORNEY

B. G. DUNHAM.

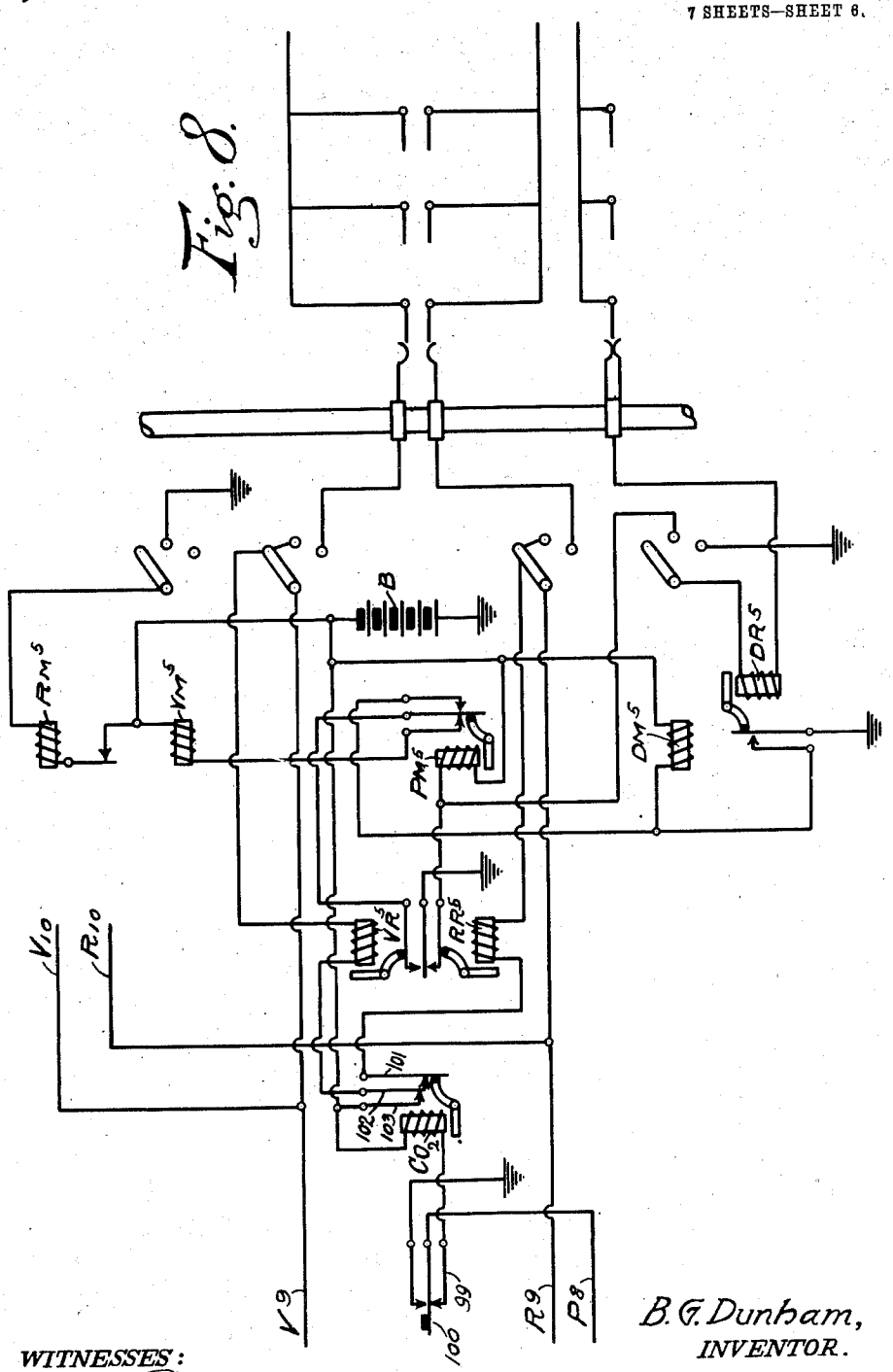
AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

APPLICATION FILED OCT. 5, 1904.

901,698. Patented Oct. 20, 1908.

7 SHEETS—SHEET 6.

Fig. 8.



WITNESSES:

Harael C. Prado

L. G. McMeen

B. G. Dunham,
INVENTOR.

BY Kempster B. Miller
ATTORNEY

B. G. DUNHAM.

AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

APPLICATION FILED OCT. 5, 1904.

901,698. Patented Oct. 20, 1908.

7 SHEETS—SHEET 7.

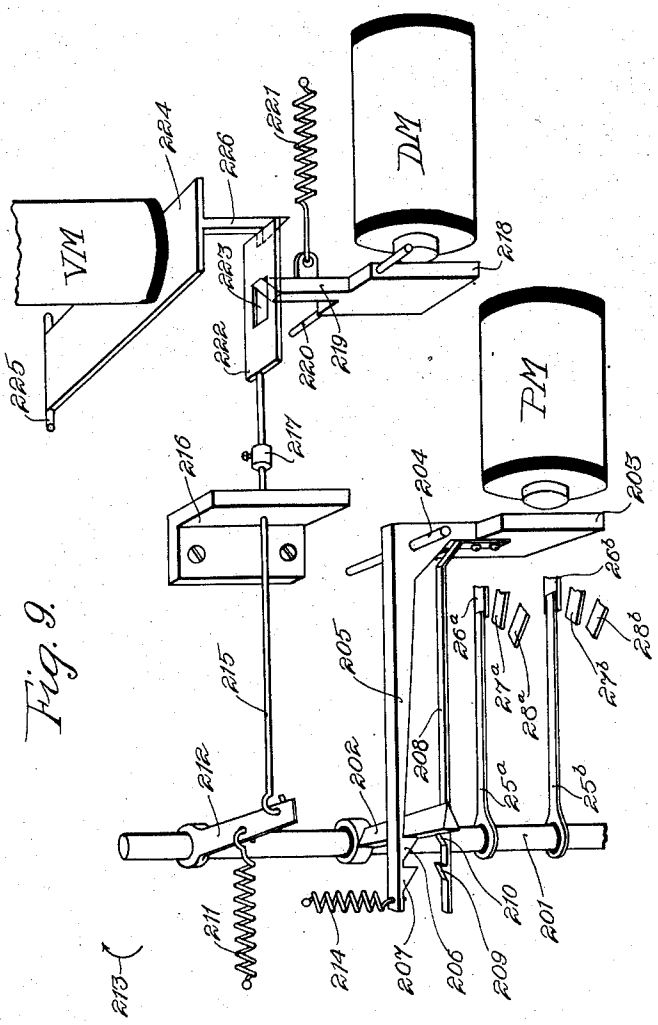


Fig. 9.

Witnesses:
Arthur H. Boettcher,
Leonard W. Novander.

Inventor
B. G. Dunham
By Charles A. Brown
Attorney

UNITED STATES PATENT OFFICE.

BERT G. DUNHAM, OF CHICAGO, ILLINOIS, ASSIGNOR TO STROMBERG-CARLSON TELEPHONE MANUFACTURING COMPANY, OF ROCHESTER, NEW YORK, A CORPORATION OF NEW YORK.

AUTOMATIC TELEPHONE-EXCHANGE SYSTEM.

No. 901,698. Specification of Letters Patent. Patented Oct. 20, 1908.

Application filed October 5, 1904. Serial No. 227,288.

To all whom it may concern:

Be it known that I, BERT G. DUNHAM, a citizen of the United States of America, and a resident of Chicago, county of Cook, and State of Illinois, have invented a new and useful Improvement in Automatic Telephone-Exchange Systems, of which the following is a specification.

My invention relates to automatic telephone exchange systems; that is, those systems wherein the connection between any two lines is made by automatic switches at the central office, these switches being directed in their action by mechanism at the subscriber's station under the control of the subscriber who desires to make a call.

In systems of the kind installed at the time of my invention, either the vertical and rotary relays of all the switches are included in series. In case it is desired to adapt the advantages of that bridging method to a system as I have described herein, having as many as five digits in the number of the subscriber, to place four sets of vertical and rotary relays in the bridge across the line would introduce certain difficulties. For instance, if these relays were bridged across the line at the first, second and third selectors, as well as at the connector, the exact and reliable operation of the relays would be more difficult to secure while being actuated by the mechanism at the subscriber's station.

In another of my inventions for which I have made application for a patent, I have arranged to place vertical and rotary relays in bridges across the line, keeping the number of such bridges at a reasonable minimum, and eliminating the existence of a large number of relays in series with the line. In that system, which is suitable in an exchange having all of the lines of its subscribers centering in one office or a plurality of offices relatively near to each other, three wires are required for each of the trunks between switch groups. It is to do away with the necessity of one of the three wires in the trunks which extend between offices in an exchange requiring a plurality of offices, or between groups of switches in the same office, which is the object of my invention, the wires of each trunk being two, that number being required for the purpose of conversation.

My invention is illustrated in the accompanying sheets of drawings, which form a portion of this application, and in which,

Figure 1 is a diagrammatic representation of the conditions which exist in a "five digit" connection; Fig. 2 shows the circuit at the subscriber's station, adaptable for use with my invention; Fig. 3 shows the circuits of a calling subscriber's selector switch; Fig. 4 shows the circuits of a pair of trunk release relays; Fig. 5, the circuits of a second selector switch; Fig. 6, those of the third selector switch; Fig. 7, those of the connector switch, Fig. 8, the circuits of a first selector switch of the line being called. Fig. 9 is a diagrammatic representation of the features of the side switch employed.

Like characters refer to like parts throughout the several views.

In Fig. 1 is shown in simplified form the talking circuit of my improved system, the stations, lines and relays being similarly lettered to the corresponding parts in subsequent figures. From this it will be seen that the vertical and rotary relays of each switch involved in the connection are adapted to be bridged across the circuit instead of connected in series therewith, and that from a point between the vertical and rotary relays in each switch there is a connection to the ungrounded pole of the battery, B. Two condensers, 87 and 88, are inserted in the respective limbs of the talking circuit at the connector switch, the purpose of which will be pointed out later on.

A single pair of series relays, VR′ and RR′, are connected in series in the limbs of the trunk circuit extending between the first and second selectors. These are adapted to control the circuit of the disconnect magnet of the first selector, this latter being placed in the private wire of that selector. The bridges at both first and second selectors are cut off, and it is due to this pair of series relays that the disconnecting action of the first selector is secured without the addition of an extra or third individual wire to the metallic circuit trunk line, extending between the first and second selectors. Two wire trunks instead of three wire trunks, may thus be made available for use in this system, when, owing to there being a plurality of central offices, it becomes necessary to make first selectors in one office operate in conjunction with second selectors and connectors in other offices.

An understanding of the circuits of the

subscriber's station adapted for use with my invention may be had by reference to Fig. 2. The talking apparatus, consisting of a receiver, transmitter and induction coil, may be connected between the vertical and rotary limbs of the lines, V and R, respectively, by the action of the hook switch, 3, in a manner well understood. Under normal conditions, that is, when the receiver is upon the hook, the bell or ringer, 4, is connected between the two sides of the line, this connection extending through the spring, 5, and the arm, 6, of the hook when the telephone is not in use. When the receiver is removed from the hook this connection is broken, and the talking contacts completed in an obvious manner. All ground connections at the subscriber's station are primarily controlled at the pair of contacts, 7, these contacts being held open as long as the receiver is on its hook, and after the receiver has been removed, until the impulse transmitting device has been put into operation.

The impulse transmitting device acts by causing the springs, 8, or 9, to engage the ground spring, 10, according to whether impulses are to be sent over the vertical or rotary sides of the line. That is, if six impulses are to be transmitted, the spring, 8, will be pressed against the spring, 10, six times, thus allowing that many impulses to flow from the central office over the vertical side of the line to ground. It is obvious from the presence of the spring, 7, that no such impulse can take place unless the receiver has been removed from its hook, and the impulse transmitter operated, for only under these conditions can the contact between springs, 7, be closed. In a similar manner an impulse over the rotary side of the line may be secured by pressing the spring, 9, against the spring, 10. It should be remembered that all selecting is done over the vertical side of the line by sending a series of impulses corresponding to the digits belonging to the number of the subscriber wanted. Each series of impulses over the vertical side of the line caused by the movements of the spring, 8, is followed by a single impulse over the rotary side of the line caused by the movement of the spring, 9.

When the hook, 3, is depressed at the close of the conversation, its arm, 11, serves to press the springs, 12, 13 and 14, momentarily into engagement with each other, thereby grounding both the vertical and rotary sides of the line through the spring, 14, and the contact, 7. The mechanical arrangement of parts is such that the springs, 12, 13 and 14, are not brought into engagement with each other as the hook rises, or while it is either depressed or elevated.

15 is the spring actuated by the ringing button, this spring normally bearing against spring, 16, and serving to hold closed the talking circuit. When, however, the ringing button is depressed, spring, 15, engages spring, 17, thereby grounding the vertical side of the line for the operation of the ringing relay at the connector switch.

Referring now to Fig. 3, the two limbs, V and R, of the subscriber's line may be seen entering at the left of the sheet. These limbs correspond with those shown in Fig. 2, leading from the mechanism at the subscriber's station. Branches of these wires extend to contacts multiplied through the banks of a group of connector switches in the office in which the first selector illustrated in this figure, is located. Accompanying this multiplied branch of the line, composed of the conductors, V′ and R′, is another conductor, P. In the selector switch under consideration, this conductor extends to the spring, 18, of the off-normal switch, which is closed into contact with the point, 19, when the selector has its shaft in the normal position. The cut-off relay, CO, has one of its terminals connected to the contact, 19, for purposes which will be described later. In all the processes of setting up a connection on the part of this first selector, the relay, CO, is not operated because the first act of the switch spring, 18, is to break contact with the point, 19, when the shaft of the selector is stepped up.

The relay, VR, has one of its terminals connected with the live pole of the battery, B, through the contact of springs, 22 and 21, of the cut-off relay. Similarly, relay, RR, has one of its terminals connected to the battery, through the contact of the springs, 23, 22 and 21. The remaining terminal of the relay, VR, is connected with the line wire, V, through contact of the lever, 25^b, with the point, 26^b; and the relay, RR, has its winding connected to the line wire, R, through the contact of the lever, 25^c, with the point 26^c.

The levers, 25^b and 25^c, are parts of a device known as a side switch, and to be described later. This side switch is illustrated diagrammatically in Fig. 9 and the same reference characters are used, where possible, as those used in the other figures. No attempt is made, in this figure, however, to illustrate associated parts which are not directly concerned in the operation of the side-switch. Thus, for example, the private magnet, PM, is shown without the contacts 31 and 32 which, in fact, are associated with this magnet as shown, for example, in Fig. 3. The rotatably mounted shaft, 201, carries the side-switch levers 25^a, 25^b, etc. only two of which are shown, however. The associated contacts are shown at 26^a, 27^a, 28^a, and at 26^b, 27^b, and 28^b. The arm, or lever, 202, having a triangular cross-section is rigidly mounted upon the shaft, 201. The

private magnet, PM, is provided with an armature, 203, pivoted at 204 and having an arm 205, extending toward the lever, 202. A spring, 211, cooperating with a spring arm, 212, tends to cause a rotation of the side-switch shaft and its switch arms in the direction of the arrow, 213. Thus upon the energization of the private magnet PM, the arm, 205, is depressed and this causes the tooth, 206, on the escapement arm to strike the top of the tooth, 210, on the spring, 208, thus forcing the spring out of engagement with the escapement arm, 202. The face of the tooth, 206, is only slightly to the left of the face of the tooth, 210, so that the substitution of the tooth, 206, to retain the escapement arm 202 in its position in place of the teeth 210 does not permit any material rotation of the side-switch shaft due to the tension of the spring, 211. When, however, the deënergization of the private magnet, PM, permits retraction of the armature, 203, due to the influence of the spring, 214, the face of the tooth, 210, will not engage the front surface of the escapement arm, 202, and this arm and shaft will be permitted to turn to the left under the influence of the spring, 211, until it strikes the face of the tooth, 209. So, also, a subsequent energization of the private magnet, PM, will first cause the tooth, 207, to be substituted for the tooth, 209, to retain the side-switch shaft in its position, and then upon the deënergization of the private magnet the side-switch shaft will be caused to move a step further in advance. The wire, 215, which is connected with the arm, 212, passes through a hole in the rigidly supported guide, 216, and is provided with an adjustable stop, 217, by means of which the forward rotation of the side-switch shaft is limited.

The restoration of the side switches and the shaft upon which they are mounted to their normal position is brought about by the energization and subsequent deënergization of the disconnect-magnet, DM. In addition to the mechanism associated with this magnet for causing restoration of the shaft, 35, to its normal position, the armature, 218, of the magnet, DM, is provided with a catch, 219. The armature is pivoted at 220 and returned to its normal position by a comparatively stiff spring, 221. The wire, 215, which is quite springy, is provided at its end with a very thin, flexible plate, 222, this plate having a suitable opening at 223. The vertical magnet, VM, is equipped with an armature, 224, pivoted at 225, and provided at its extremity with a catch, 226. The energization of this magnet, VM, raises the armature, 224, and by means of the catch, 226, it raises also the plate, 222, disengaging it from the restraining influence of the catch, 219, and making the rotation of the side-switch shaft, 201, subject only to the operation of the escapement associated with the private magnet, PM.

The restoration of the selector mechanism upon the energization and deënergization of the disconnect-magnet, DM, restores the plate, 222, to the position shown in Fig. 9. When next this particular mechanism is called into service the first energization of vertical magnet, VM, immediately releases the plate, 222, from the catch, 219, and puts the side-switch under the control of the escapement associated with the private magnet, PM.

A succession of ground contacts with the vertical wire caused by the act of the subscriber in instituting a call, will close a succession of contacts with the springs, 29 and 30, of the relay, VR. The resulting circuit will be from the battery, B, through the vertical magnet, VM, contact of the springs, 31 and 32, of the magnet, PM, to ground, at the spring, 30. This will cause as many impulses in the magnet, VM, as there are ground contacts in series at the substation, lifting the shaft vertically as many steps. Each series of vertical ground impulses at the substation is followed by one ground impulse upon the rotary wire. Under the conditions previously described, this one impulse will cause a contact of the spring, 33 of the relay, RR, with the ground spring, 30. The circuit will be established from the live pole of the battery, B, through the winding of the private magnet, PM, to the ground mentioned, operating the magnet, PM, in one impulse. Any contacts made between the springs controlled by the magnet need not be here considered. The important thing which happens is that, through the escapement associated with the armature of the magnet, PM, the side switch composed of levers, 25^a, 25^b, 25^c and 25^d, will be permitted, through the agency of a controlling spring, to advance one step, making contact of each lever upon its second point, as 25^a upon 27^a, and similarly of the other levers. By this motion of the side switch levers, a circuit will be established from the live pole of the battery, B, through the rotary magnet, RM, and the contact, 34, which its armature controls, to the ground at the point, 27^a. The mentioned contact associated with the magnet, RM, is one which is adapted to be broken by the later operation of the stroke of the armature of the magnet, similar to the action of the well-known vibrating electric bell. Current through the indicated path, therefore, will cause the magnet, RM, to vibrate its armature, and through the action of the pawls not shown in these drawings, will rotate the shaft, 35, in the arc of the bank opposite which the wipers, 36 and 37, had been brought by the before-mentioned vertical steps of that shaft. Likewise the wiper, 38, will engage contact pieces by this rotary mo-

tion in the arc of contact pieces associated with the wire, P'. The second act of the mentioned motion of the side switch to its second position, was to place the lever, 25^d, upon the contact, 27^d. The intent of this act is to provide means for stopping the rotary motion of the shaft as soon as a trunk line which is not already in use, has been selected from those over which the wipers are passing. By means to be described more fully later, the trunk line is guarded against being selected when it is busy by the existence of a ground upon the contacts of its private wire, as P'. It is also intended that the absence of the ground on such a contact will cause or permit the rotation to cease, and that trunk to be selected. Assuming that the contacts first made by the wiper, 38, upon the private contacts of successive trunk lines, found those contacts grounded, a circuit would be established from the live pole of the battery, B, through the magnet, PM, the contact, 27^d, the lever, 25^d, the relay, DR, the wiper, 38, and the mentioned grounded contact. This will energize the magnet, PM, causing it to draw up its armature; and as successive ground contacts are found, as described, the magnet, PM, will continue to hold its armature; and as it is the drawing up and falling away of the armature of the magnet, PM, which permits the escapement to advance the side switch a further step, this result will not be reached until the magnet, PM, has released its armature. Such release will occur as soon as the wiper, 38, engages a contact upon which there is no ground, and which is therefore associated with a trunk which is not busy. The resulting release of the armature of the magnet, PM, will, through its escapement, cause the side switch to advance a further step, reaching its third and extreme position. The immediate result will be, by the advance of the lever, 25^a, to the open contact, 28^a, to stop rotation of the rotary switch, 35, by the rotary magnet, RM. The selector has thus finally moved upon a trunk which is not busy, which has been the intent from the beginning. Another result of the side switch motion is to extend the lines, V and R, through the springs, 25^b and 25^c, respectively, to contacts 28^b and 28^c, respectively, to the wipers, 36 and 37, respectively. The wires, V and R, are thus effectively extended to the conductors, 39 and 40, which extend to a second selector either in the same office or in another.

In addition to its efficacy as described, the contact of the wiper, 38, upon the private conductor, P', acts, when the side switch has moved to its third position, to place a ground upon the conductor, P', through the relay, DR. This is effective in preventing incursion of another first selector upon a trunk which has thus been taken, and this position is maintained throughout the existence of the connection of this first selector with the taken trunk.

Fig. 4 illustrates the circuit of the two relays, VR' and RR', which are associated with the trunk line selected as described, extending between the first selector shown in Fig. 3, and the second selector shown in Fig. 5. It will be noticed that the winding of the relay, VR', is in series with the conductor, V^2, and that the winding of the relay, RR', is in series with the conductor, R^2. As these relays have no office to perform in the setting up of the connection, consideration of their functions will be reserved until the actions of disconnection are to be considered.

Referring to Fig. 5, the conductors, V^3 and R^3, are the extensions of the conductors, V^2 and R^2, of Fig. 4, these being also extensions of the conductors, 39 and 40, of Fig. 3. In Fig. 5, the relays, VR^2 and RR^2, have each a winding connected to the battery, B. Through the agency of levers, 45^b and 45^c, of the side switch, similar to that described with reference to Fig. 3, and their contacts, 46^b and 46^c, the other terminals of the windings of the relays, VR^2 and RR^2, are connected to the conductors, V^3 and R^3, respectively. Upon the subscriber signaling the second digit of the number of the desired subscriber, the series of ground contacts upon the wire, V^3, will actuate the relay, VR^2, in as many impulses as there are units in that digit. Contacts between the spring, 41, and the point, 42, cause the following results: Current from the battery, B, will flow through the magnet, VM^2, the contact between the springs, 43 and 44, and to ground by contact upon 41 and 42, causing as many impulses in the magnet, VM^2, as there are contacts at the relay, VR^2. Through the agency of a pawl, the shaft, 49, will be lifted in a corresponding number of vertical steps, finally stopping opposite the row of bank contacts which contains the trunks leading to the thousand in which will be found the called subscriber. But as each series of vertical contacts at the substation is followed by one ground contact on the rotary wire, such an impulse will be given and will cause the relay, RR^2, to be operated in one impulse by current through it from the battery, B, to the line wire under the existing conditions of the side switch. This contact will cause current to flow from the battery, B, through the magnet, PM^2, the spring, 50, to the ground 42. This will cause the attraction and release of the armature of the magnet, PM^2. The contacts broken and made by the springs of the magnet, PM^2, need not be here considered. The important thing to happen is that the armature in drawing up and falling back effects, by that double action, an advance of the side switch, 45^a, 45^b, 45^c and 45^d, one step through the agency of the escapement which is associated

with these levers, and the armature, of the magnet, PM^2. One result is to connect the lever, 45^a, with the point, 47^a, permitting current to flow from the battery, B, through the rotary magnet, RM^2, and its contact, 51, to ground; as described with reference to the magnet, RM, in Fig. 3, impulses will succeed each other through the magnet, RM^2, causing it to rotate the shaft, 49, in the arc of the bank contacts before which the vertical impulses had stopped the wipers, 52 and 53. Because, as before described, trunks which are busy have their private contacts grounded, the wipers, 54, will either engage grounded contacts connected to the private wire, P^4, or will engage contacts which are not so grounded. If the former, a circuit will be established from the battery, B, through the magnet, PM^2, the contact, 47^d, the lever, 45^d, the relay, DR^2, the wiper, 54, to ground. This will serve to actuate the magnet, PM^2, and if successive ground contacts or busy trunks are engaged by the wiper, 54, the armature of that magnet will not fall away. As soon, however, as a contact not grounded is engaged by the wiper, 54, the magnet, PM^2, will release its armature, and through the escapement that act will advance the side switch a further step, placing the lever, 45^a, upon the contact, 48^a, and the other levers similarly. One result of this movement is to stop further impulses in the magnet, RM^2, and further rotation of the shaft, 49. The wipers, 52 and 53, are thus left upon contacts connecting with the trunk conductors, V^4 and R^4, and the wiper, 54, upon the contacts of the private wire, P^4. But because the levers, 45^b and 45^c, respectively, are upon the contacts, 48^b and 48^c, respectively, the trunk wires, V^3 and R^3, are extended to the trunk wires, V^4 and R^4, respectively. Also contact between the lever, 45^d and 48^d, serves to place a ground through the relay, DR^2, upon the wiper, 54, and the contacts of private wire, P^4, with which it is now connected. This serves to guard the selected trunk against connection on the part of any other second selector.

Referring to Fig. 6, V^5 and R^5, are extensions of the wires, V^4 and R^4, shown leaving Fig. 5. The relay, VR^3, has one of its terminals permanently connected to the wire, V^5, and the other to battery, B. The relay, RR^3, has one of its terminals connected to the wire, R^5, and the other to the battery, B. When a subscriber operates his instrument to select with reference to the third digit of the number he is calling, a series of ground contacts will be made with the vertical wire at his station, which wire is now extended to the wire, V^5, and this will cause, by current flowing through the relay, VR^3, a series of contacts between the springs of that relay. Current will then flow from the battery, B, through the vertical magnet, VM^3, lever, 65^b, contact 66^b, the contact of springs, 55 and 56, to the contact between the relay springs, 57 and 58 to ground. The vertical magnet, VM^3 will thus be actuated in as many steps as there are units in the digit called, lifting the shaft, 59, as many steps, stopping it opposite that arc of the bank contacts which contains trunks to connector switches serving the group of 100 subscribers containing the called one. As a ground contact upon the rotary wire at the substation always follows a series of vertical ground contacts, such a succeeding impulse will actuate the relay, RR^3, operating its springs. Current will then flow from the battery, B, through the magnet, PM^3, to the spring, 60, and to ground at 58. The magnet, PM^3, will thus be energized in a single impulse, drawing up its armature and releasing it. Contacts made between the springs associated with the magnet, PM^3, need not be here considered. The important thing which happens is that the attraction and release of the armature of the magnet, PM^3, acts, through the medium of an escapement associated with it and the levers, 65^a, 65^b, 65^c, 65^d and 65^e, to advance those levers of the side switch one step. The contact of the lever 65^a, with the point, 67^a, by reason of current from the battery, B, through the rotary magnet, RM^3, and its contact, 69, to ground, through the lever, 65^a, and point, 67^a, causes a succession of impulses in the magnet, RM^3, the action being similar to that of a vibrating bell. These impulses act through the armature of the magnet and proper pawls, to rotate the shaft, 59, in the arc of the bank contacts before which the vertical impulses had placed the wipers, 70 and 71, and the rotation will continue as long as the circuit conditions of the magnet, RM^3, remain unchanged. It has been described that a trunk line leading from a selector is made busy by having a ground placed upon its contacts, wherever they may appear. In the rotation which succeeds the movement of the side switch to its second position, the contacts, 72, either will successively engage grounded contacts connected to the private wire, P^6, or will engage one which is not grounded. In the case of an engagement with a ground contact, current from the battery, B, through the magnet, PM^3, the lever, 65^e, the contact, 67^e, the wiper, 72, and the grounded private contact in question will cause the armature of the magnet, PM^3, to be attracted. If the further rotation of the shaft causes the wiper, 72, to continuously engage grounded contacts, the armature of the magnet, PM^3, will be retained. When, however, a contact which is not grounded is engaged by the wiper, 72, the magnet, PM^3, will release its armature, and by that act, through the escapement, will advance the side switch

to its third and extreme position. The immediate result will be the opening of the circuit through the magnet, RM^3, so that current will no longer flow, and further rotative impulses will not be given. Another result is the extension by the contact of 65^c, with 68^c, and 65^d with 68^d, of the trunk wires, V^5 and R^5, to the trunk wires, V^6 and R^6. The lever, 65^e, having advanced to its contact, 68^e, a ground is placed upon the private wiper, 72, and therefore upon all of the contacts of the private wire, P^6, associated with the trunk which has been selected. The act of selection having terminated in this manner, the third selector has extended the built-up trunk to a connector which continues the further action from this stage, while the incursion of another selector upon the chosen trunk is prevented.

The connector to which the trunk has now been extended, is shown in Fig. 7, in which the vertical relay, VR^4, is permanently bridged between the live pole of the battery, B, and the vertical wire, V^7, and the rotary relay, RR^4, is permanently bridged between the live pole of the battery, B, and the wire, R^7. Upon the subscriber actuating his substation instrument, relative to the fourth digit of the desired number, the vertical relay will make contacts resulting in a flow of current from the battery, B, through the vertical magnet, VM^4, contact, 76^a, side switch lever 75^a, springs, 73 and 74, of the private magnet, PM^4, the springs, 79 and 80 of the relay, VR^4, to ground. This will operate the vertical magnet, VM^4, in as many steps as there are impulses, lifting the shaft, 81, of the switch until its wipers, 83 and 84 stand in readiness to engage contacts of the arc of the bank in which is the line of the desired subscriber. An impulse over the wire, R^7, in response to a contact of ground with that conductor at the substation, which rotary contact succeeds each series of vertical contacts, will cause current to flow from the battery, B, through the private magnet, PM^4, and the spring, 85, to ground, at the spring, 80. The attraction and release of the armature of the private magnet, PM^4, will actuate the springs of that magnet, but their contacts need not be here considered. The important thing which happens is that, through the agency of the escapement the four levers, 75^a, 75^b, 75^c and 75^d, of the side switch, will be advanced one step. The engagement of the lever, 75^a, with the contact, 77^a, will place the rotary magnet, RM^4, in the relation previously occupied by the vertical magnet, VM^4. The next series of impulses on the vertical wire will again actuate the vertical relay with the result that its contacts will cause current to flow from the battery, B, through the magnet, RM^4, the contact, 77^a, the lever, 75^a, the contact between the springs, 73 and 74, and between springs, 79 and 80, to ground, causing motions of the armature of the magnet, RM^4, rotating the shaft, 81, until the wipers, 83 and 84, stop upon the contacts of the called line; it will be understood that the last digit of the desired number corresponds in number of units with the number of impulses received in this last motion of the mechanism. The rotary impulse which follows this vertical series will actuate the relay, RR^4, causing an impulse of current from the battery, B, through the private magnet, PM^4, and to ground, through contact of the spring, 85, with the spring, 80. The private magnet will attract and release its armature, advancing its side switch through the escapement of its mechanism, to its third position, the lever, 75^a, and the other levers, being similarly situated with reference to being upon their third contact points. The trunk conductors, V^7 and R^7, will thus be extended through the condensers, 87 and 88, respectively, to the springs, 89 and 90, of the calling relay, CR, and by contacts of these springs respectively, with springs, 91 and 92, to the wipers, 83 and 84; thence to the contacts of the lines, V^8 and R^8, which lead to the instrument of the called subscriber. On the assumption that the line of the called subscriber is not already busy, either by a call instituted by that subscriber, or by another for his line, there will be no ground on the contacts of the private wire, P^7, and the operation of completing the connection as described will not have been defeated. Supposing that it has been established as indicated, the next operation on the part of the subscriber is to press his ringing button, which places a ground upon the vertical wire. This, by current through the relay, VR^4, through the battery, B, will operate that relay, causing current to flow from the battery, B, through the calling relay, CR, the contact, 78^a, the lever, 75^a, contact of springs, 73 and 74, of the private magnet, PM^4, contact of 79 upon 80, and to ground. The calling relay, CR, being thus energized, will move its springs, 91 and 92, from contact with the springs, 89 and 90, respectively, and into contact with springs, 93 and 94, respectively, placing the terminals of the ringing generator, G, in connection with the wipers, 83 and 84, and thus with the line of the desired subscriber, ringing his bell. Conversation may then ensue.

Upon the assumption that at the completion of the last series of impulses over the vertical wire, and the consequent rotary motion of the wipers, 83 and 84, ending in contact of those wipers with the called line, the private wire, P^7, had been grounded, a condition which would exist if the called line were busy, a circuit would have been established, the side switch being in its second

position, such that upon the receipt by the relay, RR^4, of the impulse due to the rotary contact succeeding the vertical series, current would flow from the battery, B, through the disconnect magnet, DM^4, the contact between springs, 95 and 96, of the rotary relay, RR^4, to the side switch contact, 77^d, the side switch lever, 75^d, the wiper, 86, to the grounded contact of the wire, P^7, the result would be the actuation of the disconnect magnet, DM^4. This, by its act of pulling up, would release the vertical and rotary pawls of the shaft, and set the side switch back to its normal position. This is in effect a complete release of the connector upon finding a busy line, and it will be noted that this action precedes the act of attempting to ring upon the line, such attempt to ring being the grounding of the vertical wire at the substation, will be made by the subscriber, as he has no knowledge of the action of the connector, or of its having been prevented in any way from securing connection with the called line. The response of the relay, VR^4, to this grounding of the vertical wire, will cause current to flow from the battery, B, through the vertical magnet, VM^4, the side switch contact, 76^a, the lever, 75^a, contacts, 73 and 74, and 79 and 80, to ground. This will lift the shaft of the switch one or more steps, depending on the number of pressures of the ringing button. The springs, 97 and 98, of the off-normal switch will then be allowed to close together, and as the side switch is in its normal position. interrupted current from the auxiliary battery, B′, will flow through the interrupter, I, (shunted by the condenser, K,) the lamp resistance, L, springs, 97 and 98, contact 76^b, of the side switch, lever, 75^b, the condenser, 87, to and through the telephone at the substation, back to the connector switch over the rotary wire, R^7, and its intermediate parts, through the relay RR^4, to the other pole of the battery, B′. This will cause a sound to be heard in the receiver of the calling subscriber, which he will recognize to mean that the line which he has called is busy, whereupon he will hang up his telephone.

It is to be noted with reference to the foregoing that the extension of the wires, V^8 and R^8, is to the line of the called subscriber, as stated, but the route to that line is via the first selector of the called line, over the wire, V^9 and R^9, to the wires, V^{10} and R^{10}, shown in Fig. 8, extending from the central office to the subscriber. In order that the mechanism of the first selector of the called line may not be involved in any of the operations of connecting with the line, or of ringing upon it, the cut-off relay, CO^2, in Fig. 8, comes into action. This is by virtue of the contact of the wiper, 86, in Fig. 7, with a contact of the private wire, P^7, which is indicated as P^8, in Fig. 8. Current thus flows from the battery, B, in Fig. 8, through the relay, CO^2, the contact of springs, 99 and 100, of the off-normal switch of the first selector, in Fig. 8, over the private wire, P^8, to the private wire, P^7, the wiper, 86, the side switch lever, 75^d, to ground at 78^d. It is this later ground application which made the trunk busy in the connection, and it acts as well to energize the relay, CO^2, breaking contacts between the springs, 101, 102 and 103, removing connection between the battery, B, and the vertical and rotary relays, VR^5 and RR^5. It is thus that the bridge of the first selector of the called line is removed from the circuit, and that the conditions shown in Fig. 1, with reference to line bridges, are established.

Returning to the consideration of Fig. 7, it will be seen that in case the subscriber had been called, and wished during the existence of the connection with his line, to institute a call, or otherwise to be released from the connection placed upon his line, he may secure such release. He would first pull the dial of his instrument, establishing contact with the springs, 7, of his telephone, as illustrated in Fig. 2, and thereafter hang up his receiver. This will establish connection between the springs, 12, 13 and 14, grounding both sides of the line, and actuating the relays, BS and BR, in Fig. 7, the circuit in both cases being traced from the battery, B, through the relay, the respective levers, 75^b and 75^c, their contacts, 78^b and 78^c, the wipers, 83 and 84, the lines, V^8 and V^9, and R^8 and R^9, to the substation telephone. The relays, BS and BR, being both actuated at the same time, will extend ground from the spring, 104, to the spring, 106; the circuit of the latter is such that current from the battery, B, will flow through the disconnect magnet, DM^4, energizing that magnet, and by withdrawing the pawls from the vertical and rotary ratchets, will permit the shaft, 81, to return to its normal position by action of its spring and gravity. This will reset the side switch to its normal position, freeing the line of the called subscriber from connection, allowing the cut-off relay, CO^2, to reconnect the relays, VR^5 and RR^5, to the battery, thus enabling a call to be instituted by the previously called subscriber.

Returning to the assumption of a conversation having resulted from the origination of a call, disconnection at the end of the conversation is accomplished by the calling subscriber in the following manner: When it is remembered that the contact between the springs, 7, of Fig. 2, has existed during the progress of the switching and of the conversation, and that the hanging up of the telephone will close together the springs, 12, 13 and 14, as the hook switch descends, it will be seen that the two line wires at the calling substation are grounded during this time.

This will actuate simultaneously the relays, VR^4 and RR^4, in the connector shown in Fig. 7. The first result is by virtue of current from the battery, B, through the magnet, PM^4, and the contact between springs, 85 and 80, to energize the magnet, PM^4, closing the contact of spring 74 upon spring, 107. The energization of the relay, VR^4, will at the same time cause current to flow from the battery, B, through the disconnect magnet, DM^4, the contact of springs, 107 and 74, and of springs, 79 and 80, to ground, thus energizing the disconnect magnet, DM^4, and withdrawing the pawls from the vertical and rotary ratchets, and permitting the shaft, 81, to return to its normal position through the action of its spring and gravity. At the same time the side switch levers, 75^a to 75^d inclusive, will be restored to their normal position. The restoration of the shaft breaks connection of the wipers, 86, with the private wire, P^7, and its extension, P^8, in Fig. 8, and this removes ground from that contact, enabling a succeeding call to find that that called line is not busy, and at the same time releasing the relay, CO^2, also shown in Fig. 8. This restores the connection between the vertical and rotary relays, VR^5 and RR^5, of that first selector, placing it in condition to execute a call made by its subscriber. Similarly the grounding of the wires of the line operates to disconnect the mechanism of the third selector, shown in Fig. 6. This is by virtue of the current from the battery, B, through the private magnet to the ground between the springs, 60 and 58, operating the private magnet, PM^3, and its contacts. As the vertical relay is operated at the same instant, current flows from the battery, B, through the disconnect magnet, DM^3, contact between springs, 61 and 56, and 57 and 58, to ground, energizing the disconnect magnet, DM^3, withdrawing the pawls from the vertical and rotary ratchets as soon as the armature of the disconnect magnet, DM^3, became deënergized. It will be seen that, as to the connector shown in Fig. 7, and the third selector shown in Fig. 6, the disconnection of the switch was a result of functions of its own relays; but by reference to Fig. 1, it will be seen that these are the only relays which are permanently bridged upon the connection during its existence; the release, therefore, of the first and second selectors must take place due to some other agency than the bridged relays, because there are none such. The action is as follows: In Fig. 6, showing the third selector, at the moment of release the disconnect magnet, DM^3, is energized, and through a contact between its springs, 108 and 109, causes current to flow from the battery, B, through the resistance, 110, practical at about 100 ohms, over the private conductors, P^5 and P^4, the latter in Fig. 5, the wiper, 54, through the disconnect relay, DR^2, and the lever, 45^d, to ground at the point, 48^d. The closure of the contact of the relay, DR^2, causes current to flow from the battery, B, through the disconnect magnet, DM^2, and the springs, 111 and 112, to ground. This energizes the disconnect magnet, DM^2, attracting its armature, which upon its release will withdraw the pawls from the vertical and rotary ratchets of the shaft, 49, allowing it to return to normal position, through the agency of its spring and gravity. But the trunk line between the first and second selectors, which in the case of an exchange having a plurality of offices, might be an interoffice trunk, has in series with it at some point in the office containing the first selector, the relays, VR′ and RR′, hereinbefore reserved for this description. These relays have been operated in unison with all impulses over either wire since the selection of the trunk which includes them, but their operations have not resulted in contact between the springs, 116 and 117, until the simultaneous motion of their armatures. At such a time as disconnect conditions are set up, the springs, 116 and 117, are brought into contact. Current results through this contact from battery, B, springs 116 and 117 through the resistance, 118, practical at about 100 ohms, over the wire, P^2, the wire, P′, the contacts thereof, the wiper, 38, through the disconnect relay, DR, the arm, 25^d, to ground at the contact, 28^d. The relay, DR, is thus energized, attracting its armature, and closing its contact. Current results, flowing from the battery, B, through the disconnect magnet, DM, to ground, at the springs, 119 and 120. The magnet, DM, is energized, and upon the release of its armature, withdraws the pawls from the vertical and rotary ratchets of the shaft, 35, restoring it to normal position through the agency of its spring and gravity. All the switches involved in the connection are thus restored to normal position, and the grounds which have caused the various trunks involved in the connection to be busy, have been removed, leaving those trunks free for other use.

It will be observed with reference to Fig. 5, that the conductor, P^3, has not been described to have any useful function. When it is remembered that calls coming into a given office, in an exchange having a plurality of offices, may or may not come from distant offices, it will be seen that a first selector of the same office as that containing the second selector shown in Fig. 5, might institute a call which would select the selector in question. In such a case, considering Fig. 3 to represent the first selector, and Fig. 5 to represent the second selector, both being in the same office, the wiper, 38, in Fig. 3, in engaging the private wire, P′, would

be extended in connection with the private wire, P^3; this would leave the contact, 113, in such a relation that when, at the time of disconnection, the magnet, DM^2, became energized by virtue of the things which have been described, current would flow from the battery, B, through the resistance, 115, the contact between 114 and 113, to and through the disconnect relay, DR, in Fig. 3, instead of resulting from actions of the relays, VR' and RR', shown in Fig. 4, and previously described. The intent is that disconnection of the first selector shown in Fig. 3, shall be accomplished in the case of an interoffice connection, without the agency of the third wire in the trunk; and in case of a connection in the same office, by means of such a third wire in the trunk. The result of this arrangement is to establish a condition of the greatest economy in investment, whatever may be the progress of the call.

Considering again Fig. 7, the joint action of the relays, BS and BR, has been described. In case, however, a toll operator at a toll board associated with such an automatic mechanism as this, and having trunks extending to this mechanism after the manner of subscribers' lines, and capable of being operated by or through the agency of mechanism which she has at her command, should call a subscriber over that arrangement, this called subscriber might desire to signal the toll operator at a time when she was not listening upon the trunk over which she had called him. To do so it would be necessary only for him to press his ringing button, after having made a movement of the dial of his instrument, to cross together the springs, 7, as shown in Fig. 2. This pressure of the ringing button would ground the vertical wire shown as entering at V^8 in this figure. Current would flow from the battery, B, through the relay, BS, the springs, 89 and 91, the wiper, 83, over the wire, V^8, to his station, operating the relay, BS; as a consequence of its contact, current would flow from the battery, B, through conductor 150 to the toll board T, through a convenient signal or relay 151, in that board, through conductor 152, to the spring, 105, and its contact with 104 to ground. This would energize the relay at the toll board, causing it to display a signal in consequence, or instead of the relay, a convenient electromagnetic visual signal might be employed.

It will be seen that in this system some of the selecting switches have their controlling magnets removed from across the circuit of the line during the time when these switches are involved in a connection. The subsequent release of the connecting switches is obtained through the energization of the release magnet either over a third individual wire of the trunk when the trunk involved has three wires, or over the two sides of the metallic circuit of a trunk which has no third or individual wire. It is to this latter case that this application is particularly directed as by it trunks having two wires only are made available instead of trunks having at least three wires, as has been the case in all prior systems. The reduction of the number of wires in a trunk line is not of controlling importance when all the switches are placed in a single central office, but when trunk lines extending between central offices are involved, the extra expense due to the first cost and subsequent maintenance of a third wire for each trunk is in many cases prohibitive.

I do not wish to limit myself in all respects to the exact details and circuit connections here shown. For instance, while I have described a system in this application with particular reference to an exchange wherein the subscribers' numbers are composed of five digits, it is obviously applicable to apparatus and mechanism required by systems having a greater or less number of digits. Again, while the invention has in this application been described with particular reference to the type of selecting switches in which the selecting contacts have both a longitudinal and a rotary motion, it is clear that the invention is equally applicable to other forms of switches in which the selecting contacts, under the control of the respective limbs of the line, move in one case to select a plurality of groups of contacts, and in the other case to select individual contacts of said group, regardless of whether the motions of these selecting contacts are vertical or rotary or otherwise.

It is also obvious that many changes may be made without departing from the spirit of my invention.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent, is—

1. In an automatic telephone system, a subscriber's line, a metallic circuit trunk line, a selector serving to connect said subscriber's line with said trunk line, controlling magnets for said selector, switches operated by said controlling magnets to open the circuit of said magnets upon the completion of a selection, and electromagnet mechanism controlled over the line circuit to actuate said selector to disconnect said subscriber's line from said trunk line.

2. In an automatic telephone system, a subscriber's line, a selecting switch therefor, a trunk line, controlling magnets normally bridged across the subscriber's line for causing said switch to select and connect with said trunk line, means for automatically disconnecting said controlling magnets from said line after their operation, a source of current adapted to supply current over said

trunk line to said subscriber's line, and means operated by current from said source over said trunk line to cause said switch to disconnect said subscriber's line from said trunk line, substantially as described.

3. In an automatic telephone system, a metallic circuit line, a substation in said line, a selecting switch for said line, controlling magnets for said switch, a disconnect magnet for said switch, a metallic circuit trunk line, means at said substation for causing the selecting switch of said line to select and connect with said trunk line, means for automatically disconnecting said controlling magnets from said line after such selection and connection, and means operated over the limbs of said trunk line for closing the circuit of said disconnect magnet to cause said selecting switch to release said trunk, substantially as described.

4. In an automatic telephone system, a metallic circuit line, a substation and a selecting switch for said line, controlling magnets for said switch normally in operative relation with said line, a metallic circuit trunk line, means at said substation for causing its selecting switch to select and connect with said trunk line, means for automatically placing said controlling magnets in inoperative relation with said line after such selection and connection, relays connected with the limbs of said trunk, and means controlled by said relays for causing said selecting switch to disconnect said line from said trunk line, substantially as described.

5. In an automatic telephone system, a metallic circuit line, a substation and a selecting switch for said line, a pair of controlling magnets for said switch normally bridged across said line, a source of current connected between said magnets and a third conductor, a metallic circuit trunk line, means at said substation for connecting the limbs of said line with said third conductor for causing said selecting switch to select and connect with said trunk line, means for automatically disconnecting said controlling magnets from said line after such selection and connection, relays connected in the limbs of said trunk line, and means controlled by said relays for causing said selecting switch to disconnect said line from said trunk line, substantially as described.

6. In an automatic telephone system, a metallic circuit line, a substation and a selecting switch for said line, a pair of controlling magnets for said switch normally bridged across said line, a source of current connected between said magnets and a third conductor, a metallic circuit trunk line, means at said substation for connecting the limbs of said line with said third conductor for causing said selecting switch to select and connect with said trunk line, means for automatically disconnecting said controlling magnets from said line after such selection and connection, a pair of relays connected respectively in series in the limbs of said trunk line, and a release magnet for said first selector controlled by said relays for causing said selecting switch to disconnect said line from said trunk line, substantially as described.

7. In an automatic telephone system, a metallic circuit line, a substation and a selecting switch for said line, controlling magnets for said switch normally in operative relation with said line, a metallic circuit trunk line, means at said substation for causing said selecting switch to select and connect with said trunk line, means for automatically placing said controlling magnets in inoperative relation with said line after such selection and connection, a pair of relays serially connected in the limbs of said trunk, a local circuit for said pair of relays, a disconnect magnet for said selecting switch adapted to be connected with said local circuit, and means for simultaneously operating said pair of relays to close the circuit of said disconnect magnet, substantially as described.

8. In an automatic telephone system, a built-up circuit between two subscribers' lines, selecting switches and trunk lines involved in building up said circuit, controlling magnets connected with said circuit at some of said selecting switches, other controlling magnets disconnected from said circuit at other of said selecting switches, a source of current, disconnecting magnets associated with those switches having disconnected controlling magnets, said disconnecting magnets being adapted upon energization to restore said switches to their normal positions and means associated with the switches having connected controlling magnets for supplying currents over the limbs of said built-up circuit to operate said disconnecting devices to discontinue said built-up circuit, substantially as described.

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

BERT G. DUNHAM.

Witnesses:
SAMUEL G. MCMEEN,
HAZAEL C. PRADO.