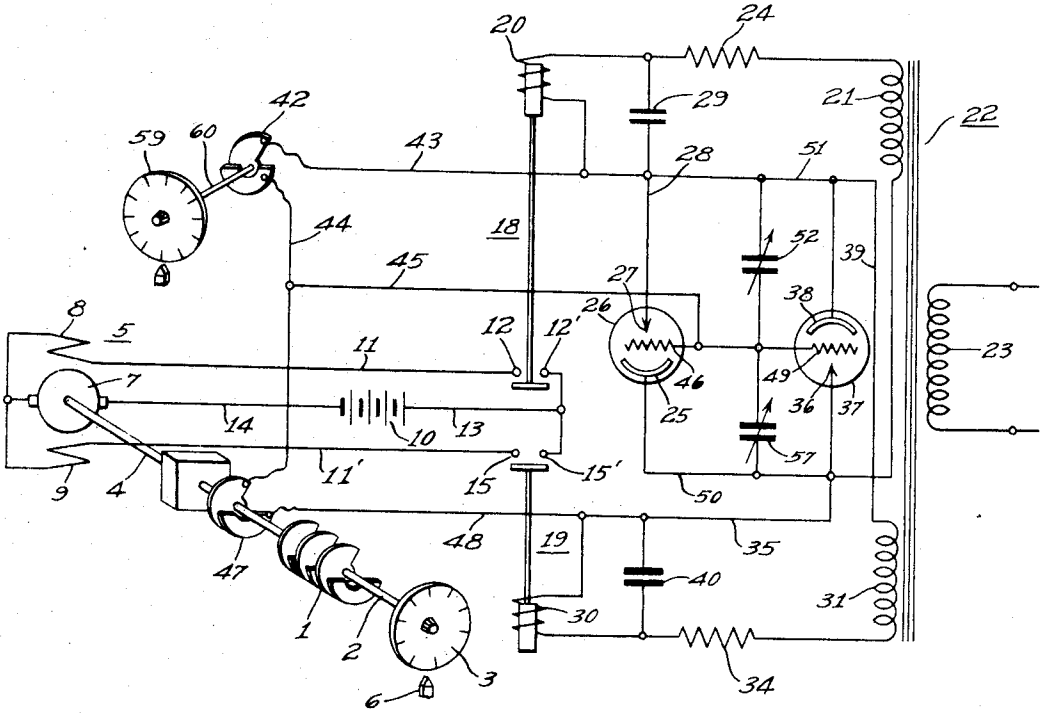
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REMOTE CONTROL

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## REMOTE CONTROL

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This invention relates to control systems, and more particularly, to electrical systems in which the direction and the extent of the movement of the apparatus to be controlled may be automatically obtained in accordance with the direction and the extent of movement of a control instrument located nearby or at a distance from the controlled apparatus.

Systems of this type find extensive application for various purposes, such as the control of the movement of guns on a battleship, from a central location or the simultaneous indication of an instrument at a distance point.

The invention is particularly adaptable to the remote tuning of radio receivers in that it provides continuous progressive movement of the tuning dial by the simple manual adjustment of a similar dial at a remote point. This application of the invention was chosen for the purpose of illustration in order to simplify the understanding thereof, although no limitation is intended thereby for it will be readily seen that the nature of the controlled apparatus has no bearing on the invention herein described and may be anything from a large elevator to a small indicating instrument.

The principle of operation of the invention is based upon the particular characteristics of gaseous electric discharge devices of the positive control type. By positive control is meant the type which becomes conductively energized when the control grid is positive with respect to the cathode. These devices may have cold or thermionic cathodes. As an example, the discharge device known as the "grid-glow tube" and described in United States Patent No. 2,062,268 is particularly suitable in connection with the present invention. A cold cathode type of the above tube is shown in the embodiment of the invention herein described and a device of the above described general type is to be understood by the terms "tube" or "discharge tube" wherever it is applied. The great sensitivity of this tube to small variations of a leakage path between its anode and control electrode for producing gaseous discharge and conduction between anode and cathode thereof is one of the desirable factors to which may be added the ease of control to produce a nonconductive state by means of another high resistance leakage path between its control electrode and cathode which will counter-balance the effect produced by the first-mentioned leakage path. This state may be designated as an electrical equilibrium maintaining the tube nonconductive as long as a balance exists between the two opposing leakage paths. The function of the grid-glow tube will be further explained in connection with the description of the operation of the control system.

A particular feature of this invention is that when the control system is applied to remote tuning of any apparatus, for instance, a radio receiver, the tuning operation at the remote point involves merely the turning of a dial which may be graduated in kilocycles or meters in the same manner as the original tuning dial of the receiver, and that the setting thereof in any direction and to any small increment of the scale will effect the energization of the conventional tuning motor to drive the receiver tuning condenser in the same direction and to the same or any desired increment of the dial scale.

Another feature of the invention is that the control system when in standby condition, consumes no power from the supply and that the control circuit associated therewith operates merely upon capacitive change and potential charges; hence, carries no current.

An advantage of the control system in accordance with this invention resides in that only two conductors are necessary between the remotely located tuning element and the radio receiver to be controlled.

Other features and advantages will be apparent from the following description of the invention, pointed out in particularity by the appended claims, and taken in connection with the accompanying drawing, in which the single figure illustrates a schematic arrangement of the remote actuation of a tuning condenser assembly.

Referring to the figure, the apparatus to be controlled is shown here in perspective as a gang condenser 1, the shaft 2 of which carries a dial 3 at one end and at the other end is connected through suitable reduction gearing to the shaft 4 of an electric motor 5. The gang condenser 1 is intended to represent symbolically the tuning element of a radio receiver. All connections of this condenser with the receiver and other components of the receiver have been omitted inasmuch as the invention does not concern itself with the particular type of radio receiver intended to be controlled. Any receiver may be provided with a suitable tuning motor for automatic actuation and such receivers are well known in the art. Moreover, it is not essential that the dial 3 be that of a radio receiver. It is sufficient to state that it is desired to set the dial 3 to any predetermined position with respect to the indicator 6 in order to automatically actuate a similar dial located at the remote point.

The motor 5 herein shown is of the dual-field type having a field winding 8 and 9, each being adapted to be energized from a source shown here by the battery 10. The field 8 is connected in series with the armature to the battery 10 through conductor 11, switch contacts 12 and 12' and conductors 13 and 14, whereas the field 9 is connected to the battery 10 in series with the armature 7 through conductor 11', switch contacts 15 and 15' and conductors 13 and 14. In this manner, when the switch contacts 12 and 12' are bridged, the motor is energized to rotate in one direction and when the switch contacts 15 and 15' are bridged, in the opposite direction. The bridging of the contacts 12 and 12' is effected by the relay 18 and the bridging of the contacts 15 and 15' by the relay 19.

The source of energization for the winding 20 of the relay 18 is the secondary winding 21 of a transformer 22. The winding 21 is connected to one terminal of the winding 20 through a resistance 24. The other terminal of the winding 21 connects to the cathode 25 of the grid-glow tube 26. The anode 27 thereof connects through conductor 28 to the other terminal of the winding 20. The latter is suitably bypassed by a condenser 29. The energizing circuit of the relay 18 between the winding 20 and the energizing source comprising the secondary winding 21 includes in series, the resistance 24 and the cathode-anode path of the grid-glow tube 26.

The relay 19 is similarly connected in that one terminal of its winding 30 connects to one terminal of another secondary winding 31 of the transformer 22 in series with resistance 34, and the other terminal through conductor 35 to the anode 36 of a second grid-glow tube 37. The cathode 38 thereof connects through conductor 39 to the other terminal of the winding 31. Condenser 40 is connected directly across the terminals of the winding 30.

From the above description, it is seen that the two tubes 26 and 37, respectively, are interconnected with respect to their electrodes in such manner that the control electrodes 46 and 49 are directly connected with each other, whereas the anode of one tube connects to the cathode of the other and vice versa. Such connection of tubes is generally referred to as "back-to-back connection." The conductive energization of the tube 26 will permit current to flow from the winding 21 to the relay winding 20 and, similarly, conductive energization of the tube 37 will permit current flow from the winding 31 to the relay winding 30. The circuit for energizing the grid-glow tubes is shown to be alternating current obtained directly from a suitable power supply line to which the primary winding 23 of the transformer 22 may be connected. The current through the windings 20 and 30 will be pulsating direct current by virtue of the rectifying action of each glow tube. The condensers 29 and 40, in connection with their respective windings to which they are connected, act as filters or energy storing means to maintain operation of the relays 18 and 19, respectively, during the non-conducting half-cycles.

In order to control the energization of the tubes and thereby the operation of the relays 18 and 19, a capacitive control circuit is provided between electrodes of the respective tubes in that a condenser 42 is connected through conductors 43, 44 and 45, between grid 46, and anode 27 of tube 26, and another condenser 47 through conductors 44, 45 and 48, between anode 36 and grid 49 of the tube 37. The condenser 47 is mechanically interlinked with the tuning condenser and rotates simultaneously therewith. The cathode 25 of tube 26 is interconnected through conductor 50 with the anode 36 of tube 37 and correspondingly the anode 27 of tube 26 through conductor 51 with the cathode 38 of tube 37. Through this interconnection, the condenser 42 while connected between anode 27 and grid 46 of tube 26, is also effectively connected between grid 49 and cathode 38 of tube 37. Similarly, the condenser 47 while connected to the anode 36 and grid 49 of tube 37, is also effectively connected to the cathode 25 and grid 46 of tube 26. In parallel with each condenser 42 and 47 are condensers 52 and 57, respectively.

Before describing the operation of the system, let it be mentioned again that the action of the grid-glow tube as to initiation of space current conductivity depends upon the leakage between its grid-anode and grid-cathode path. A lower resistance path between grid and anode as, for example, an increase of capacity, will cause a state of conductivity whereas a similar path between its grid and cathode, will nullify the above effect. Moreover, an increase of the leakage between grid and cathode will bias the tube in lowering its sensitivity to conduction until this path is counter-balanced or offset by an increase in the leakage between grid and anode of the tube. A leakage path may be provided either by an ohmic resistance or by an impedance such as an inductance or a capacity. The latter was chosen here in illustrating a preferred embodiment of the invention because capacitive leakage elements have certain practical advantages. To mention a few, variable condensers of the type generally used in circuits may be employed and thereby the calibration of the remote dial made uniform with that of the tuning dial of the receiver. The use of variable resistances or inductances introduces certain mechanical difficulties particularly in obtaining a certain uniform rate of change in the resistance or impedance value between two components. However, no limitation is intended in showing variable condensers as the leakage elements.

Following the circuit herein shown, it is seen that the condenser 42 provides a certain leakage path between grid and anode of the tube 26 depending upon its particular capacitive adjustment, and that this path may be counter-balanced by the condenser 47 which provides a leakage path between grid 46 and cathode 25 of the same tube. At a particular setting, the two condensers provide equal leakage paths and thereby maintain a state of equilibrium in the tube, at which time it is non-conductive, although sensitive to any capacitive change between its grid and anode to effect conduction. The same is true with respect to the tube 37 except in the reversed order. Here, the capacity 47 provides the leakage path between anode 36 and grid 49, whereas the condenser 42 provides the counter-balancing leakage path between cathode 38 and grid 49. Condensers 52 and 57 are small with respect to the operating condensers 42 and 47 serving merely as trimmer capacitors to compensate for capacitive differences that may exist when the two operating condensers are in the same position and also for the capacity introduced by the conductors.

Referring to the operation of the control system, let it be assumed that it is desired to move the tuning condenser 1 in counterclockwise di-

rection to the extent represented by three divisions on the dial 3. To do this, the condenser 42 at the remote point is turned also in a counterclockwise direction to the extent represented by three divisions on the dial 59 which is attached to the shaft 60 thereof. The result will be an increase in the capacity of the condenser 42 providing a leakage path of lower resistance between anode 27 and grid 46 of the tube 26. The latter becomes immediately conductive permitting current to flow to the winding 20 of the relay 18. This, in turn, closes the circuit between contacts 12 and 12', energizing the motor 5 through its field winding 8, which is so poled as to rotate the tuning condenser 1 of the radio receiver through a suitable reduction gearing also in a counterclockwise direction. The motion thereof rotates the condenser 47 to increase its capacity similarly. When this capacity reaches the corresponding value of the capacity 42, the leakage path between cathode 25 and grid 46 will be increased until it equals that offered by the condenser 42, thereby reestablishing again the condition of balance or electrical equilibrium. The tube 26 becomes non-conductive, releasing the relay 18, which disconnects the motor winding 8. It may well be mentioned here that the capacity increase of the condenser 42 while it provided a leakage path of lower resistance between the grid and cathode of the tube 26, it also provided a similar path between the cathode 38 and grid 49 of the tube 37, whereby this tube became biased to non-conduction and its sensitivity was reduced to a certain degree. Hence, when the condenser 47 is moved by virtue of the actuation of the motor, the increase of this capacity which provides an increase of leakage path between anode 36 and grid 49 of the tube 37 does not cause actuation of the tube 37 due to the bias aforementioned. When equilibrium is re-established, the capacitive leakage paths in both tubes are again neutralized and the sensitivity of both tubes restored.

Considering control in the opposite direction, the clockwise setting of the dial 59 will cause a capacitive setting of the condenser 42 of lower capacity resulting in a higher resistance leakage path between grid and anode of tube 26. A higher resistance leakage path between anode and grid is equivalent, in effect, to a lower resistance leakage path between cathode and grid, which as was stated before, provides a certain bias for the tube. Consequently, tube 26 will not be conducting; as a matter of fact, its sensitivity will be lowered. Furthermore, the capacitive change of the condenser 42 provides also a higher resistance leakage path between cathode 38 and grid 49 of tube 47. A high resistance leakage path between these electrodes, in effect, is equal to a lower resistance path between anode 36 and grid 49 which will trigger the tube 37 into conductive action, whereby the relay 19 will be energized, closing the contacts 15 and 15' and switching into the circuit the field winding 9 of the motor 5. The rotation of the tuning condenser 1 will now be energized in a clockwise direction until the condenser 47 will be lowered in capacity to a degree which will counter-balance the higher resistance path between grid 49 and cathode 38 of tube 37. In other words, the decrease of capacity of condenser 47 will decrease the leakage path between anode 36 and grid 49. When a state of equilibrium is reached, the tube will be non-conductive and the relay 19 disconnects the motor from the circuit.

I claim as my invention:

1. In a control system, apparatus to be controlled as to its movement, control means for said apparatus including a pair of discharge tubes connected back-to-back, the space current conductivity of which initiates movement of said apparatus, individual energizing circuits for said tubes, a circuit capacitively interconnecting said tubes for maintaining electrical equilibrium thereby preventing space current conductivity of said tubes, capacitive means at a control point for disturbing said equilibrium and thereby initiating movement of said apparatus and capacitive means coactively associated with said apparatus for restoring said equilibrium upon predetermined movement thereof.

2. In a control system, apparatus to be controlled as to its movement in one direction and in the opposite direction, control means for said apparatus including a pair of discharge tubes connected back-to-back, the space current conductivity of one of said tubes initiating movement of said apparatus in one direction and the space current conductivity of the other of said tubes in the other direction, circuits for individually energizing said tubes, a second circuit capacitively interconnecting said tubes for maintaining electrical equilibrium and thereby preventing space current conductivity of said tubes, means at a control point for effecting a change of capacitance in said second circuit thereby disturbing said equilibrium, said last mentioned means being operable upon increase of capacitance to cause conductive energization of one of said tubes and upon decrease thereof to cause conductive energization of the other of said tubes, and means coactively associated with said apparatus for effecting a capacitance change in said second circuit in such sense as to restore said equilibrium upon a predetermined movement of said apparatus.

3. In a control system, apparatus to be controlled as to its movement in one direction and in the opposite direction, control means for said apparatus including a pair of discharge tubes connected back-to-back, the space current energization of one of said tubes initiating movement of said apparatus in one direction and the space current energization of the other of said tubes in the other direction, circuits for individually energizing said tubes, a second circuit capacitively interconnecting said tubes for maintaining electrical equilibrium and thereby preventing the energization of said tubes, means at a control point for effecting a change of capacitance in said second circuit thereby disturbing said equilibrium, said last mentioned means being operable upon increase of capacitance to cause energization of one of said tubes and upon decrease thereof to cause energization of the other of said tubes, and means coactively associated with said apparatus for effecting a capacitance change in said second circuit in such sense as to restore said equilibrium upon movement of said apparatus determined by the extent of said capacitive change at said control point.

4. In a control system, a pair of discharge tubes each having an anode, a cathode and a grid electrode, an energizing circuit for each of said tubes between the anode and cathode including in series means responsive to current flow between said electrodes, apparatus controlled by said means, a circuit interconnecting the anode and grid electrode of one of said tubes and the grid electrode and cathode of the other of said tubes including

impedance elements for effectively counter-balancing their grid anode and grid cathode paths, respectively, producing thereby a state of electrical equilibrium at which said tubes are non-conducting, means associated with one of said elements for changing the impedance between anode and grid electrode of one of said tubes disturbing thereby said equilibrium and initiating current flow in one of said tubes, and means coactively associated with said apparatus for changing the impedance between grid and cathode of the other of said tubes thereby restoring said equilibrium upon predetermined actuation of said apparatus.

5. In a control system, a controlled apparatus adapted to be rotated in both directions, a pair of discharge tubes, each having at least an anode, a cathode, and a control electrode, circuit arrangement for causing rotation of said apparatus in one direction upon conductive energization of one of said tubes and in the other direction upon conductive energization of the other of said tubes, means for establishing electrical equilibrium between said tubes whereby said tubes are non-conducting comprising a pair of variable capacities, one of said capacities being connected between certain electrodes of said tubes and located at a remote point from said apparatus and the other of said capacities connected between similar electrodes of said tubes and interlinked with said apparatus for rotary movement of capacitive change, whereby a desired change of said remote capacity effects a disturbance in said equilibrium causing rotation of said apparatus and corresponding rotation of said other capacity restores said equilibrium upon said last-mentioned capacity being adjusted to a value sufficient for neutralizing the effect of said first-mentioned capacity.

6. In a control system, a controlled apparatus adapted to be rotated in both directions, a pair of discharge tubes, each having at least an anode, a cathode, and a control electrode, circuit arrangement for causing rotation of said apparatus in one direction upon conductive energization of one of said tubes and in the other direction upon conductive energization of the other of said tubes, means for establishing electrical equilibrium between said tubes whereby said tubes are non-conducting comprising a pair of variable capacities, one of said capacities being connected between control electrodes and the anode of one of said tubes and between control electrode and cathode of the other of said tubes and located at a remote point from said apparatus and the other of said capacities being connected between control electrode and cathode of said first-mentioned tube and between control electrode and anode of said second mentioned tube and interlinked with said apparatus for rotary movement of capacitive change, whereby a desired change of said remote capacity effects a disturbance in said equilibrium causing rotation of said apparatus and corresponding rotation of said other capacity restores said equilibrium upon said last-mentioned capacity being adjusted to a value corresponding to that of said first-mentioned capacity.

7. In a control system, a controlled apparatus adapted to be rotated in both directions, a pair of discharge tubes each having anode, cathode and grid electrodes, circuit arrangement for causing rotation of said apparatus in one direction upon conductive energization of one of said tubes and in the other direction upon conductive energization of the other of said tubes, a pair of adjustable condensers one being located at a remote point and effective to produce a capacitive leakage path between anode and grid electrode of one of said tubes, and simultaneously a similar path between cathode and grid electrode of the other of said tubes, the other of said condensers being attached to said apparatus for varying its capacity upon rotation and effective to produce a capacitive leakage path between cathode and grid electrode of said first tube, and correspondingly between anode and grid electrode of said second tube, the effective capacitive reactance of said condensers at a certain adjustment being complementary to balance opposing effects of said leakage path, thereby establishing a state of electrical equilibrium between said tubes, said tubes being then non-conductive, manually adjusting means for said first condenser for creating a leakage path between grid and anode of one of said tubes greater than said path between grid and cathode thereof, causing conductive energization of one of said tubes and rotation of said controlled apparatus in one direction, and upon movement of said control apparatus a corresponding adjustment of said second condenser for producing a leakage path between cathode and grid electrode of said tube opposing the effect of said first leakage path upon adjustment of said condenser to a predetermined value whereby said state of equilibrium is re-established.

8. In a control system, a motor, a source of energy therefor, switching means for energizing said motor for operation in one direction and switching means for energizing said motor for operation in the reverse direction, a pair of grid-glow tubes each having an anode, a cathode and a grid electrode, individual energizing circuits for said tubes between anode and cathode electrodes, one of said circuits including said first switching means and the other of said circuits said second switching means, means for controlling the direction and extent of rotation of said motor comprising a variable capacity effectively connected between anode and grid electrodes of one of said tubes and between grid and cathode electrode of the other of said tubes, a second variable capacity effectively connected between grid and cathode of said first-mentioned tube and between grid and anode of said second tube, a change of said first capacity in one direction being effective for operative energization of one of said tubes and in the other direction of operative energization of the other of said tubes causing actuation of said motor in corresponding directions, said second capacity being mechanically interlinked with the movement of said motor and operable in cancelling the effect of said first capacity.

9. In a control system, apparatus to be controlled as to its movement, control means for said apparatus including a pair of discharge tubes connected back-to-back, the space current conductivity of which initiates movement of said apparatus, individual energizing circuits for said tubes, a circuit including an adjustable impedance element interconnecting said tubes for maintaining electrical equilibrium and thereby preventing space current conductivity of said tubes, adjustable impedance means at a control point for disturbing said equilibrium and thereby initiating movement of said apparatus, and means coactively associated with said apparatus for effecting adjustment of said first mentioned impedance means thereby restoring said equilibrium upon predetermined movement of said apparatus.

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