

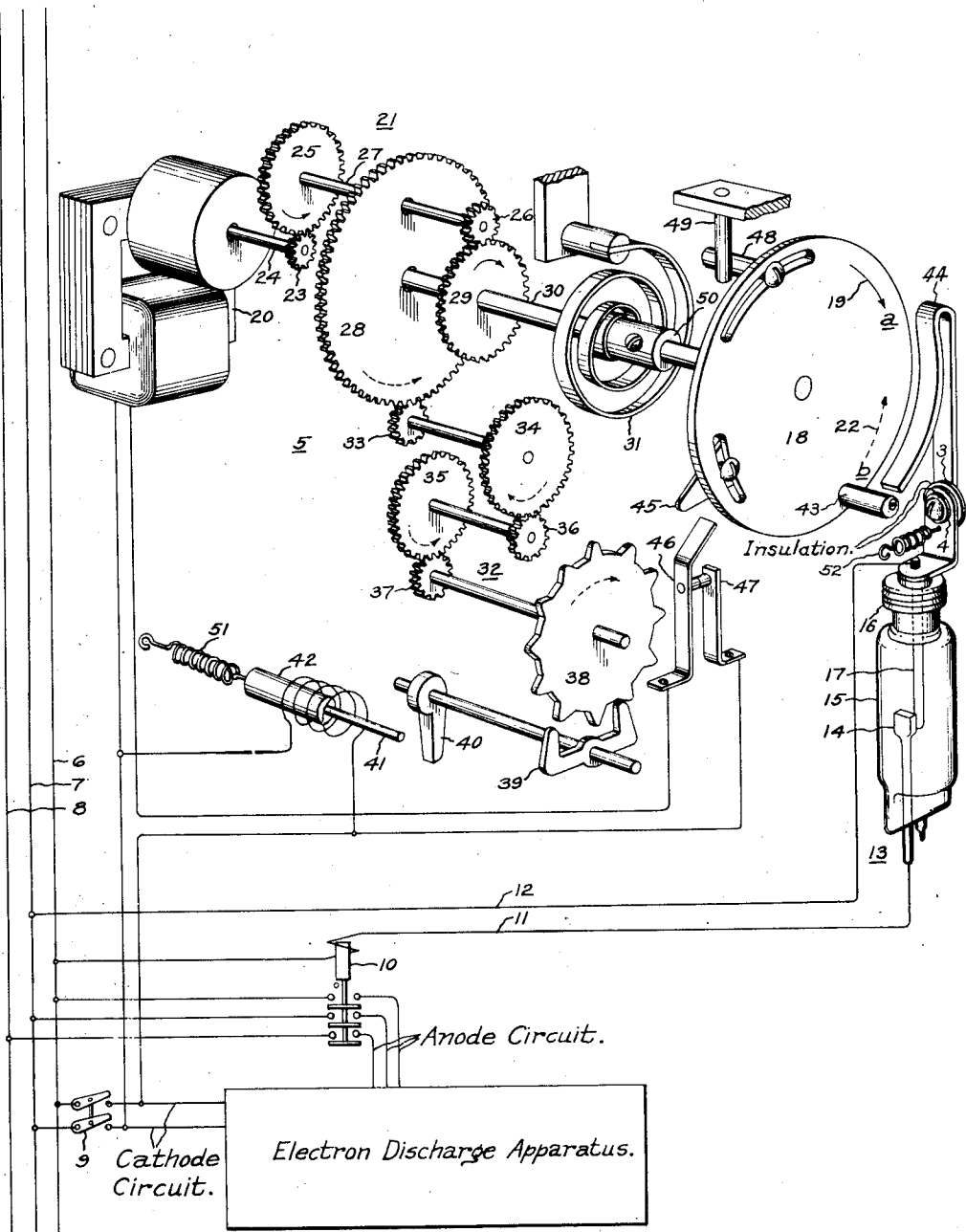
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CONTROL DEVICE

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## CONTROL DEVICE

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My invention relates to improvements in control devices and more particularly to improvements in devices for controlling the application of potential to the anode of an electric discharge valve of the thermionic cathode type in accordance with the thermal characteristic of the cathode.

Where electric valves of the thermionic cathode type, such for example as those having incandescent cathodes or those provided with electron emitting cathodes activated from an independent heater, are used, it is essential to the satisfactory operation of the valves that the cathode attain the normal operating temperature before a valve is energized to carry the load current of the translating circuit in which the valve is used and that the current in the valve be interrupted whenever the cathode temperature drops below the normal operating value. This is particularly true with electric valves of the vapor electric discharge type, whose operation depends on the ionization of the contained vapor. If a valve of this type is energized to carry the current of the translating circuit before its cathode reaches the proper temperature, an abnormally large part of the potential of the translating circuit will be consumed in the valve. The effect of this is to destroy the electron emitting properties of the cathode by positive ion bombardment. Inasmuch as the heating time of a cold valve may be anywhere from two or three minutes up to thirty minutes or more, it will be obvious that where thermionic cathode valves are used intermittently at intervals less than this time, much delay would result if it were necessary each time the cathode circuit is interrupted to wait the full period before energizing the anode circuit. The delay involved follows whether the cathode circuit is purposely interrupted, or accidentally as in case of an overloaded circuit breaker. Even if such delay could be tolerated in some industrial applications, it is absolutely out of the question under more critical conditions, such as are involved in gunfire control. Inasmuch as the heating and cooling characteristics of the cathode of a valve of the thermionic cathode type may differ appreciably, it is necessary to correlate the valve control with such differences in order to minimize the loss in operating time and insure safety. Accordingly one object of my invention is to provide an improved control device whereby the normal flow of current from the anode circuit of an electric valve of the thermionic cathode type can be prevented until the cathode reaches the proper operating temperature. Another object

of my invention is to provide an improved control device whereby an electric valve of the thermionic cathode type can be prevented from operating in a translating circuit when the cathode of the valve falls below its proper operating temperature. A further object of my invention is to provide an improved control device which operates on the basis of the heating and cooling characteristics of the cathode so as to take care of differences between such characteristics. A still further object of my invention is to provide an improved control device whereby the time in which the anode circuit can be re-energized may be reduced in accordance with the heat storage or thermal condition of the cathode. These and other objects of my invention will appear in more detail hereinafter.

My invention will be better understood from the following description when considered in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

The single figure of the accompanying drawing illustrates in expanded perspective a control device 5 embodying my invention and shown as arranged for controlling the anode circuit of an electron discharge apparatus which is assumed to include one or more electric valves of the thermionic cathode type. The cathode circuit of the electron discharge apparatus may be energized from an A. C. bus 6, 7, 8 through the contacts of any suitable switching means 9. The anode circuit may also be energized from the bus 6, 7, 8 through the contacts of any suitable switching means, such as a contactor 10, whose energizing circuit 11, 12 is under the control of the control device 5. For this purpose, the control device may include any suitable switching means 13, examples of which are well known to the art. The particular switching means illustrated is of the vacuum type wherein a fixed electrode or contact 14 is mounted in an evacuated chamber 15, to which is secured a bellows device 16. This device supports the movable contact 17 which is operated by the device 5 in accordance with the heating characteristic of the cathode of the valve to be controlled, as will hereinafter appear.

For operating the switching means 13, the control device 5 includes a movable element, such as a rotatable member 18, which is arranged to be driven in the forward direction, indicated by the full line arrow 19, by any suitable means, such as a motor 20 through the intermediary of a gear mechanism 21. In order that the control member 18 may rotate in the reverse direction, indicated by the broken line arrow 22, independ-

ently of the motor 20, the gear mechanism 21 is preferably of a differential type. As shown, the gear mechanism 21 includes a reducing gear train such as the pinion 23 on the motor drive shaft 24, gears 25 and 26 on a shaft 27, which is free to turn in and with the differential gear 28 and a gear 29 which is secured to the shaft 30 to which the control member 18 is secured. The differential gear 28 is free to turn on the shaft 30.

In order to insure the reverse rotation of the control member 18, I provide means such as a spiral spring 31 in which energy is stored while the member 18 is being rotated in the forward direction. Since the spring 31 while being wound constitutes a load on the motor 20 the differential gear mechanism must be held to insure forward rotation of the shaft 30. For this purpose, I provide means such as an escapement mechanism 32 which comprises a suitable gear train including gears 33, 34, 35, 36, and 37, an escapement gear 38, a ratchet 39, and a pawl 40. The pawl 40 may be locked to prevent escapement by suitable means, such as a locking bar 41 actuated by an electro-magnet 42 which is energized simultaneously with the motor 20.

In order that the reverse rotation due to the dissipation of the energy of the spring 31 may drive the escapement 32 without reversing the motor 20, this motor may be of any suitable type having, for example, an irreversible drive shaft. For definite timing characteristics and simplicity in operation, the motor may be self-starting and operate at practically uniform speed. I have chosen to illustrate such a motor which is disclosed, for example, in United States Letters Patent 1,495,936, issued May 27, 1924, the drive shaft of this motor being practically irreversible because of its high gear reduction ratio.

Inasmuch as the switching means 13 is to control the application of potential to the cathode circuit, the circuit of the motor 20 is energized simultaneously with the closure of the cathode supply switch 9, which also energizes the magnet 42 to lock the escapement mechanism so as to insure forward rotation of the control member 18. This member carries a projecting crank 43 which, upon forward rotation to an intermediate position *a*, engages a resilient operating arm 44 attached to the movable contact 17 and preferably insulated therefrom by suitable means such as an insulating washer 3 and bushing 4. The engagement of the arm 44 and the crank 43 occurs an interval of time after the energization of the motor sufficiently long to insure the heating of the cathode to a temperature at which it is safe to apply the anode voltage. The member 43 may be eccentrically mounted, as shown, to provide for adjustment of the pressure between contacts 14 and 17. As shown, the control member 18 may be arranged to operate through a further range to a final position *b*. During this range of movement from *a* to *b*, the crank 43 keeps the spring arm 44 in a position to maintain the switching means 13 actuated to the circuit closed position. When the controlling member reaches its final position, the circuit of the motor 20 is interrupted by an arm 45 on the control member 18 which engages contact 46 to separate it from contact 47.

Since in many valves of the thermionic cathode type, the time-temperature curve or rate at which the cathode is heated differs from the rate at which it cools, I make the forward angular velocity of the control member 18 different from the reverse angular velocity. Generally speaking,

the cooling of the cathode is more rapid than the heating, and consequently the reverse angular velocity should be greater than the forward. This is accomplished in my device through suitable proportioning of the ratio drive of the differential gear mechanism and the escapement gear mechanism. In order to vary the time of moving the control member 18 in the forward direction from the initial position shown in the figure to the intermediate position *a*, the control member may be provided with an adjustably positioned arm 48 which engages a suitable stop 49. The operating range *b* to *a* over which movement of the control member takes place while the cathode temperature is falling from the normal operating temperature to the safe operating temperature may be varied by having the switching arm 45 adjustably positioned, as shown. The time during which the reverse motion of the control member occurs can be varied by controlling the initial tension of the spring 31 through suitable means indicated, for example, as an adjustable collar 50 secured to the shaft 30 and the spring.

Assuming the parts positioned as shown in the drawing and that the electron discharge apparatus is to be started with the cathode of the valve cold, then the cathode supply switch 9 is closed. This energizes the cathode, the motor 20, and the magnet 42 of the escapement lock 41, since they are all connected in parallel as shown. The energization of the electromagnet 42 puts the locking bar 41 in the path of the pawl 40, thereby locking the escapement mechanism 32. Consequently, the operation of the motor through the reduction gear mechanism 23, 25, 26, and 29 rotates the shaft 30 in the forward direction indicated by the full line arrows on the gear 29 and the control member 18. The control member 18 is therefore moved from the initial position shown until the crank 43 thereon has moved to the position *a*, where it engages the switch operating arm 44. The time interval for this angular movement to take place is that required by the cathode to attain a temperature safe for operation of the valve. Upon engagement between the crank 43 and the arm 44, the switch 13 is actuated to close its contacts 14 and 17, thereby completing the energizing circuit 11 and 12 of the contactor 10, which closes and completes the anode circuit of the electron discharge apparatus. From the intermediate position *a*, the control member continues to turn in the forward direction, indicated by the full line arrow 19, until the crank 43 attains the position *b*, which corresponds to the point where the thermal input to the cathode is balanced by the heat losses. At this point the switch arm 45 operates the contacts 46 and 47, thereby de-energizing the circuit of the motor 20. As long as the arm 43 is positioned anywhere between the intermediate position *a* and the final position *b*, the switch 13 will be maintained closed to keep the cathode circuit energized and the potential on the anode circuit.

During the forward rotation of the control member 18 the spring 31 is wound for the reverse movement and tends to turn the member 18 in the reverse direction indicated by the broken line arrow 22. Movement in the reverse direction, however, cannot take place until the pawl lock 41 is released, since this lock prevents the escapement from operating and also since the drive shaft 24 of the motor 20 is irreversible. If now for any reason, whether accidental or inten-

tional, the cathode circuit is interrupted, as for example by opening the switch 9, then the electromagnet 42 is de-energized and the locking bar 41 is retracted by the spring 51, whereupon the escapement mechanism is free to operate. Then under the bias of the spring 31, the control member 18 is turned in the reverse direction, indicated by the broken line arrow 22, at a rate which corresponds to the cooling time-temperature characteristic of the cathode.

If before the crank 43 has moved sufficiently in the reverse direction to get beyond the intermediate position *a*, potential is restored to the cathode circuit, then no interruption in operation of the electron discharge apparatus will occur because the magnet 42 will be re-energized to lock the escapement mechanism 32 and from the range *b* to *a* the switch arm 44 is maintained in position to keep the switching means 13 actuated and the contactor 10 energized. In this case, the control member 18 will begin to turn in the forward direction to the final position *b* as before.

If, however, the cathode potential is off for a time greater than it takes the arm to move from position *b* to position *a*, then the switch 13 will open and drop out the contactor 10, thereby de-energizing the anode circuit. In the meantime, the control member 18 continues to turn in the reverse direction, at a rate substantially proportional to the initial cooling rate of the cathode. If the cathode potential is off long enough for the cathode to return to the cold condition, then all the parts will return to the position shown in the drawing. Suitable biasing means such as a spring 52 may be used to insure positive separation of the contacts 14 and 17 when the crank 43 releases the arm 44. Assuming, however, that at some point prior to the cold condition the cathode potential is restored, then the escapement mechanism is again locked and the control member 18 is caused to turn in the forward direction immediately. In other words, without waiting for the cathode to get cold, timing is started at a point corresponding to the then existing temperature of the cathode so that it is unnecessary to wait the amount of time from the cold condition of the cathode to the thermal condition in which it was at the time the cathode potential was restored. Thus, it is merely necessary for the control member 18 to turn through an angular range corresponding to the thermal loss of the cathode for the interval that the cathode potential was removed less the time in turning from *b* to *a*. In other words, it is not always necessary to await the full amount of time from the cold condition of the cathode to the safe operating temperature before starting operation. This is highly important in many specific applications of electric valves in critical situations.

While I have shown and described my invention in considerable detail, I do not desire to be limited to the exact arrangement shown, but seek to cover in the appended claims all those modifications that fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A control device comprising a movable member, driving means operative when energized for a predetermined time to move said member in one direction through an intermediate position to a final position, means operative on failure of energization of said driving means to move

said member in the opposite direction, means energized concurrently with said driving means operative only while energized to prevent movement of said member in said opposite direction, means actuated by said member when it reaches the intermediate position and maintained in the actuated condition while the member is in the range of movement between and including said intermediate and final positions regardless of the direction of movement of the member, and means for deenergizing only said driving means when the member reaches the final position whereby to retain the member in said final position until said preventing means is deenergized.

2. A control device comprising a movable member, driving means operative when energized for a predetermined time to move said member at a given velocity, in one direction through an intermediate position to a final position, means operative on failure of energization of said driving means to move said member in the opposite direction at a different velocity than in the one direction, means energized concurrently with said moving means operative only while energized to prevent movement of said member in said opposite direction, means actuated by said member when it reaches the intermediate position and maintained in the actuated condition while the member is in the range of movement between and including said intermediate and final positions regardless of the direction of movement of the member, and means for deenergizing only said driving means when the member reaches the final position whereby to retain the member in said final position until said preventing means is deenergized.

3. A control device comprising a rotatable member, means comprising a constant speed motor for rotating said member at a given angular velocity in one direction through an intermediate position to a final position when energized for a predetermined time, means in which energy is stored during the rotation of said member in said one direction operative on failure of energization of said motor to rotate the member in the opposite direction at a greater angular velocity than in the one direction, electromagnetic means energized concurrently with said motor operative only while energized to prevent the rotation of said member in said opposite direction, switching means actuated by said member when it reaches the intermediate position and maintained in the actuated condition while the member is in the range of movement between and including said intermediate and final positions regardless of the direction of movement of the member, and other switching means for deenergizing said motor when the member reaches the final position whereby to retain the member in said final position until said electromagnetic means is deenergized.

4. A control device comprising a movable member, driving means operative to move said member in one direction through an intermediate position to a final position when energized for a predetermined time, means operative on failure of energization of said driving means during the movement of said member in said one direction to move the member in the opposite direction, means effective concurrently with the energization of said driving means to prevent movement of said member in said opposite direction, means actuated by said member when it reaches the intermediate position and maintained in the actuated position while the member is in the range

of movement between and including said intermediate and final positions, and means for de-energizing only said driving means when the member reaches the final position and leaving said preventing means effective whereby to retain the member in said final position until said preventing means is rendered ineffective.

5. A control device comprising a rotatable control member, a motor, a differential mechanism between said motor and said member, means for locking said differential mechanism to effect rotation of said member at a definite angular velocity in a forward direction, switching means actuated to a circuit controlling position by said member at an intermediate point of its movement and maintained in said circuit controlling position during a predetermined range of movement of the member, means controlled by said member for stopping the member at the end of said range of movement and maintaining it stationary until the differential mechanism is released by said locking means, and means operative upon the release of said locking means for rotating said member in the reverse direction at a greater angular velocity than in the forward direction including means in which energy is stored while the member is being rotated in the forward direction.

6. A control device comprising a rotatable control member, a motor having an irreversible drive shaft, a differential mechanism between the drive shaft of said motor and said member, an escapement mechanism coupled to said differential mechanism, means for locking said escapement mechanism to effect rotation of said member in a forward direction when said motor is energized, switching means actuated by said member at an intermediate point of its movement and maintained in the actuated condition during a predetermined range of movement of the member, means controlled by said member for de-energizing the motor at the end of said range of movement whereby to stop the forward rotation of the member at the end of said range of movement, and means operative upon the release of said locking means for rotating said member in the reverse direction including means in which energy is stored while the member is being rotated in the forward direction.

7. A control device comprising a rotatable control member, a constant speed motor having an irreversible drive shaft, a differential mechanism between the drive shaft of said motor and said member, an escapement mechanism coupled to said differential mechanism, electromagnetic means for locking said escapement mechanism to effect rotation of said member at a definite angular velocity in a forward direction when said motor is energized, switching means actuated to a circuit controlling position by said member at an intermediate point of its movement and maintained in said circuit controlling position during a predetermined range of movement of the member, means controlled by said member for de-energizing the motor at the end of said range of movement whereby to stop the forward rotation of the member at the end of said range of movement, and means operative upon the release of said locking means for rotating said member in the reverse direction at a greater angular velocity than in the forward direction, including a resilient means in which energy is stored while

the member is being rotated in the forward direction.

8. A control device comprising a rotatable control member, means for rotating said member at a definite angular velocity in a forward direction through an intermediate position to a final position, switching means actuated to a circuit controlling position by said control member when it reaches said intermediate position and maintained in said circuit controlling position while said control member is in and between its intermediate and final positions, means for stopping the member in said final position, means for rotating said control member in the reverse direction at a greater angular velocity than in the forward direction including means in which energy is stored while the member is being rotated in a forward direction, and means for preventing said reverse rotation energized simultaneously with said rotating means but releasable upon de-energization to permit said reverse rotation.

9. A control device comprising a movable control member, a motor, a differential mechanism between said motor and said member, means for locking said mechanism to effect movement of said member from an initial position in one direction at a definite velocity, means actuated by said member at an intermediate point of its movement and maintained in the actuated state during a predetermined range of movement of the member, means for stopping the member at the end of said range of movement and maintaining it stationary until said differential mechanism is released by said locking means, and means operative upon the release of said locking means for moving said member in the opposite direction at a different velocity.

10. A control device comprising a movable control member, a motor, a differential mechanism between said motor and said member, means for locking said mechanism to effect movement of said member in one direction, means actuated by said member at an intermediate point of its movement and maintained in the actuated state during a predetermined range of movement of the member, means for stopping the member at the end of said range of movement and maintaining it stationary until said differential mechanism is released by said locking means, and means operative upon the release of said locking means for moving said member in the opposite direction.

11. A control device comprising a movable control member, a motor, a differential mechanism between said motor and said member, means for locking said mechanism to effect movement of said member from an initial position in one direction at a definite velocity, means actuated by said member at an intermediate point of its movement and maintained in the actuated state during a predetermined range of movement of the member, means for stopping the member at the end of said range of movement and maintaining it stationary until said differential mechanism is released by said locking means, and means operative upon the release of said locking means for moving said member in the opposite direction at a greater velocity than in the one direction including means in which energy is stored while the member is being moved in said one direction.

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