May 25, 1943. N. I. HALL 2,320,076

SELECTING SYSTEM

Filed Nov. 21, 1941

FIG. 1

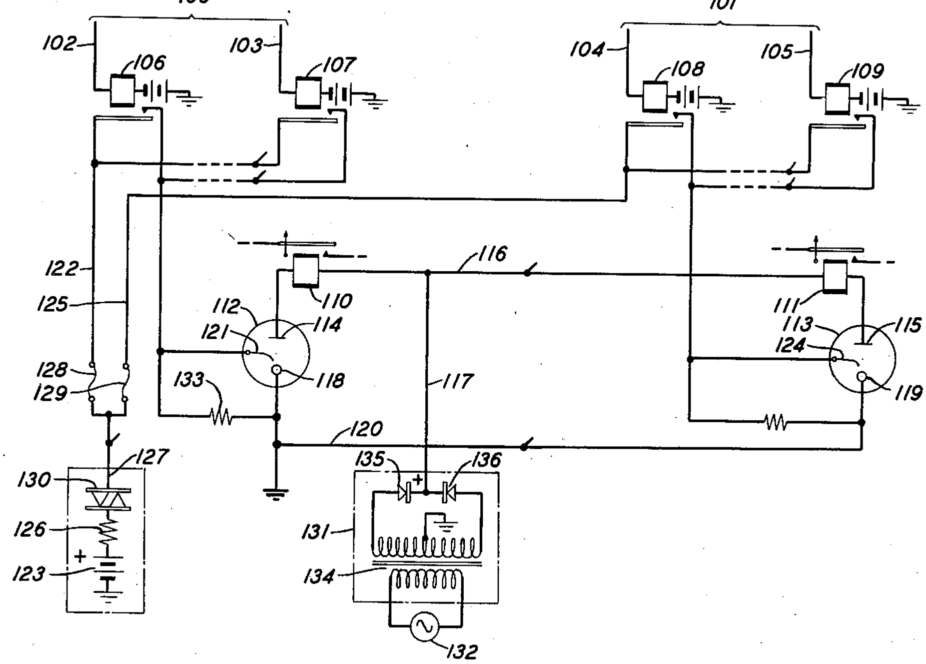
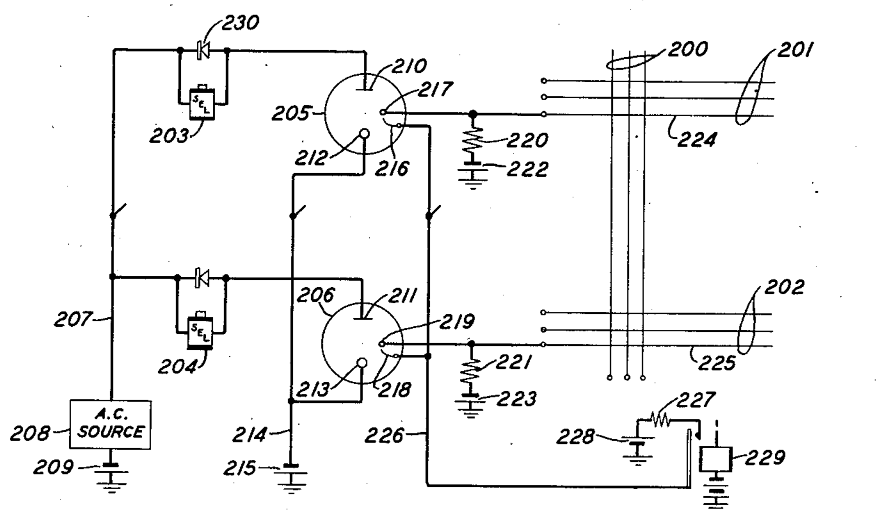


FIG. 2



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SELECTING SYSTEM

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4 Claims. (Cl. 179—18)

This invention relates to selecting systems and particularly to systems in which selections are made automatically in a group of lines, circuits, or other electrical devices.

An object of the invention is to increase the certainty with which lines, trunks, circuits, or other devices of a group are rendered unselectable in response to the selection of one of them for use.

Another object is to cause the selection of one of a plurality of equivalent circuits or devices by operating a discharge tube individual thereto and to utilize the characteristics of these discharge tubes to insure that one alone is rendered effective and that all others are rendered ineffective when a plurality of them are seized simultaneously.

Another object is to utilize a common impedance element for controlling the operating voltages applied to said tubes and to utilize a source of alternating or pulsating voltage for varying the characteristics of the tubes to insure the effective operation of one tube to the exclusion of the other.

Other objects of the invention are to simplify, to increase the speed of operation and otherwise to improve selecting and controlling systems.

These objects are realized by means of a selecting system in which a plurality of lines, circuits, relays, or other equivalent devices, from which selection is to be made, are provided with a plurality of discharge tubes, one for each of the several circuits or devices, together with means for causing the ionization or initial discharge of said tubes at random; in which the starting or ionizing voltage for each tube is applied through a common impedance element; and in which a source of alternating or pulsating voltage is applied to the main discharge gaps of the tubes. In the practical operation of a selection system of this kind attempts to seize any two of the tubes, although subject to random occurrence, are more likely to fall in sequence than simultaneously. And the first tube to ionize, although preceding only slightly an attempt to seize a second tube, will usually set up a sufficient voltage in the common impedance to lock out the second tube and all others as well. However, because the attempts do fall at random, it frequently happens that two or more tubes have their starting gaps ionized at substantially the same instant. But even in these instances it would be highly undesirable to permit the failure that would result from double operation. In the present system such a failure is made practically impossible by the combined effect that is obtained by the use of the common impedance in the initial ionizing circuits of the tubes and the alternating or pulsating voltage on their main gaps. More specifically the effect of the alternating voltage applied to the main gaps of the tubes is to change the sustaining characteristics of the tubes at different rates. Since the sustaining voltage of the starting gap of a particular one of a plurality of simultaneously ionized tubes is lowered more rapidly than the sustaining voltage of the other tubes, said particular tube remains ionized under the application of the ionizing voltage through the common impedance element, whereas the remaining tubes become extinguished after one or more cycles of the alternating voltage because the voltage drop across said impedance element has reduced the voltage applied to their starting gaps below the sustaining value. Therefore, current from the alternating source flows in the main gap of the particular tube as long as the starting gap remains ionized, and all other tubes are ineffective since they are locked out by the reduced voltage caused by the common impedance element.

A feature of the invention is a selecting system of the kind above described in which both electrodes forming the start gap of each tube are connected in direct multiple relation with the corresponding electrodes of all other tubes of the group. By this means of multipling both electrodes of all tubes the full effect of the voltage drop in the common impedance element is realized, and a greater assurance is given against the possible operation of two tubes simultaneously.

Other features and advantages of the invention will be described more fully in the following detailed specification.

In the drawing accompanying the specification:

Fig. 1 shows the invention applied to the selection of group relays in a line switching system; and

Fig. 2 illustrates the invention applied to the selection of the operating magnets of a crossbar switch.

Although the invention is applicable to selecting and controlling systems in general and without regard to the specific purposes for which these systems are used, it is disclosed in the drawings in connection with line switches of the crossbar type when employed in telephone systems. These crossbar line switches serve to extend calling subscribers' lines to idle trunks, and the controlling circuits therefor usually include horizontal and vertical group relays which determine the order of sequence in which calling lines are served. Fig. 1 shows a portion of the control circuits for one of these switches and illustrates a number of the horizontal group relays to which the selective and lock-out features of this invention are applied. Fig. 2 shows the application of the selection and lock-out features of the invention to the select magnets of one of the crossbar line switches.

A crossbar switch of the type to which reference is here made is disclosed in the patent to Reynolds 2,021,329 of November 19, 1935. The controlling and operating circuits of these switches, when used as line switches in an automatic telephone system, are disclosed and described in detail in the patent to Busch et al. 2,224,251 of December 10, 1940.

The subscribers' lines, which appear in one of these line switches, are divided into a plurality of groups. Two of these groups of lines 100 and 101 are shown in Fig. 1 of the drawing, each of the lines 102, 103, 104, 105, etc., being provided with an individual line relay 106, 107, 108, 109, etc. A plurality of group relays 110, 111, etc., are also provided, there being one of these relays for each group of lines 100, 101. The usual practice is to divide the total number of lines into ten groups, in which case there would be ten group relays.

Since the calls are initiated at random on the lines of the several groups and since it is essential that only one of the group relays should operate at a time, it is necessary to provide some means for selecting a particular one of the relays for operation and to prevent the operation of all other relays pertaining to groups having simultaneous calls therein. This exclusive selection is accomplished by means of a series of space discharge tubes, each tube 112, 113 of the series being associated with and individual to a corresponding one of the group relays 110, 111.

The windings of the group relays are connected respectively to the anodes of the tubes so that the relay obtains its operating current in the main discharge circuit of the tube. For example, the windings of relays 110 and 111 are connected respectively to the anodes 114 and 115 of tubes 112 and 113. The other terminals of the relays are multipled by a common conductor 116 which in turn is connected over conductor 117 to a source of alternating or pulsating current. The cathodes of all tubes of the group, including the cathodes 118 and 119 of tubes 112 and 113, are connected in direct multiple relation by means of the common multiple conductor 120, which in turn is connected directly to ground. The starting electrode of each tube is connected through contacts of the line relays of the corresponding group to a common supply circuit for applying starting voltage to the control gap of the tube. For example, the starting electrode 121 of tube 112 is connected in multiple to the front contacts of all line relays 106, 107 in the associated group, and the armatures of these relays are connected in multiple over conductor 122 to the common branch 127 of the supply circuit, which includes battery 123 and resistor 126. In like manner the starting anode 124 of tube 113 is connected through the front contacts of relays 108 and 109 and multiple conductor 125 over the common branch 127 of the supply circuit to battery 123.

The individual branches 122, 125, etc., of the voltage supply circuit include fuses 128, 129 for protecting the respective tubes. The common branch 127 of the supply circuit also includes a variable resistor 130 the purpose of which is to increase the current flow in any one of the individual branches sufficiently to melt the fuse thereof in case the branch becomes accidentally connected directly to ground.

The anode supply circuit 117 is connected to a rectifier 131 which serves to rectify the alternating voltage furnished by the generator 132. The rectified voltage is thus applied to the supply conductor 117 in the form of pulsations of positive potential.

The manner in which selection and lock-out are effected in the circuits shown in Fig. 1 will now be explained in detail. Assume that line 102 in the group 100 and line 104 in the group 101 initiate calls at substantially the same time. In response to these calls the corresponding line relays 106 and 108 operate. When relay 106 closes its contacts, a circuit is completed for the application of starting voltage to the control gap of the associated tube 112. This circuit may be traced from the positive pole of battery 123, resistor 126, resistor 130, fuse 128, conductor 122, contacts of relay 106, starting electrode 121, cathode 118 to the grounded conductor 120. The voltage thus applied across the control gap 121—118 causes this gap to ionize. The resistor 133 which is connected across the control gap is high in value and does not effectively shunt the gap. At the same time the call on line 104 causes the operation of relay 108, and a starting circuit for the tube 113 is closed from battery 123, resistor 126, resistor 130 through the fuse 129, conductor 125, contacts of relay 108, starting electrode 124, cathode 119 to the grounded conductor 120. The voltage applied to the control gap 124—119 causes the ionization thereof.

Thus the starting gaps of tubes 112 and 113 may commence to ionize at substantially the same instant, and the same might be true of other tubes corresponding to groups having lines in a calling condition at this time. If these tubes were permitted to continue their ionization and to transfer the ionization from the control gaps to the main gaps at the same time, the result would be that a plurality of group relays 110, 111 would energize simultaneously and cause a false operation of the system. This false operation, however, is obviated in the present system by using pulsating or alternating voltage on the anodes of the tubes instead of the usual direct voltage source. I have found that when an alternating or pulsating voltage is applied to the anodes of the tubes the sustaining characteristic of the starting gaps of a plurality of tubes undergoes a change which varies substantially among the different tubes. More specifically the voltage across the control gap which is sufficient to sustain ionization is automatically decreased in response to the increasing potential on the anode of the tube resulting from the application of the alternating or pulsating voltage to the anode-cathode gap. As the sustaining voltage of the control gap of a particular tube decreases, it is possible to lower correspondingly the voltage applied by the supply circuit without causing the quenching of the control gap, provided that the supply voltage remains somewhat greater than the minimum sustaining voltage. This decrease in the sustaining voltage of the control gap in response to the increasing anode potential occurs in each of the several tubes which have ionized their control gaps simultaneously. However, I have, as above mentioned, found by numerous experiments that in any given series of tubes the rate of change of the sustaining voltage of any one tube differs from that of the others. Therefore, although two or more tubes may commence their ionization at the same instant, one of these will have its control gap sustaining voltage lowered more rapidly than the others when the anode of the tube rises in positive potential in response to the next application of a positive alternation or a positive impulse. Consequently the current flowing through the common resistor 126 and through the control gap of the preferred tube and also in parallel through the control gaps of the other simultaneously ionized tubes produces a voltage drop which lowers the potential of the starting anodes 121, 124, etc., of all of the non-preferred tubes below their sustaining voltages. The result is that the preferred tube continues its ionization, whereas the remaining tubes, either in the first positive cycle or in an immediately succeeding positive cycle of the anode voltage, quench their control gaps and thus become inoperative.

Returning, for example, to the two tubes 112 and 113, assume that the simultaneous ionization of the control gaps of these tubes occurs at an instant when no potential is being applied to the anodes 114 and 115. A moment later positive potential is applied to these anodes, and the value of this potential continues to rise until it reaches the maximum. As the anode potential rises the voltage necessary to sustain ionization across the control gap in each tube decreases. Since, however, the rate of decrease of the sustaining voltage differs for the two tubes 112 and 113, it may be assumed that the sustaining voltage of the tube 112 decreases at a faster rate than that of the tube 113. As the tube 112 lowers its sustaining voltage it draws more and more current from the common supply circuit 127, and the discharge current flowing from the battery 123 through the common resistor 126 lowers the positive potential of the starting electrodes 121, 124 of all tubes in the group. This lowered potential results in a reduced applied voltage across the starting gap 121—118, but the reduction still does not lower the applied voltage below the sustaining voltage of the gap. Therefore, the tube 112 continues to maintain the ionization of its control gap. The control gap 124—119 of the other tube 113 fails to maintain its energization since the applied voltage from the common supply circuit 127 is reduced more rapidly than the sustaining voltage of the gap. And the same would be true of any other tubes that may simultaneously ionize their gaps.

Thus at some point in the rise of the anode voltage the ionization of tube 112 transfers from the control gap 121—118 to the main gap 114—118, and current flows over the supply circuit 117 through the winding of group relay 110, anode 114, cathode 118 to the grounded circuit 120. The control gap 121—118 remains ionized constantly under control of the line relay 106, and current flows in the main gap of the tube through the relay 110 on each positive alternation or positive impulse from the supply conductor 117. The relay 110 operates in this circuit and remains operated during the brief intervals of current cessation by reason of its slow-releasing character. After the relay 110 has performed its functions and it is desired to release the same, the circuit of line relay 106 is opened, or the circuit of the control gap 121—118 is opened at any other convenient point. The opening of the circuit for this control gap terminates the ionization thereof, and the main gap of the tube fails to ionize on succeeding alternations of the anode potential. After a brief interval the relay 110 releases.

It will be noted that the full benefit of the voltage drop produced across the resistor 126 in the common branch of the circuit extending to the starting electrodes of the tubes is realized by connecting all of the starting electrodes 121, 124 directly in multiple to the common branch conductor 127 and on the other hand by connecting the cathodes 118, 119 of all tubes directly in multiple to the conductor 120, which in turn is connected to ground or to the negative pole of the battery 123.

Although the rectifier 131, comprising transformer 134 and rectifying elements 135 and 136, is used to convert the alternating voltage from the source 132 into positive pulsations, it will be understood that this rectifier may be omitted and the alternating voltage applied from the source 132 directly to the common conductor 116.

The resistor 130 is one having a non-linear voltage resistance characteristic. The resistance of this unit is relatively high under normal operating conditions and in combination with resistor 126 limits the starting current to the desired value. However, should one of the conductors 122, 125 become grounded by inadvertence, the increased voltage applied across the resistor 130 decreases its resistance to such an extent that the increased current flowing through the corresponding one of the fuses 128, 129 causes it to melt.

In Fig. 2 a crossbar switch is partially illustrated for connecting incoming lines, such as the line 200, to outgoing lines or trunks 201, 202, etc. The horizontal or select bars of the switch are operated by means of individual select magnets 203, 204, etc., there being one of these select magnets for each of the outgoing circuits 201, 202.

In order that the select magnets, which are subject to random selection, may be operated one at a time, the individual discharge tubes 205, 206, etc., are provided for effecting the exclusion or lock-out of all magnets except the one chosen for operation. As in Fig. 1, the anodes 210, 211 of the tubes are connected respectively to the windings of the select magnets, and the other terminals of these windings are joined by the common multiple conductor 207 and connected to the alternating potential source 208 which in turn is connected in series to the negative pole of battery 209. The battery 209 applies a negative potential to the anodes of the tubes to balance the negative potential applied to the cathodes by the battery 215. This permits the voltage across the main gap of an operated tube to fall to zero each time the alternating current source 208 passes through zero and prevents an operated tube from remaining locked after the control gap ionization ceases. The cathodes 212, 213 are all connected directly in multiple to the common conductor 214 and thence to the negative pole of battery 215.

The lock-out tubes 205, 206 differ from those shown in Fig. 1 in that they are provided with separate or insulated control gaps. For example, the control gap of tube 205 is formed by a starting anode 216 and a starting cathode 217. Likewise the control gap of tube 206 is formed by a starting anode 218 and a starting cathode 219. The starting cathodes 217 and 219 are connected respectively through resistors 220 and 221 to the negative pole of battery 222 and battery 223. These starting cathodes are also connected respectively to the sleeve conductors 224 and 225 of the outgoing circuits 201 and 202. The starting anodes 216, 218, etc., are connected directly in multiple by the common conductor 226, which includes in circuit therewith the common resistor 227 and the supply battery 228.

The operation of the selection circuit shown in Fig. 2 will now be described. Assume that it is desired to effect the selection of any one of a plurality of idle outgoing circuits 201, 202, etc., for the purpose of extending the line 200 to such idle circuit. Inasmuch as a number of these outgoing circuits may be idle at the time, it is necessary that only one be selected, and it does not matter which one, and that all other idle outgoing circuits be positively excluded to avoid the possibility of a double connection.

When the time arrives for making the selection, a relay 229 is operated in any suitable manner to close a circuit from the positive pole of battery 228 through the common resistance 227, contacts of said relay, thence to the starting anodes 216, 218 of all tubes in the group. Each tube corresponding to an idle outgoing circuit 201, 202 will have full negative potential applied to the starting cathode thereof from the batteries 222, 223. Assume, for example, that both circuits 201 and 202 are idle at the moment; the starting gaps of both tubes 205 and 206 ionize, therefore, when the relay 229 is operated. If at this moment the source 208 is of the proper polarity, the ionization of the starting gap 216—217 transfers to the auxiliary starting gap 212—216. The circuit for maintaining ionization of the auxiliary gap may be traced over conductor 226, starting anode 216, main cathode 212, conductor 214 to the negative pole of battery 215. Similarly, the ionization of the starting gap 218—219 of tube 206 may transfer at the same time to the auxiliary starting gap 213—218. As soon thereafter as the source 208 becomes positive, an increasing positive potential is applied to the anodes 210, 211, and this increasing positive potential changes the sustaining characteristics of the starting gaps of the tubes at different rates as hereinbefore explained. Consequently, the ionization of the starting gap of one of the tubes is maintained while the starting gap of the remaining tubes is quenched by the voltage drop produced across the common resistor 227 in the starting gap circuit. If it is assumed that the tube 205 changes its sustaining voltage more rapidly than the others, then the starting gap 212—216 of this tube maintains its ionization and the other tubes are quenched. Consequently, the tube 205 transfers the ionization of the starting gap to the main discharge gap 210—212, and current of positive polarity flows from the source 208 through the winding of magnet 203, anode 210, cathode 212 to the negative pole of battery 215 and thence to ground. The magnet 203 causes the operation of the crossbar switch and the extension of the line circuit 200 to the selected idle outgoing circuit 201. The purpose of the rectifying unit 230 is to prevent the magnet 203 from releasing during sucessive alternations of the source 208.

As soon as the circuit 201 is seized, a ground potential is applied to the sleeve conductor 224 in any suitable manner to render the control gap 216—217 ineffective, so that this circuit will not be selected when a subsequent connection is being established to an idle one of the outgoing circuits. At some convenient time in the operation of the system the relay 229 is released to quench the ionized control gaps of all tubes.

While the space discharge tubes illustrated herein may be of any suitable type, such as those filled with different gases, it has been found that better results are obtained in the systems disclosed when tubes filled with argon are employed.

What is claimed is:

1. In combination, a plurality of discharge tubes each having electrodes forming a starting gap and a main discharge gap, a common circuit for applying at random a starting voltage to cause the ionization of the starting gap of one or more of said tubes, a source of alternating voltage applied to the main gaps of all of said tubes and serving to alter at different rates the sustaining characteristics of the starting gaps of any tubes that happen to ionize simultaneously, and an impedance element in said common circuit for producing a voltage drop in response to the current flowing in the starting gaps of said tubes, the voltage drop of said impedance element serving to lower below the sustaining value the voltage applied to the starting gaps of all tubes except the particular tube that has its sustaining characteristic altered most rapidly by said alternating voltage.

2. In combination, a plurality of discharge tubes each having electrodes forming a starting gap and a main discharge gap, a common circuit for applying at random a starting voltage to cause the ionization of the starting gaps of a plurality of said tubes simultaneously, a source of alternating voltage applied to the main gaps of all of said tubes and serving to lower at different rates the sustaining voltage of the starting gaps of said tubes, and a resistance element in said common circuit for producing a voltage drop in response to the current flowing in the starting gaps of the ionized tubes, the voltage drop of said resistance element serving to lower below the sustaining value the voltage applied to the starting gaps of all tubes except the particular tube that has its sustaining voltage lowered most rapidly by said alternating voltage.

3. In combination, a plurality of discharge tubes each having two starting electrodes forming a starting gap and a main electrode forming a main gap with one of said starting electrodes, a common circuit including in multiple relation one of the starting electrodes of each of said tubes, a common circuit including in multiple relation the other starting electrodes of each of said tubes, means for applying at random over said common multiple circuits a starting voltage to cause the ionization of the starting gaps of a plurality of said tubes simultaneously, a source of voltage applied to the main gaps of all of said tubes and serving to alter at different rates the sustaining characteristics of the starting gaps of the simultaneously ionized tubes, and an impedance element in one of said common circuits for producing a voltage drop in response to the current flowing in the starting gaps of said tubes, the voltage drop of said impedance element serving to lower below the sustaining value the voltage applied to the starting gaps of all tubes except the particular tube that has its sustaining voltage lowered at the highest rate.

4. In combination, a plurality of discharge tubes each having electrodes forming a starting gap and a main discharge gap, a circuit for the starting gaps of said tubes including a common

branch and an individual branch for each tube, means for closing said individual branches at random to apply a starting voltage to cause the ionization of the starting gap of the corresponding tube, a source of alternating voltage applied to the main gaps of all of said tubes and serving to alter at different rates the sustaining voltage of the starting gaps of any two or more of the simultaneously ionized tubes, an impedance element in said common branch for producing a voltage drop in response to the current flowing in the starting gaps of said tubes, the voltage drop of said impedance element serving to lower below the sustaining value the voltage applied to the starting gaps of all tubes except the particular one that has its sustaining voltage altered more rapidly, a main discharge circuit for each of said tubes, and means in the main discharge circuit of the operated tube responsive to the flow of alternating current therein as long as the individual branch circuit of said tube remains closed.

NATHAN I. HALL.