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G. L. USSELMAN ET AL

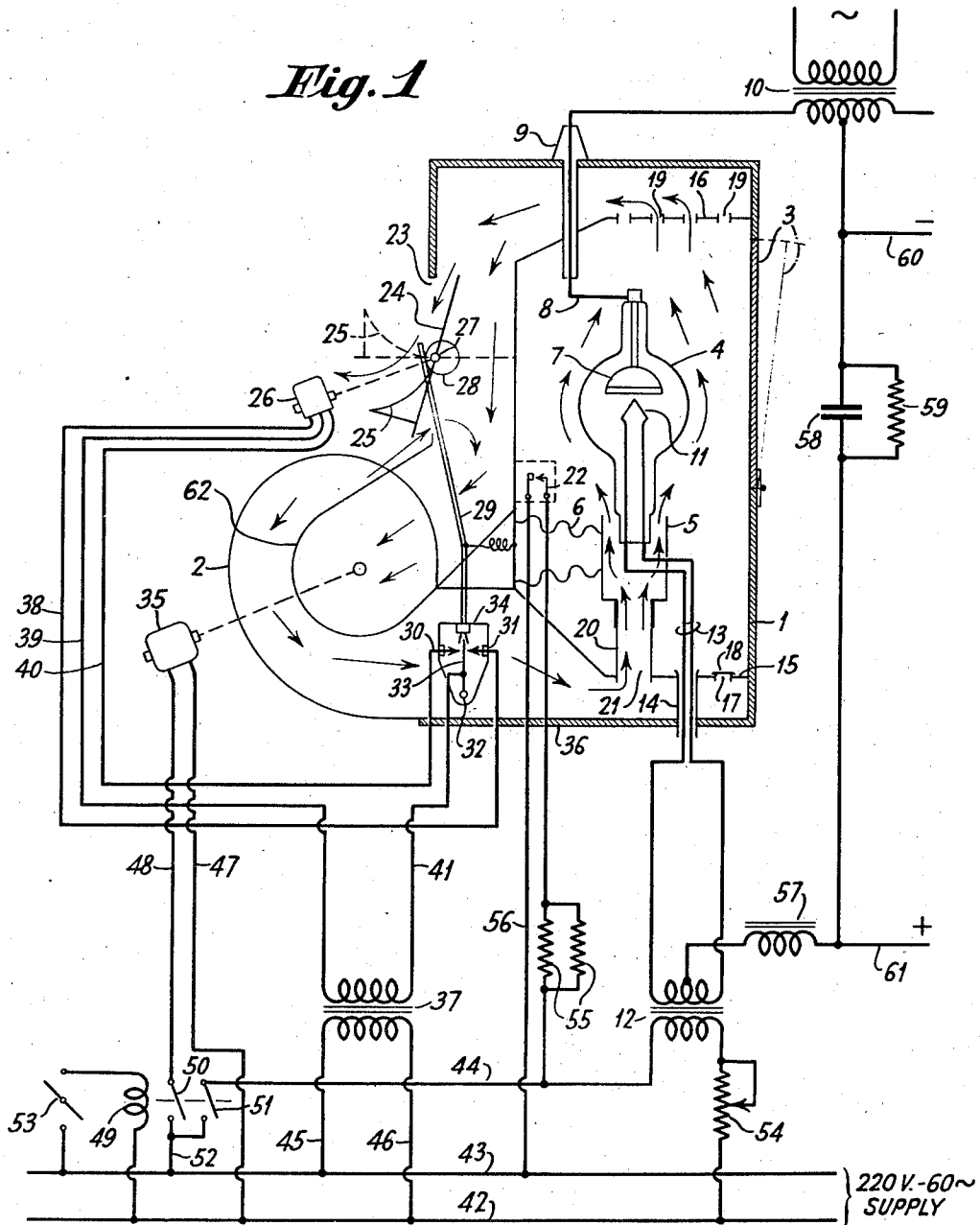
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COOLING SYSTEM

Original Filed Dec. 12, 1936

2 Sheets-Sheet 1

Fig. 1



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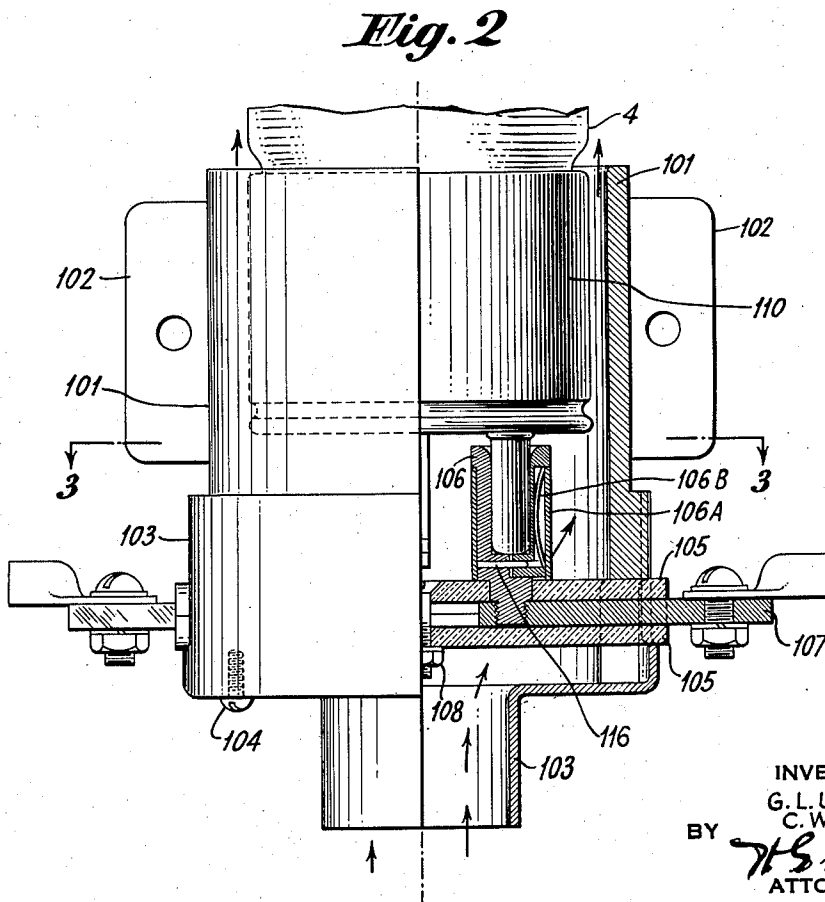
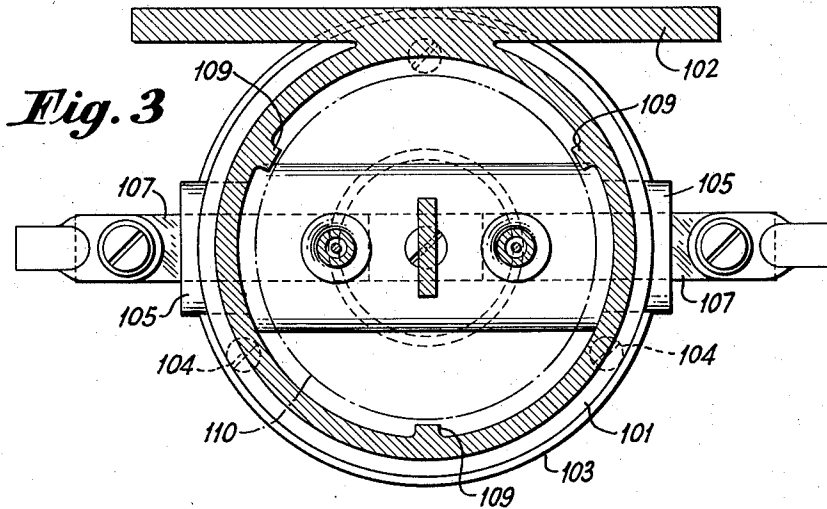
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COOLING SYSTEM

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This invention relates to an improved cooling system for tubes.

An object of this invention is to provide a simplified and improved cooling system for rectifier tubes, particularly those of the mercury vapor type.

Another object of this invention is to improve the operating reliability and life of rectifier tubes generally.

The present system uses a special type of socket for blowing cooling air upward from the lower end of the rectifier tubes and an insulating box for controlling the flow of the air about the rectifier tubes. Two thermostats, a blower and a motor-driven damper are used to regulate the temperature of the air passing by the tubes. There is also provided an electrical control circuit to operate this apparatus.

The present temperature control system has several advantages over the ordinary system. In the first place, the cool air during the running period is forced by the blower to pass by the lower end of the tubes first and the heated air then rises, due to forced draft and to natural circulation. This insures that the mercury condensation will be at the bottom of the tube where it should be. Mercury condensation in any upper part of the tube is likely to result in or cause arc-back. That is, if any mercury condenses on the anode or falls on it from some upper part of the tube, the anode may act like a cathode when an alternating potential is applied to it from the plate transformer and consequently conduct current in both directions through the rectifier tube. These arc-backs are very destructive to the tubes and other parts of the rectifier.

A second advantage is as follows: When the rectifier is shut down, that is, when not delivering plate potential, the blower is shut down. In this condition, the temperature in the box is maintained by a thermostat which turns on and off reduced or normal filament power in the rectifier tubes at various intervals to maintain the air in the box and the tube envelopes at an approximately desired constant average temperature. Since the warm air in the box will rise due to convection, the lower end of the tubes will be the cooler, which is to be desired as stated above. Also, since the filaments in the rectifier tubes are also used as the box heaters they, being situated directly under the anodes, are very effective in preventing mercury condensation on the anodes, and thereby prevent arc-backs which are ordinarily most prevalent at or about the time when the rectifier first starts delivering plate voltage.

Another advantageous feature of this invention resides in controlling the temperatures of the air forced past the rectifier tubes, which is accomplished by means of a thermostatically controlled damper, a blower and an insulated box.

Other desirable features and advantages of this invention will appear from the more detailed description given hereinbelow and with reference to the accompanying drawings, wherein:

Fig. 1 is a schematic showing of my improved cooling system;

Fig. 2 is an elevation partly in section of a rectifier socket; and

Fig. 3 is a plan view of Fig. 2.

Referring now in detail to Fig. 1, the insulation covered box 1 and blower 2 form the exterior portion of the unit. The box is fitted with an access door 3 for exchanging the rectifier tubes 4. Each tube is carried or supported by special tube socket 5 which in turn is supported by some sort of high voltage insulator 6. The anode 7 of tube 4 is connected through lead 8 which passes through insulator 9 to a plate transformer circuit represented by 10. The cathode 11 is connected at the base of the tube through tube socket 5 to filament transformer 12 by means of leads 13 which pass through a close fitting insulating tube 14. The box 1 is fitted inside with lower partition 15 and upper partition 16. There are several holes 17 with removable covers 18 in partition 15. The upper partition 16 is also supplied with several air holes 19. The tube socket 5 is fitted at the bottom as shown with an insulating air duct or tube 20, which extends through a hole 21 in the lower partition 15. On the back wall inside of box 1 and located at about the same height as the lower part of tube 4, is mounted thermostat 22 used for temperature regulation of the box by means of heat from cathodes 11. On the back part of box 1 is mounted air duct 23 which is connected to the air intake 24 of blower 2. In air duct 23 is mounted a damper 24 with its deflector 25. Damper 24 is operated by reversible motor 26. Also, on the damper shaft 27 is mounted adjustable eccentric cam 28. This cam engages rod 29 which controls the making and breaking of contacts 30 and 31 of a second thermostat 32. The middle or movable contact 33 of thermostat 32 is located between fixed contacts 30 and 31. The latter contacts are carried on a triangular base member 34. Thermostat 32 is mounted in the output duct 36 of blower 2. This output duct is

connected to the lower chamber in box 1. Blower 2 is driven by a second motor 35.

The damper motor 26 is driven and controlled by transformer 37 and thermostat 32 through leads 38, 39, 40, 41, as shown in Fig. 1. Transformer 37 is connected to the 220 volt, 60 cycle supply leads 42 and 43 by leads 45 and 46, as shown. The direction of rotation of motor 26 is governed by the position of movable contact 33. Blower motor 35 is connected to power bus 42 by lead 47 and to power bus 43 by lead 48, through contact 50 of start-stop relay 49 and lead 52, as shown. Start-stop relay 49 is controlled by a main switch or relay 53, as shown in Fig. 1. Filament transformer 12 is connected to power supply bus 42 through filament rheostat 54, and it is connected to power bus 43 through lead 44, contact 51 of relay 49 and lead 52, or through resistors 55, thermostat 22 and lead 56, as shown.

The cathode or filament 11 of tube 4 is connected to the positive lead of the output circuit and to filter condenser 58 with bleeder resistor 59 through the center tap of filament transformer 12 and reactor 57. The anode 7 of tube 4 as shown by Fig. 1 is connected through lead 8 to the secondary of transformer 10. The center tap of transformer 10 is connected to the negative lead of the output circuit and to the filter condenser 58 with bleeder resistor 59.

Fig. 1 is only a schematic cross-section; the ends of box 1 are parallel to the plane of the paper, that is, one end is near the observer and the other end is away from the observer, the figure being made simple in order to aid clear explanation. This, however, may introduce some uncertainty in mechanical construction and electrical circuits. For instance, plate transformer 10 and the output circuit in general is shown schematically whereas in an actual rectifier the circuits may be more complicated. Likewise, Fig. 1 shows only one tube whereas a rectifier unit in practice may comprise two, four, six, or even more tubes. In such a unit, the tubes are placed adjacent each other forming a row, that is, the observer in this case is looking at a row of tubes end-on. One rectifier, in which this invention was put into commercial practice employed four tubes, another employed six tubes. Another difference which may be pointed out in Fig. 1 is that in actual practice the holes 17 in lower partition 15 are located between the holes 21, i. e., between the tubes. There are many other features not shown in Fig. 1 such as in the door 3 there are located two or three glass windows for observing the condition of the rectifier tubes at various times. There are certain control circuits not shown, which apply anode power after a certain time delay when proper filament power has been applied. Also, in practice door 3 is equipped with electrical interlocks to remove any high voltage anode power when the door is open.

Figs. 2 and 3 show an assembly and sectional view of the special tube socket. The metallic body of the socket 101 is supported by the lugs 102. On the lower part of body 101 is fitted air duct connection cap 103. The two parts 101 and 103 are fastened together by screws 104, as shown. The body 101 and cap 103 also form a clamp to hold insulators 105. The latter insulators hold in place connection clips 106 and conductor strips 107. Clips 106 make the filament connections. Connection clips 106 are made of two inner contact shoes like a split

sleeve. One of the inner shoes screws into connection strip 107. The two inner contact shoes are held together by an external sleeve 106A. A flat curved spring 106B is fitted between the external sleeve 106A and an inner shoe to insure good contact. A pin 116 is driven in contact shoes 106 and serves to hold the shoes in place, so that the loose shoe will not pull out of position. A screw 108 also holds the two insulators 105 and the contact clip assembly together. It should be noted that both parts 101 and 103 are slotted to admit assembly of the contact clips 106, 107 and insulators 105. It should also be noted that insulators 105 are made with shoulders to hold them in position in the socket. The three ribs 109 shown in Fig. 3 are for the purpose of holding the tube 4 in position, leaving a clearance space between the tube base 110 and the tube socket body 101, for air flow. The arrows show the path of air flow in the socket and upward around the tube envelope. The lower end of part 103 is made to fit inside an air duct, the latter preferably being made of insulating material, such as "Bakelite," glass or mica. Parts 101, 102, 103, 104, 106, 107, 108, 109 may be made of any suitable metal, such as brass, copper, aluminum and iron. Parts 105 may be made of some suitable insulating material, such as "Micalex" or "Isolantite," glass or porcelain.

The operation of this invention is as follows: Assume that in Fig. 1 rheostat 54 has been adjusted to give correct filament voltage when contact 51 of relay 49 was closed. In the shutdown condition, relay 49 is deenergized and contacts 50 and 51 are open. Blower 2 and motor 35 are shut down, reduced or approximately normal filament power is applied intermittently through resistors 55 by means of the contacts of thermostat 22. The value of resistors 55 may be changed to suit summer or winter operation, i. e., less resistance being required for winter operation. This may be arranged so that two resistors may be used in parallel for winter and one may be used for summer operation. The thermostat 22 by virtue of being connected in series with the voltage supply resistances 55 and the primary of filament transformer 12 turns the filaments 11 off and on at such a rate as to heat and hold at a fairly constant temperature the air in the box about the region of the lower half of the tubes. The heat insulation on the box 1 helps to hold this temperature constant. The slight amount of air convection in the box is sufficient to keep the air in the top part of the box hotter than that in the lower part. This fact, coupled with the fact that the filaments are used as the box heaters, has an important beneficial influence on the operation of the rectifier tubes, for the following reasons.

For best operation to prevent arc-back and to promote a long tube life, (1) the tube temperature should be kept within from 35° to 40° C. This means that when the tubes are operating or are started in operation as rectifiers, this temperature should be maintained. (2) Also, to prevent arc-back, no condensed mercury should be allowed to collect on the anode or to fall on it during the time when anode voltage is applied.

The first point requires substantially constant tube wall temperature of the correct value to insure constant mercury vapor pressure of proper value, which is a factor in the arc-back tendency of a mercury vapor rectifier tube. The second point requires that the upper part of the tube and

the anode be kept at a higher temperature than the lower part of the tube, so that all mercury vapor condensation will take place in the lower part of the tube. In this way, no liquid mercury can fall or collect on the anode during the time when voltage is applied to it. In other words, the heated filament, being very close to the anode, the latter is kept hotter than the envelope of the tube. Also, as stated before, the fact that the air in the upper part of the box is warmer than that in the lower part insures that no mercury vapor will condense on the upper walls of the tube.

During the shutdown period, damper 24 and its control mechanism is still in operation and in the summer time this damper would, in most cases, not move but during cold weather it would close because thermostat 32 would gradually become cooled off since the blower is not running in the shutdown condition.

When the rectifier is to be started for delivering plate power in the form of rectified, that is, direct current, the control switch or relay 53 is closed which in turn closes start-stop relay 49. This closes contacts 50 and 51 and other contacts, not shown, for applying plate voltage. This applies steady full normal filament power because resistors 55 and thermostat 22 are short-circuited by contact 51. The closing of contact 50 causes the blower to function. After the filament has had full power applied for about one minute, anode voltage is applied from plate transformer 10.

When the blower 2 is operating, air is forced into duct 36 past thermostat 32 and into the lower chamber of box 1 formed by lower partition 15. The air is then forced up through tube 29 into tube socket 5, where it comes in contact with and flows up along the tube wall absorbing heat as it passes upward. Since the air becomes more heated and consequently absorbs less heat as it travels toward the top of the tube, the upper part of the tube will be warmer than the lower end of the tube. This warm air passes through the holes 19 in the upper partition 16, out and down through the duct 23 to the blower intake 62 where it is again forced into the lower duct 36 past thermostat 32 and up through the tube socket 5, and so on.

After a number of these air cycles, the circulating air will absorb extra heat and become heated due to the higher filament power now in use and due to the tube losses in conducting plate current. This rise in air temperature passing thermostat 32 will cause it to function to move contact 33 against (assume) contact 30. This will cause motor 26 to rotate the damper 24 in a clockwise direction opening up the damper so that some warm air passes out at the top of the damper and a like amount of cool air passes in to the blower at the bottom of the damper. The action of cam 28 and rod 29 moves the contact carriage 34 and contact 35 is then moved away from contact 30. This latter action stops the damper movement until contacts 33 and 30 are again made. In other words, cam 28, rod 29 and contact carriage 34 act as a stabilizer to prevent hunting and too frequent operation of the damper. It also prevents straining the thermostat elements. The curved part 25 of damper 24 is for the purpose of deflecting the outgoing warm air away from the lower or cool air intake. In other words, it makes the damper more efficient; there are baffle plates or side shields, not shown in the sketch, on each side of damper 24 to prevent the heated air from get-

ting back into the ventilating system around the edge of the damper.

The arrows show in a general way the paths of the air flow. The above action goes on until the air is sufficiently cooled. Should the air which is forced up through tube socket 5 become too cool, contacts 33 and 31 of thermostat 32, will close, which will cause the damper to close as long as contact is being made; so that less cool air is taken in from the outside. When the air is sufficiently cooled, the action of cam 28 and rod 29 moves carriage 34 and contact 31 away from central contact 33 and so on, until a stable temperature is obtained by proper opening of the damper 24.

The action of cam 28 (on damper shaft 27) through rod 29 and the contacts 30, 31 and 33 is to refine and make the operation of thermostat 32 and damper 24 more accurate and more sensitive. The damper moves only when the thermostat 32 and contact 33 is moving because when contact 33 is stationary, contact 30 or 31 is backed off by the cam arrangement (which breaks contact with 33). This is accompanied by a like movement of the damper. Thus, when the temperature of the air passing thermostat 32 is substantially constant, contact 33 is floating between contacts 30 and 31, touching neither one. Any small change in blower output air temperature will quickly be corrected by thermostat 32 and the damper 24.

Extra openings 17 with removable covers 18 have been provided to increase the air circulation in the box 1 if the air circulation is not sufficient during hot weather or in hot climates.

The damper motor 26 is provided with limit switches (not shown) which limit its range of rotation to ninety degrees, so that damper 24 can operate in any position from closed to full open.

The box 1 is usually constructed with a metal frame and the walls are made of some suitable heat and electrical insulating material such as asbestos, fire-proof material being preferable.

When the transmitter shuts down, start-stop relay 49 opens contacts 50 and 51, after plate power has been removed. This shuts off the blower and the temperature control is resumed by thermostat 22 through intermittent filament heating.

While only one form of cooling device is shown, it is to be distinctly understood that this invention is not to be limited to this form of device but may include other modifications.

What is claimed is:

1. A system for regulating the temperature of a mercury vapor rectifier tube having a quantity of mercury subjected to condensation normally located within the lower portion thereof whereby arc-backs in said tube are prevented by keeping the anode and upper portion of said tube free from condensed mercury vapor, comprising temperature responsive switching means adjacent said tube, and means responsive to said switching means for controlling through a series resistance the heating power supplied to the cathode of said tube in such a way that the anode and upper portion of said tube are maintained at a temperature unsuitable for the condensation of mercury thereon.

2. A system for regulating the temperature of a mercury vapor rectifier tube comprising a mercury vapor tube having an anode and cathode, means for controlling within predetermined limits the cathode temperature and vapor pressure within said tube, a housing enclosing said mercury

vapor tube, a tube socket device within said housing having an air passage arranged between the base of the tube and the side walls of said socket, and means comprising a blower adjacent said housing for controlling the temperature of air entering said passage.

3. In combination, means for regulating mercury vapor rectifier tube temperatures by regulating the heat on the cathode of the tube during the time the anode voltage of the tube is shut off, a second means for regulating the tube temperature by circulating air around the outside of said tube when the anode voltage is applied, and a third means rendering the first of said means inoperative during the time the anode voltage is applied.

4. In a rectifier system including the combination of a blower for forcing temperature regulated air through a tube socket device and up and around the envelope of a vapor filled tube, a tube compartment enclosing said tube, means for controlling the air temperature by the use of a thermostatically controlled damper for taking in and mixing a portion of cooled air with the warm air of the tube compartment, and means for causing the mixed air to pass over the temperature regulating thermostat, and a second temperature regulating device within said tube compartment for controlling the temperature on the cathode of said tube when said blower is inactive.

5. In a system for temperature regulating an electron discharge device mounted within a container, said device having an anode and a cathode, a damper mounted in a wall of said container for controlling air temperature within said container, a blower outside said container, a cam mechanism, a thermostat associated with a rod engaging said cam, said rod controlling a pair of contacts located each side of a middle contact on said thermostat, the combination of said thermostat, rod, and cam operating to control the blower air output temperature, said cam mechanism being arranged to prevent over-travel or hunting of the damper and to prevent distortion of any of the thermostat elements.

6. A temperature regulating system comprising an electron discharge device having an anode and cathode, a container for said device and a pair of thermostats located within said container, one of said thermostats being arranged to control the temperature within said device and the surrounding air temperature outside said device when anode voltage is absent, the other one of said thermostats arranged to control a means for maintaining the temperature of said anode and surrounding air temperature when anode voltage is present.

7. A system for regulating the temperature and vapor pressure of an electron discharge device having at least an anode and cathode, an insu-

lating housing for said electron discharge device, tube socket for inserting the base of and supporting said device insulatingly supported within said housing, said socket having a space between its inner walls and the base of said device for the passage of air flow up past the said base and around the envelope of the said device, and a plurality of guides integral with the inner wall of said socket for supporting the electron discharge device centrally in said socket and to allow equal flow of air all around the said device for ventilating purposes.

8. A system for regulating the temperature of a mercury vapor rectifier tube having a quantity of mercury subjected to condensation normally located within the lower portion thereof, said rectifier tube having at least anode and cathode circuits, a power supply for heating said cathode circuit, a thermostat and a resistance in series with said power supply, and external means responsive to the action of said thermostat for partially heating said cathode through said resistance when said anode circuit is inactive to keep the condensation of said mercury in the lower portion of said tube.

9. The method for preventing condensation of mercury on the electrodes of a mercury vapor rectifier tube, including the steps of maintaining the electrodes at a higher temperature than that at which mercury condenses during idle periods prior to the operation of said rectifier, and maintaining said rectifier at a higher temperature than that at which mercury condenses during the operation of the rectifier.

10. The method as claimed in the preceding claim characterized by the fact that the temperature of said rectifier is maintained substantially constant at a value substantially higher than that at which mercury condenses both prior and during operation of said rectifier tube.

11. A system for regulating the temperature of a mercury rectifier tube having a quantity of mercury subjected to condensation normally located within the lower portion thereof, whereby arc-backs in said tube are prevented by keeping the anode and upper portion of the tube free from condensed mercury vapor, comprising temperature responsive switching means adjacent said tube and means responsive to said switching means for controlling the heating power supplied to the cathode of said tube in such a way that the anode and upper portion of the tube are maintained at a temperature unsuitable for condensation of mercury thereon, and means for directing cooling fluid around the base of said tube whereby any condensation which does take place occurs at the base of the tube away from the anode of said tube.

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