

July 25, 1939.

B. D. BEDFORD

2,167,472

THERMOSTATIC CONTROL OF ELECTRON DISCHARGE APPARATUS

Filed Nov. 18, 1936

2 Sheets-Sheet 1

Fig. 1.

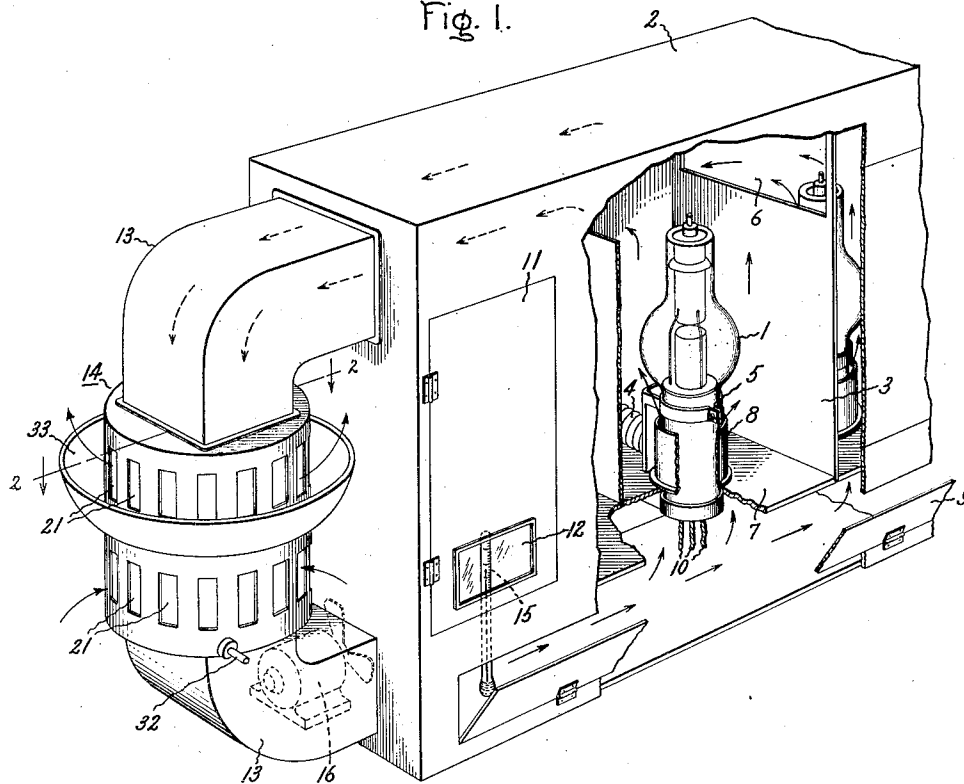
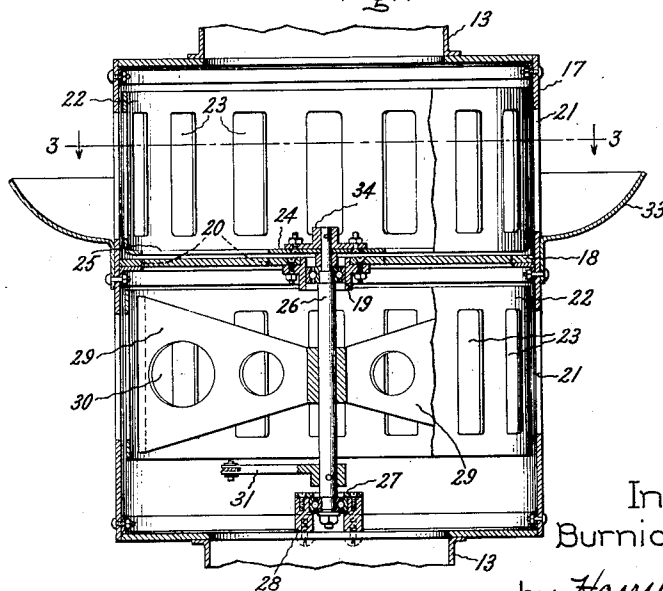


Fig. 2.



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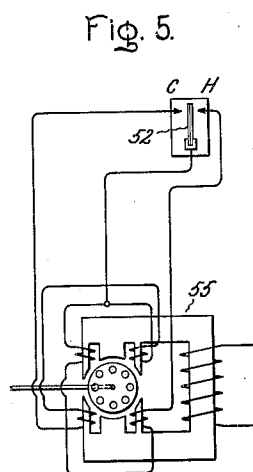
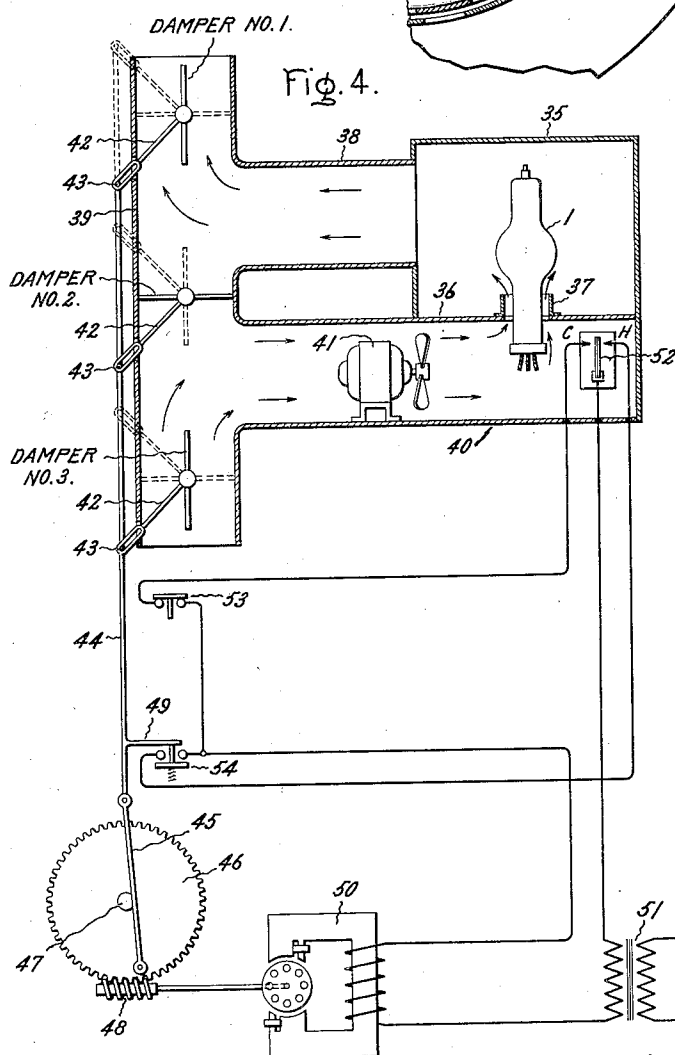
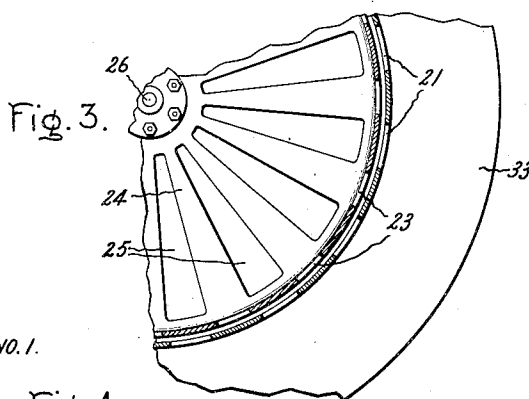
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UNITED STATES PATENT OFFICE

2,167,472

THERMOSTATIC CONTROL OF ELECTRON
DISCHARGE APPARATUSBurnice D. Bedford, Schenectady, N. Y., assignor
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Application November 18, 1936, Serial No. 111,442

2 Claims. (Cl. 236—49)

My present invention relates to electric discharge apparatus, and more particularly to an accessory for maintaining the temperature of such devices relatively constant notwithstanding variable temperature conditions surrounding the apparatus.

Electrical discharge devices which depend upon the ionization of vapor to carry large currents are useful as power rectifiers and relays. These devices ordinarily employ a thermionic cathode as a source of electrons, a cooperating anode and an electrostatic control member or grid, and a vapor which constitutes the ionizable medium. The pressure of the medium and the impressed voltages are such that a discharge of arc-like character is produced between the electrodes, the initiation of the discharge being controlled by the voltage applied to the grid.

The operating characteristics of these devices, such as their current-carrying capacity, also the maximum operating voltage, are determined to a large extent by the vapor pressure of the ionized medium and this in turn is a function, not only of the applied voltages and load currents, but also of the temperature surrounding the device. In order that the operation may be uniform over substantial periods of time under conditions of steady applied voltages, it is important that the devices, or rather certain portions of each envelope, be maintained at constant predetermined temperatures. These devices, when serving as control or relay units, may in practice be positioned in places subject to large temperature variations, as for example, when they are presented alternately to sunlight and shadow, or to summer and winter conditions, so that unless the effects of these temperature variations are compensated, the pressure of the vapor within the device will change and may seriously impair its electrical characteristics. The vapor condenses on the coolest portion of the envelope so that the temperature of this portion determines the amount of mercury present within the tube in the form of vapor, hence, determines the degree of uniformity with which the tube operates. In those tubes which employ a fixed gas for the ionizable medium instead of a vapor, it is also desirable to maintain the entire tube or envelope at a relatively constant temperature. In accordance with my invention, I propose to regulate and control the temperature of the coolest portion of those tubes containing vapor and to control the temperature of the entire envelope of those tubes containing fixed gases, even to the extent of having the temperature of the envelope

or the coolest portion thereof remain substantially constant, notwithstanding variable loads and notwithstanding variable temperature conditions surrounding the device as a whole, so that uniformity of operation under all conditions of ambient temperature may be obtained. It will be understood that the temperature of any particular portion of the tube is dependent, not only upon the temperature of the surrounding medium, i. e., the room temperature, but also upon the heat generated in the tube due to load and cathode currents, all of which may be variable. I intend the terms "ambient temperature" and "ambient condition" as used in the specification and claims to include any or all of these effects and to refer to the temperature or condition respectively of that portion of the surrounding medium which is in the immediate vicinity of the tube and whose temperature is a direct function of that of the envelope. The improvement essentially takes the form of an enclosure accessory in which the tube, whose temperature is to be regulated, is inserted, said enclosure being provided with a fluid return path by which the temperature controlling fluid is caused to recirculate. The recirculated fluid may be directed to a particular part of the tube or the latter may be simply immersed in the fluid. A valve is provided in the fluid return path and operated either manually or automatically for controlling the temperature of the fluid as it is being recirculated.

The invention will be better understood when reference is made to the following description in connection with the accompanying drawings in which Fig. 1 is a perspective view of a multi-unit compartment, partly broken away and containing a battery or group of vapor electric devices and provided with a return or circulatory fluid path which forms the subject of this application; Fig. 2 is an enlarged cross-sectional view of the fluid admission or mixing valve shown in Fig. 1; Fig. 3 is a sectional view taken along line 3—3 of Fig. 2; Fig. 4 is a diagrammatic view of a modified fluid circulating system and an automatic means for operating the same; and Fig. 5 shows a still further modification of the automatic means for controlling the fluid circulating system.

Referring to Fig. 1, numeral 1 designates an arc or glow discharge device of conventional design whose temperature is to be maintained constant under conditions which normally would cause the temperature of the envelope to vary. A number of these tubes which constitute part of the same electrical translation system are contained in a

large, preferably rectangular, enclosure 2 which is partitioned off by upright walls 3 into cubicles or compartments for individual tubes. The tubes are preferably flexibly mounted in the cubicles by means of a support 4 of insulation material, secured to one of the walls of the compartment. The support carries a clamp 5 which embraces the reduced diameter portion of the envelope 1. The walls 3 are provided at their upper end with openings 6 so as to permit a ready circulation of air at the top between the cubicles or compartments.

The enclosure 2 is provided with a false bottom 7 which has an opening (not shown in Fig. 1) in each cubicle directly under the position of each tube 1. There is a long, vertically positioned collar 8 secured to the bottom 7 directly over each opening, the collar having an interior diameter such as to leave an annular space around the tube 1. The cubicles are therefore provided with an annular opening at the bottom around each tube and two openings at the top, one in each side wall. The space between the false bottom 7 and the lowermost wall of the enclosure 2 is made accessible from the exterior by a longitudinal door 9 hinged at the lower edge so as to swing outwardly from the upper edge. Electrical connections may be made to the tube 1 by opening this door and soldering or in any other manner connecting leads to the conductors 10 of the tube.

The tubes may be introduced into their cubicles and mounted in place through a large opening in front of each cubicle, closed by a hinged door 11. One of these doors, the first as shown, may be provided with a window 12 made of any suitable heat-resisting transparent material. The purpose of this window will be explained hereinafter. The enclosure 2 and all of the interior surfaces thereof, including the bottom 7, may be lined with heat insulation material.

There is provided at one end of the enclosure 2, a pair of openings (not shown) which are positioned at the top and bottom of the enclosure and serve as outlet and inlet ports respectively for the air or other medium which circulates thru the annular opening in the collar 8 and out thru the rectangular openings 6. These inlet and outlet ports are connected together by a large, preferably rectangular conduit 13 which contains a fluid mixing valve 14, the details of which are shown more clearly in Figs. 2 and 3. In general, this valve provides a convenient means for either permitting fluid to pass thru the return path 13 back into the enclosure, without any change in its constituency, or else by a simple manipulation of the valve, air or other fluid from the exterior is caused to mix with the fluid in the return path in such proportions as to maintain the temperature within the enclosure 2 substantially constant. A thermometer 15 is mounted within the enclosure at any desired position, depending upon whether the tube 1 is of the vapor or fixed gas type, as explained hereinbefore, and the readings of the thermometer read through the window 12. If this temperature is greater or less than a predetermined amount, the valve 14 may be adjusted either manually or automatically, as will be explained hereinafter, to permit fluid from the exterior to enter and mix with the fluid within the enclosure 2 so as to make the necessary temperature adjustment. In Fig. 1, the valve mechanism 14 is intended to be operated manually, whereas in Figs. 4 and 5, I have shown automatic means for effecting the necessary regulation. Within the lower conduit 13, there may be pro-

vided an exhaust fan 16 to assist in obtaining a strong ventilation or rapid flow of the fluid so that all parts of the enclosure 2 are substantially at the same temperature at any given instant.

Referring more particularly to Figs. 2 and 3 which show a typical form of valve for mixing external fluid with the interior fluid in accordance with desired changes of temperature, it will be noted that the valve takes a generally cylindrical shape with peripheral openings which can be opened or shut by suitable mechanism. The valve comprises essentially a cylindrical member or casing 17 closed at the top and bottom except at the position where the conduits 13 are secured. The cylinder 17 is provided at approximately mid-way of its length with a transverse partition 18 which carries a bearing 19 and contains a number of radially extending wedge-shaped openings, the edges of which are indicated by the dotted lines 20 in Fig. 2. The casing 17 is also provided with a number of equidistantly spaced peripheral openings 21 of a generally rectangular shape. Within the two compartments formed by the partition 18, there is a pair of cylinders 22, also apertured with peripheral openings 23 which correspond in size and position to the openings 21 in the casing 17. These cylinders are adapted to rotate within the casing on the bearing member 19. The upper casing 22 is closed at the bottom by a transverse portion 24 having apertures 25 similar to the apertures in the transverse member 18, as will be seen more clearly in Fig. 3. The position of the various openings in the periphery of the casing 17 and the contained rotating cylinders 22, also the position of the openings in the lower portion of the upper casing 22 are such that when the peripheral openings register with one another, the openings in the transverse member 24 are closed by causing them to overlap the metal of the member 18. A shaft 26 is supported at one end in the ball bearing 19 and at the other end in a ball bearing 27 mounted in any suitable manner, for example, by a grooved bar 28, screwed to the bottom of the casing 17. This shaft is pinned through a hub member 34 to the upper cylinder 22 and carries a number of wedge-like radially extending vanes 29 which are secured at their outer edges to the lower cylinder 22. The vanes 29 are preferably provided with circular openings 30 so as to permit ready movement of the fluid through the various parts of the valve. It will be seen that as the shaft 26 is rotated, the casings 22 are caused to rotate in such a manner that the peripheral openings 23 are brought into register with the peripheral openings 21 to the casing 17, and if the casing is rotated further, the peripheral openings 21 and 23 are moved out of register so as effectively to close the openings. However, in this case, the openings 25 in the transversely extending portion 24 of the upper cylinder 22 register with the openings 20 in the member 18.

For rotating the shaft 26, any well-known crank and lever system 31 may be employed and operated from the exterior by pushing or pulling a rod 32 (see Fig. 1). Accordingly, when the rod is pushed in or pulled out, the shaft 26 is caused to rotate through a small circular angle and the cylinders 22 are given a corresponding movement of rotation. Depending upon the adjustments made within the valve, this movement of the rod 32 may serve either to open or close the peripheral openings and in case these apertures are opened, the openings through the transverse members are effectively closed. When the peripheral apertures are opened by the movement of the rod 32,

it is apparent that the fluid flowing through the upper conduit 13 cannot pass through the transverse member 18 and is caused to flow outwardly through the openings 21 into the atmosphere. In order to prevent the fluid expelled in this manner from passing thru the openings 21 in the upper portion of the casing 17 and returning thru the openings 21 in the lower portion of the casing and thereby re-entering the system, it may be desirable to provide a partly spherical shield 33 which is so formed as to direct the expelled fluid away from the lower openings. It is apparent that air from the exterior is permitted to enter the system through the lower openings in the casing 17 and eventually to find its way into the enclosure 2. The position of the rod 32 and therefore, the determination as to whether the peripheral apertures shall be opened or closed, either partially or entirely, may be manually effected by an operator who observes the readings on the thermometer 15. If these readings are too high and the room temperature is appreciably cooler than the fluid within the casing, the temperature of the latter may be lowered to the proper value by expelling the hot air through the apertures in the upper portion of the casing 17 and permitting fluid of lower temperature to enter the lower apertures in the casing. On the other hand, if the thermometer indicates that the temperature within the casing 2 is below normal, the rod 32 is so adjusted as to close, either partially or entirely, the peripheral openings and to open the apertures in the transverse members, permitting the fluid to pass through the valve with little or no admixture with the external air. It is therefore seen that by the use of a suitable valve in the fluid return path 13, hot air may be expelled and cooler air from the exterior admitted and mixed with the interior air in any proportion sufficient to maintain the temperature within the enclosure 2 substantially constant, at a predetermined value. This predetermined temperature depends, of course, on the type of device 1 and is such as to obtain the optimum starting and operating conditions of the particular type of tube within the enclosure 2. If the temperature of the fluid within the enclosure is too high, the device 1, when operating as a rectifier may tend to pass an arc on the inverse voltage cycle. On the other hand, if the temperature of the fluid in the enclosure 2 were too low, the voltage necessary to start the tube may become excessive. By providing the return conduit 13, together with a convenient means in the return path for either permitting the fluid to pass directly through the valve or mixing the fluid with outside air in proper proportion, it becomes a simple matter of maintaining the temperature of the fluid in the enclosure 2 substantially constant so that the disadvantages obtaining in the case of temperatures which are too high or too low are obviated.

While I have shown the thermometer 15 positioned near the bottom of the enclosure 2, it is apparent that it may be mounted at any position in the enclosure with respect to the tube 1 so as to indicate the temperature of any portion of the envelope 1, or of the envelope as a whole, from which it may be determined whether or not changes or adjustments of the valve 14 are necessary.

Instead of providing a cubicle or compartment for each tube and regulating the temperature of the fluid in each cubicle, all of the tubes may be mounted in a single compartment and if desired, the temperature-regulated fluid may be directed through individual conduits against any particu-

lar part of each tube. Such an arrangement lends itself to the pressure control of vapor tubes which are provided with envelope extensions containing the vapor condensate and the temperature of which controls the pressure of the vapor within the tube.

In case the tube 1 is of the vapor type, such as a phanotron, the nozzle effect introduced by the annular space between the collar 8 and the envelope obviously causes the temperature controlled fluid to issue as a circular jet at high velocity and directed toward the position on the envelope where the vapor forms a condensate. The temperature of the condensate is thereby controlled which, in turn, controls the pressure of the vapor within the envelope. It is apparent that the fluid circulatory system shown and described hereinbefore is highly efficient in operation in that the heat, which on occasion is necessary in order to raise the temperature of the fluid directed toward the condensate, is derived practically entirely from the upper part of the envelope due to load currents. This heat might otherwise have gone to waste. Thus, one aspect of my invention contemplates the feature of utilizing heat derived mainly from one limited portion of the tube to control the temperature of another limited portion of the tube. Still another aspect is to direct a jet of fast moving temperature-controlled air against any desired portion of the tube.

In Fig. 4, I have shown an automatic means for effecting the necessary changes in fluid temperature. The tube enclosure is indicated diagrammatically by the box 35 and as in the case of Fig. 1, this box is provided with a bottom 36 which carries a collar 37. The tube is supported in any suitable manner (not shown) within the box. One side of the box is provided with an outlet port communicating with a conduit 38 which terminates in a vertical conduit 39. The annular space around the tube communicates with an inlet conduit 40 which also terminates in the vertical conduit 39. The latter is provided with several dampers which are designated for convenience as damper No. 1, damper No. 2, and damper No. 3. These dampers are so mounted that when dampers Nos. 1 and 3 are in a vertical position, damper No. 2 is exactly in a horizontal position, as shown by full lines in the figure. A fan 41 similar to that in Fig. 1 may also be provided in the inlet conduit 40 in order to expedite the movement of the circulatory fluid. Each of the dampers carries a slotted arm 42. Within each slot there is a pin 43 which is secured to an upright rod 44 which terminates in a crank 45. This crank is secured to a large gear 46, near the periphery thereof. The gear is adapted to rotate on a fixed bearing 47 and meshes with a worm gear 48. In addition to carrying the pin 43 referred to hereinbefore, the rod 44 is also provided with a transversely extending arm 49, the purpose of which will be explained hereinafter. The worm gear 48 is adapted to be rotated through suitable shaftage by an induction motor 50, preferably of the shaded pole type. This motor is energized from a suitable source of alternating current indicated by the transformer 51. One end of the secondary winding of the transformer is electrically connected to the bimetallic strip portion 52 of a thermostatic switch of any suitable and well-known type. This switch is provided with two stationary contacts which have been labeled C and H, and are connected to a pair of limit switches 53, 54, respec-

tively. These switches comprise an armature which is suitably biased by a spring and the movement of which opens or closes the various circuits connected to the thermostatic switch. The switches are so positioned that when the crank 45 is at its lowermost position, which is the position shown in Fig. 4, the arm 49 moves the armature of the switch 54 away from its contacts so as to open the circuit. However, the armature of the upper limit switch 53 is permitted to rest on its contacts and thereby maintain its circuit closed. When the rod 44 moves to its uppermost position, as when the gear 46 is caused to rotate 180 degrees, the member 49 is moved upwardly and forces the armature of the switch 53 away from the contacts and permits the armature of the switch 54 to close its circuit.

The operation of the system shown in Fig. 4 will be clear from a tracing of the various circuits. Let us assume, for example, that the temperature of the circulating air is too high, in which case the thermostatic strip will close in the "H" direction. The motor will turn the crank in the clockwise direction until the lower limit switch 53 opens, thus stopping the motor. Under this action, damper No. 1 will be opened wide, damper No. 2 will be closed, and damper No. 3 will be opened. This is the condition illustrated by the full lines in the figure. The dampers will stay in this position until there is a change in temperature sufficient to change the position of the thermostat blade 52. Under these conditions it is apparent that hot air is expelled through the opening left by damper No. 1 into the atmosphere, and cooler air is admitted through the opening left by damper No. 3. The hot air which is moving through conduit 38 to the exterior is not permitted to come into contact with the cooler air admitted into conduit 40 on account of the fact that damper No. 2 is completely closed.

When the thermostat moves to the "C" or cold position, the motor continues to rotate in the clockwise direction until the upper limit switch 53 is kicked open by the arm 49. Dampers Nos. 1 and 3 are now closed and damper No. 2 is opened so that air is recirculated in a closed system without admitting air from the exterior.

While I have described two different positions of the respective dampers, that is, either entirely open or entirely closed, it is apparent that any desired degree of opening or closing may be obtained by suitable adjustments of the position and lengths of the linkage system.

A system which is designed to operate somewhat faster than the arrangement shown in Fig. 4 is illustrated in Fig. 5. In this case, a similar thermostatic switch is provided but instead of employing an induction motor which moves only in one direction, a motor 55 is provided of the double shaded pole type which can move either clockwise or counterclockwise, depending on whether the thermostatic strip 52 moves to the hot or cold position. In as much as motors of this general type are well known, little or no explanation appears necessary other than to state that there are provided on each pole, two shaded

poles with reverse windings. The windings of alternate shaded poles are connected in series and are adapted to be short-circuited by the movements of the thermostatic strip 52, causing the rotor to move in either direction, depending upon which group of windings is momentarily short-circuited. As in the case of Fig. 4, a shaft may be so connected to the rotor as to cause a worm gear and a large gear meshing therewith to be rotated which, in turn, moves the rod 44 shown in Fig. 4 in a vertical direction in order to open or close the various dampers.

While I have shown and described the valve mechanism 14 of Figs. 1, 2 and 3, and the damper mechanism of Fig. 4 as operating to admit the cooler fluid of the atmosphere into the tube enclosure and thereby reduce the temperature of the fluid immediately surrounding the tube, it is apparent that these mixing devices could also be employed to admit heated air into the enclosure where the fluid already within the enclosure is at a temperature, too low for satisfactory starting. In such a case, the openings 21 in the lower cylinder 22 in Figs. 1 and 2 and the lower portion of the conduit 39 in Fig. 4 may communicate with a reservoir of heated air or other fluid.

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

1. A temperature regulator for an electron discharge device, comprising an enclosure for said device, inlet and outlet fluid ports in said enclosure, a conduit connecting said ports together, and a fluid valve in said conduit, said valve including a casing containing a pair of rotatable cylinders, said casing and cylinders being provided with peripheral openings which may be caused to register with one another, said casing and one of said cylinders being provided with transverse members having openings which are caused to register with one another when said peripheral openings are out of register, and means for rotating said cylinders to cause said openings either to register or to be moved out of register with one another.

2. A temperature regulator for an electron discharge device, comprising an enclosure for said device, inlet and outlet fluid ports in said enclosure, a conduit connecting said ports together, and a fluid valve in said conduit, said valve including a casing containing a pair of rotatable cylinders, said casing and cylinders being provided with peripheral openings which may be caused to register with one another, said casing and one of said cylinders being provided with transverse members having openings which may be caused to register with one another when said peripheral openings are out of register, and means operating automatically in response to changes in temperature of said device for rotating said cylinders to cause said openings either to register or to be moved out of register with one another whereby the temperature of said device is maintained substantially constant during operation.

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