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LOCKOUT CIRCUIT

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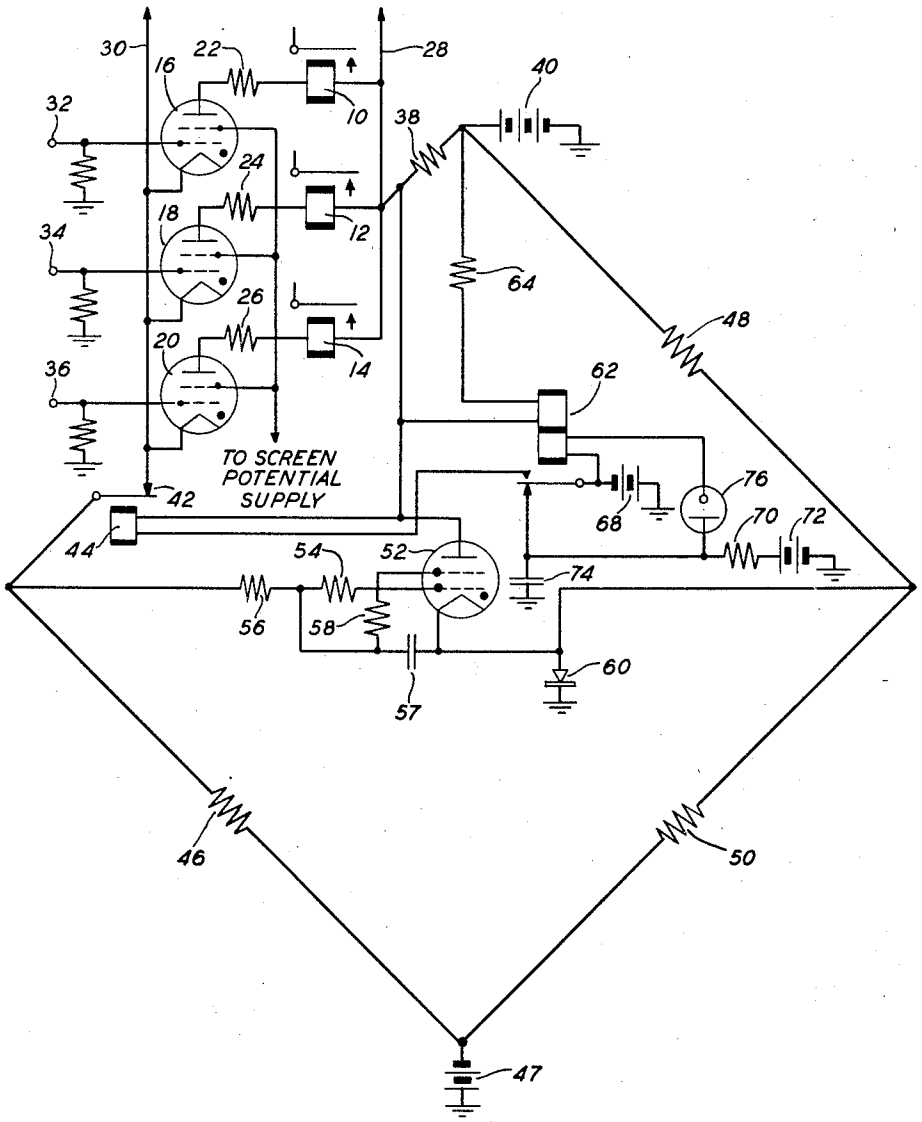

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LOCKOUT CIRCUIT

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This invention relates to lockout and selection circuits and more particularly to circuits for reliably preventing simultaneous actuation of more than one work circuit of a group from which it is desired to make a single selection.

In many kinds of control mechanism a plurality of work circuits is provided and control circuits usually including vacuum tubes are employed selectively to actuate the work circuits in response to externally supplied control signals. In one common circuit of this general nature, each of the work circuits is actuated by a relay, the winding of which is included in the anode circuit of a gaseous discharge or thyratron tube and is effective when discharge occurs in the tube to operate connected circuits. A control signal from an external source is applied selectively to the control elements of the appropriate one of the several discharge tubes whenever it is desired to cause operation of the work circuit associated therewith. Often such control signals are transmitted over considerable distances by means of a common transmission facility and are distinguished from each other on a frequency basis or by time of occurrence. In either event, the presence of noise in the transmission facility or malfunctioning of the selective transmitting device may sometimes result in the simultaneous application of more than one signal capable of actuating a discharge tube and its work circuit. Under these circumstances, work circuits other than that desired to be actuated will respond. This difficulty is, of course, particularly undesirable when the several work circuits constitute means for substituting alternative transmission facilities in a signaling system or the interconnection of a desired one of a number of alternative controlled circuits in various industrial processes.

Difficulties of the kind referred to above are commonly obviated by means of so-called lockout circuits often involving the interconnection of large numbers of relays or discharge tubes in such a way that operation of one relay or tube effectively prevents operation of any of the others. Such relay circuits may not, however, be sufficiently rapid in operation for such applications as those involved in the automatic switching of transmission facilities as disclosed, for example, in the copending application of J. B. Maggio, Serial No. 309,447, filed September 13, 1952. Other known lockout circuits which may have increased operating speeds suffer from lack of reliable operation under all circumstances. In the application of selection circuits of the type contemplated to communication facilities not even one failure of the selection device can be tolerated despite relatively wide variations in the operating conditions.

It is the object of the present invention, therefore, to provide reliable high speed lockout and selection circuits for correcting false operation involving the unwanted completion of more than one controlled operation, whether brought about by the simultaneous application of control signals or by spurious signals reaching the control elements.

The lockout or selection circuit according to the invention comprises a plurality of discharge tubes, each controlling an individual work circuit in response to an individual control signal. The anode circuits of the several discharge tubes each including the actuating element of the associated work circuit are connected in parallel through a common impedance to a source of operating potential. A second impedance shared in common by the cathodes of the several discharge tubes completes the operating anode-cathode circuits for the tubes and additional impedances are connected across the source of potential to form a four-arm bridge circuit, one arm of which comprises the first-mentioned common impedance and the parallel-connected anode circuits and associated discharge tubes. The several impedances of the bridge are so proportioned that the bridge is in effect balanced only when fewer than two of the discharge tubes are conducting. A detector is connected across the diagonal of the bridge not including the source of potential and is responsive to a particular unbalanced condition on the bridge effectively to remove the operating potentials from the discharge tubes.

The above and other features of the invention will be described in the following specification taken in connection with the drawings the single figure of which is a schematic circuit diagram of a selection circuit according to the invention.

The circuit shown by way of example in the drawings is arranged to control selectively a number of relays each of which in turn may, for example, serve to connect a spare transmission facility in place of a working transmission facility which has become unsatisfactory for communication service. Such selective operation of these relays is effected by means of voice frequency signaling tones, one for each desired operation, transmitted in common over a line and separated by frequency discrimination for application to the control circuit of the invention. In the drawing three of a plurality of controlled relays 10, 12 and 14 are illustrated. It will be understood that each of these relays serves upon operation to establish desired circuits through actuation of its associated armature. These circuits are not illustrated and may take any form desired depending upon the nature of the operation to be performed.

Each of relays 10, 12 and 14 constitutes a portion of the anode load of a discharge tube, the three relay windings being associated with discharge tubes 16, 18 and 20 respectively, by way of load resistors 22, 24 and 26. The several discharge tubes are shown as comprising gaseous discharge tubes of the type commonly referred to as thyratrons, but it is to be understood that depending upon the application to be made of the selection circuit, vacuum tubes may also be employed. Further, it is to be understood that although only three work circuits 10, 12 and 14 and associated discharge tubes are shown in the drawing, additional circuits may be added as desired and connected between lead 28 and a second lead 30, the anode circuits of all control tubes being connected in common to the first lead, and the cathode circuits of the tubes being connected in common to the second lead. The individual control signals for tubes 16, 18 and 20 may be applied to the control grids thereof in the usual manner through terminals 32, 34 and 36 respectively. The screen grids of the several tubes are provided with operating potentials and their control grids with suitable biases in the usual way, all details of these circuits not being shown, however, in the drawings.

It will be recognized that the several discharge tube circuits each including the operating winding of the associated relay as an anode load, are connected in parallel between leads 28 and 30. These parallel connected circuits are connected in series through a resistor 38 to the

positive terminal of a battery 40, the negative terminal of which is grounded. Similarly, lead 30 provides means for connecting these parallel circuits to ground through the normally closed contact 42 of a relay 44, a series resistor 46 and battery 47, the positive terminal of which is grounded. Batteries 40 and 47 thus supply operating potential to any of the discharge tubes connected between leads 28 and 30, so that upon application of a suitable control voltage discharge current can be caused to flow in any one of the discharge tubes.

As has been suggested heretofore, it may be especially desirable in certain applications of control circuits of the general type here involved to insure that not more than one work circuit is actuated at a time, regardless of whether more than one control signal is present, or regardless of the amount of noise present in the control circuits. For this purpose, and in accordance with the invention, additional impedances shown in the drawing as resistors 48 and 50 are connected in series between the positive terminal of battery 40 and the negative terminal of battery 47. It will be recognized that these additional impedances together with resistor 46 and the impedance comprising the paralleled anode circuits and discharge tubes 16, 18 and 20 in series with resistor 38 constitute a four-arm bridge circuit across one diagonal of which the batteries 40 and 47 are serially connected. The other diagonal of this bridge extends from the junction of resistor 46 and the armature of relay 44 to the junction of resistors 48 and 50.

As mentioned above the impedances constituting the arms of the above described bridge circuit are so proportioned that the bridge is in a condition herein referred to as effectively balanced only when fewer than two of the discharge tubes is conducting. Thus, when respectively (1) one or (2) none of the tubes is conducting the parallel impedance comprising their several anode-cathode circuits is sufficient (1) to balance the bridge within a required degree of precision or (2) to unbalance it in an ineffectual direction. In both of these conditions the bridge will be herein referred to as effectively balanced. If, however, two or more of the discharge tubes become conductive, the impedance of the arm of the bridge in which they are located in sufficiently reduced to unbalance the bridge in an effectual direction. A detector of suitable sensitivity to discriminate between these conditions may then be connected across the second diagonal of the bridge and may be made responsive to the last-mentioned unbalance of the bridge to effectively remove the operating potential from the several discharge tubes.

In accordance with further features of the invention, the detector is made effective, first to reduce the current drawn through the work circuit by any operated discharge tube to such an extent that the work circuit is released, and, second, completely to remove operating potentials from the discharge tubes to cause their deionization preparation to resetting the circuit for further operation. The first action of the detector, namely that of reducing the potential applied to the discharge tubes to such an extent that the work circuits are released takes place substantially instantaneously and permits reliable operation of the device at high speeds. Additional apparatus to be described hereinafter is also provided for reapplying operating potentials to the discharge tubes after a predetermined interval of time thereby resetting them to permit the selection of work circuits in the event that at a later time only one control signal is present at the input terminals.

Conveniently, and as shown in the drawing the detector may comprise an additional discharge tube 52, having its cathode connected to the junction of resistors 48 and 50 and its anode connected to the positive terminal of battery 40 by way of resistor 38 which it therefore shares with the anode circuits of control tubes 16, 18 and 20. The potential appearing across the second diagonal of the bridge is applied through resistor 56 and current limiting resistors 54 and 58 to the control and screen grids of the tube, resistor 56 together with capacitor 57 serving as a filter to prevent transient voltage surges from reaching the detector tube. When the bridge is balanced this potential will have a value near to zero with the effect that both grids of the tube 52 will be at substantially the same potential as its cathode. Thus they will shield the cathode from the anode's potential and the tube will not fire. Similarly it will not fire when the bridge is unbalanced to any extent in the above-mentioned "ineffectual" direction because the same two grids will actually be negative with respect to the cathode. Thus it is seen that the bridge may be proportioned for three possible conditions of balance: (1) "effective balance," i. e., either actual balance or, what may be deemed equivalent thereof, a relatively small amount of unbalance in an ineffectual direction when just one of the tubes 16, 18, and 20 is conducting (or, if desired, just some other predetermined number greater than one); (2) a relatively large amount of unbalance in the ineffectual direction when less than that number is conducting; and (3) "effective unbalance," i. e., an operative amount of unbalance in an opposite and effectual direction when more than that number is conducting.

Provision is made for the fact that the return path over resistor 50 and battery 47 may be inadequate to carry the intended cathode current of the tube 52 if high value bridge impedances are used for the conservation of power. Accordingly, a second return to ground is provided by way of a varistor or rectifier 60. When the bridge is balanced the cathode of tube 52 is negative with respect to ground as the voltage drop across resistor 50 in the voltage divider 48, 50 is less than the voltage of battery 47. To this end the ratio between the values of the resistors 48 and 50 should be related to the ratio of the voltages provided by the batteries 40 and 47. As a result, varistor 60 is normally non-conducting and therefore does not interfere with the intended condition of balance of the bridge since its impedance to ground from the horizontal diagonal of the bridge and across its right lower arm will have a high value until such time as an effective unbalance produced by the firing of more than one of the switching tubes causes the establishment of discharge current flow in the detector tube.

In the operation of the circuit as thus far described any unbalance at the bridge caused by the simultaneous establishment of discharge current through more than one of relays 10, 12 or 14 by virtue of, say, the simultaneous presence of two or more control signals unbalances the bridge to a sufficient extent to drive both grids of the discharge tube 52 positive and thus cause it to break down. Discharge current through this tube flows through resistor 38 in such an amount as to cause a large drop of potential thereacross. The reduced potential at the left hand terminal of resistor 38 and therefore upon lead 28 is so low that none of the operated control tubes can draw sufficient current through the associated relay windings to maintain the work circuits actuated. The work circuits are therefore released very rapidly whenever the bridge becomes unbalanced.

If, as shown in the drawing, the control tubes 16, 18 and 20 are gaseous discharge or thyratron tubes such reduction in the anode potential, while sufficient to disable the work circuits will not serve to extinguish the tubes. For this purpose, the anode of detector tube 52 is also connected to the positive terminal of battery 40 by way of the primary winding of a differential polar relay 62 and a series resistor 64. The circuit constants are so arranged that relay 62 operates whenever discharge current flows in detector tube 52. Operation of relay 62 serves to complete an operating circuit for relay 44 which may be traced from the negative terminal of battery 68, the operated contact of relay 62, the winding of relay 44, resistor 38 and battery 40 to ground. Operation of relay 44 serves to open normally closed contact 42, thus in-

terrupting the cathode circuits of the control tubes **16, 18** and **20** which are thereupon extinguished. At the same time it applies the negative pole of a battery **68** through the winding of the relay **44** to the common circuit which normally energizes all of the discharge tubes **16, 18, 20** and **52** thereby extinguishing the tube **52** which will not have been quenched along with the other tubes by operation of the relay **44**. This will take place even though the positive terminal of the battery **40** remains connected to this common circuit since during this operational step substantially all of the potential of the battery **40** will be lost as a voltage drop across the resistor **38**.

Operation of relay **62** also opens the circuit including battery **68**, resistor **70** and battery **72**. The connection to battery **68** having been removed, battery **72** begins to charge a capacitor **74** positively through the series circuit including resistor **70** and completed by way of ground. A discharge tube **76** is connected in series with a secondary winding of relay **62** and across capacitor **74**. When the potential across capacitor **74** reaches such a value as to ionize the discharge tube **76**, it breaks down and current flows therethrough. The time at which this occurs following initial operation of relay **62** upon unbalance of the bridge is determined by the RC circuit comprising resistor **70** and the capacitor **74**.

The flow of current in discharge tube **76** passes through the secondary winding of relay **62** in such a direction as to return this relay to the original position. Release of relay **62** in turn permits release of relay **44** re-establishing the cathode circuits of the control tubes and preparing them for operation in respect to any control signals then present at input terminals **32, 34** and **36**. At the same time, the re-establishment of the circuit over the unoperated contact of relay **62** extinguishes discharge tube **76** since the same potential (from battery **68**) is applied to both of its terminals. This completes the restoration of the control circuit to its original condition. If, at this time, only one control signal is present on the input to the controlling tube, the associated work circuit may be actuated. If, on the other hand, more than one control signal is still present at the input terminals, the cycle of operations just described will be repeated until such time as only one control voltage is present.

What is claimed is:

1. In a lockout and selector circuit a plurality of discharge tubes each controlling an individual work circuit and having at least anode, cathode and control grid elements, individual means for abruptly switching over each of the tubes from a substantially non-conducting to a conducting condition, a four-arm bridge one of the arms of which includes the said discharge tubes in parallel, and the other arms of which are proportioned for a predetermined condition of effective balance of the bridge only when fewer than a predetermined number of said tubes are conductive, a source of potential connected across one diagonal of said bridge to supply anode current for said tubes and means responsive to a predetermined effective unbalance of said bridge to interrupt conduction in all of said tubes.

2. In a lockout and selector circuit a plurality of discharge tubes each controlling an individual work circuit and having at least anode, cathode and control grid elements, individual means for abruptly switching over each of the tubes from a substantially non-conductive to a conductive condition, a four-arm bridge one of the arms of which includes said tubes in parallel, and the other arms of which are proportioned for a predetermined condition of effective balance of the bridge only when fewer than two of said tubes are conductive, a source of potential connected across one diagonal of said bridge to supply anode current for said tubes, a detector connected across the other diagonal of said bridge and means responsive to said detector upon a predetermined effective unbalance of said bridge for interrupting conduction in all of said tubes.

3. In a lockout and selector circuit a plurality of discharge tubes each controlling an individual work circuit and having at least anode, cathode and control grid elements, a four-arm bridge one of the arms of which includes said tubes in parallel, and the other arms of which are proportioned for balance of the bridge only when fewer than at least two of said tubes are conductive, a source of potential connected across one diagonal of said bridge to supply anode current for said tubes, a detector connected across the other diagonal of said bridge, means responsive to said detector upon a predetermined unbalance of the bridge for effectively removing the operating potential from said tubes, and a timer circuit started by said detector upon said unbalance of the bridge and effective after a predetermined interval to disable said potential removing means to permit further operation of said control tubes.

4. In a lockout and selector circuit a plurality of gaseous discharge tubes each drawing current through and controlling the operation of an individual work circuit when fired in response to individual control signals, a source of operating potential for said tubes, an impedance connected in a common circuit between said source of potential and the anodes of all of said tubes, said impedance and the parallel impedance of said tubes comprising one arm of a four-arm bridge, the remaining arms comprising first, second and third impedances, said first impedance being connected as a cathode impedance in common for all of said tubes, means for connecting said source of potential across one diagonal of said bridge to supply operating potentials to said tubes, and a detector connected across the other diagonal of said bridge and responsive to an unbalance of the bridge upon simultaneous conduction of at least a predetermined plurality of said tubes to effectively remove the operating potentials therefrom.

5. In a lockout and selector circuit a plurality of discharge tubes each controlling an individual work circuit and having at least anode, cathode and control grid elements, a four-arm bridge one of the arms of which includes said tubes in parallel, and the other arms of which are proportioned for a predetermined condition of effective balance of the bridge only when fewer than at least two of said tubes are conductive, a source of potential connected across one diagonal of said bridge to supply anode current for said tubes and means responsive to a predetermined effective unbalance of said bridge to reduce the current in any of said tubes which are conducting disabling the work circuits controlled thereby, means also responsive to such unbalance thereafter to remove the operating potentials from said tubes to extinguish the flow of current therein, and means for re-establishing said operating potentials for said tubes after a predetermined time interval.

6. In a lockout and selector circuit, a plurality of discharge tubes each responsive to an individual signal to control an individual work circuit, means for connecting said tubes in parallel, an impedance shared in common by the cathode circuits of said tubes, additional impedances connected to complete a bridge circuit adjacent arms of which include said parallel-connected tubes and said impedance respectively, the impedances of said bridge being proportioned for a predetermined condition of effective balance only when fewer than at least two of said control tubes are conductive, a source of potential connected across one diagonal of said bridge to supply operating potentials for said tubes, a detector circuit connected across the other diagonal of the bridge and means responsive to said detector upon a predetermined effective unbalance of said bridge effectively to prevent operation of any of said work circuits.

7. In a lockout and selector circuit a plurality of control tubes each having at least anode, cathode and control grid elements and responsive to an individual signal to control an individual work circuit, means for connecting

said tubes in parallel, a source of operating potential for said tubes, a first impedance connecting the paralleled anode circuits of said tubes to one terminal of said source of potential, a second impedance connecting the paralleled cathodes of said tubes to the other terminal of said source of potential, additional impedances connected to complete a bridge circuit having said source of potential across one diagonal thereof, a detector tube having at least anode, cathode and control grid elements, means for connecting the grid and cathode respectively of said detector tube across the other diagonal of said bridge, and means connecting the anode-cathode circuit of said detector tube across said source of potential by way of said first impedance said detector being responsive to a predetermined unbalance of the bridge to draw current through said first impedance to reduce the operating potentials of said control tubes.

8. In a lockout and selector circuit a plurality of control tubes each having at least anode, cathode and control grid elements and responsive to an individual signal to control an individual work circuit, means for connecting said tubes in parallel, a source of operating potential for said tubes, a first impedance connecting the paralleled anode circuits of said tubes to one terminal of said source of potential, a second impedance connecting the paralleled cathodes of said tubes to the other terminal of said source of potential, additional impedances connected to complete a bridge circuit having said source of potential across one diagonal thereof, a detector tube having at least anode, cathode and control grid elements, means for connecting the grid and cathode respectively of said detector tube across the other diagonal of said bridge, and means responsive to current flow in said detector due to a continued predetermined unbalance of said bridge to open the cathode circuits of said control tubes.

9. In a lockout and selector circuit a plurality of control tubes each having at least anode, cathode and control grid elements and responsive to an individual signal to control an individual work circuit, means for connecting said tubes in parallel, a source of operating potential for said tubes, a first impedance connecting the paralleled anode circuits of said tubes to one terminal of said source of potential, a second impedance connecting the paralleled cathodes of said tubes to the other terminal of said source of potential, additional impedances connected to complete a bridge circuit having said source of potential across one diagonal thereof, a detector tube having at least anode, cathode and control grid elements, means for connecting the grid and cathode respectively of said detector tube across the other diagonal of said bridge, and means responsive to current flow in said detector due to a continued predetermined unbalance of said bridge to open the cathode circuits of said control tubes, said means comprising a relay responsive to current flow in said detector and operative also effectively to remove the operating potential from the anode of said detector tube.

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