May 3, 1966 J. W. KENDALL, JR 3,249,791

ELECTRON TUBE AND COMBINATION FOR SENSING AND REGULATING THE CATHODE TEMPERATURE THEREOF

Filed June 12, 1963 3 Sheets-Sheet 1

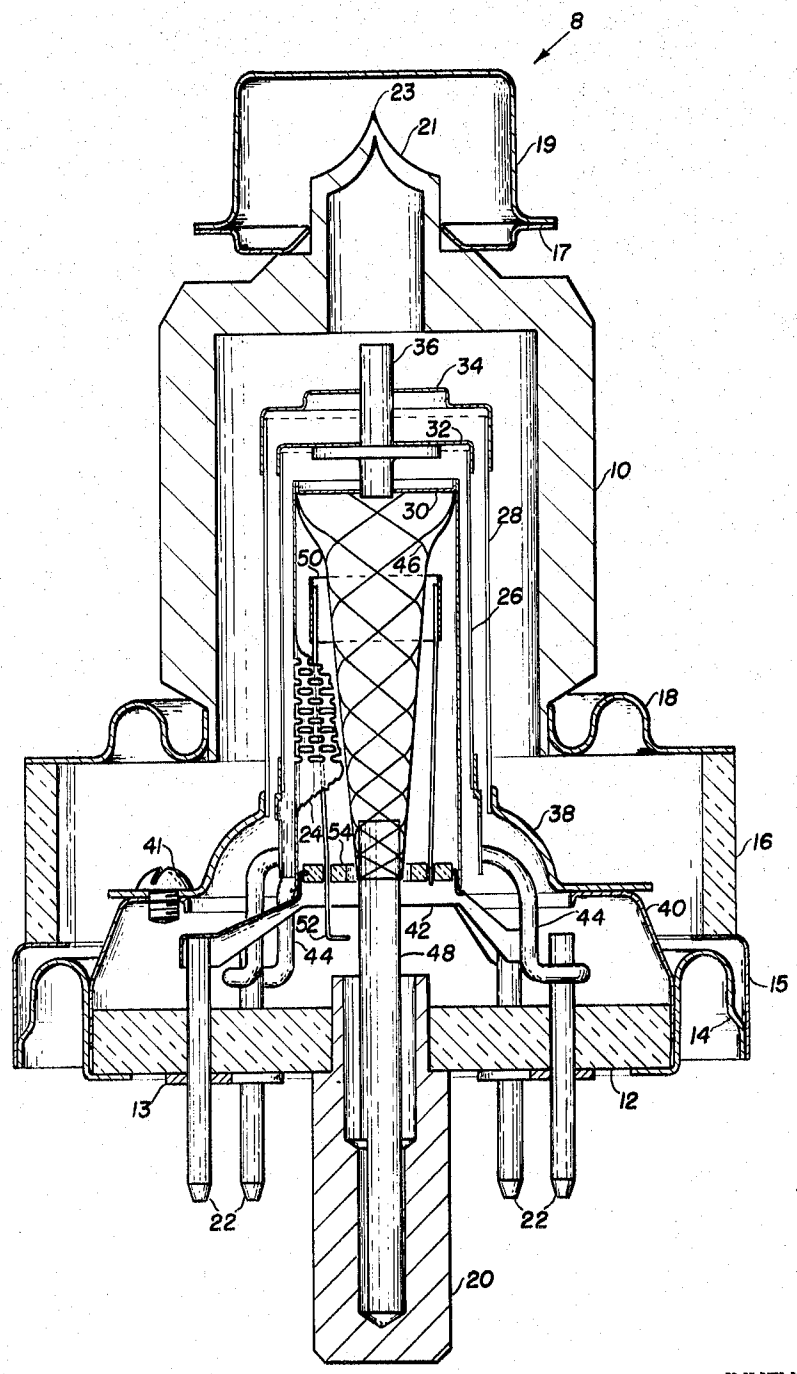


Fig. 1

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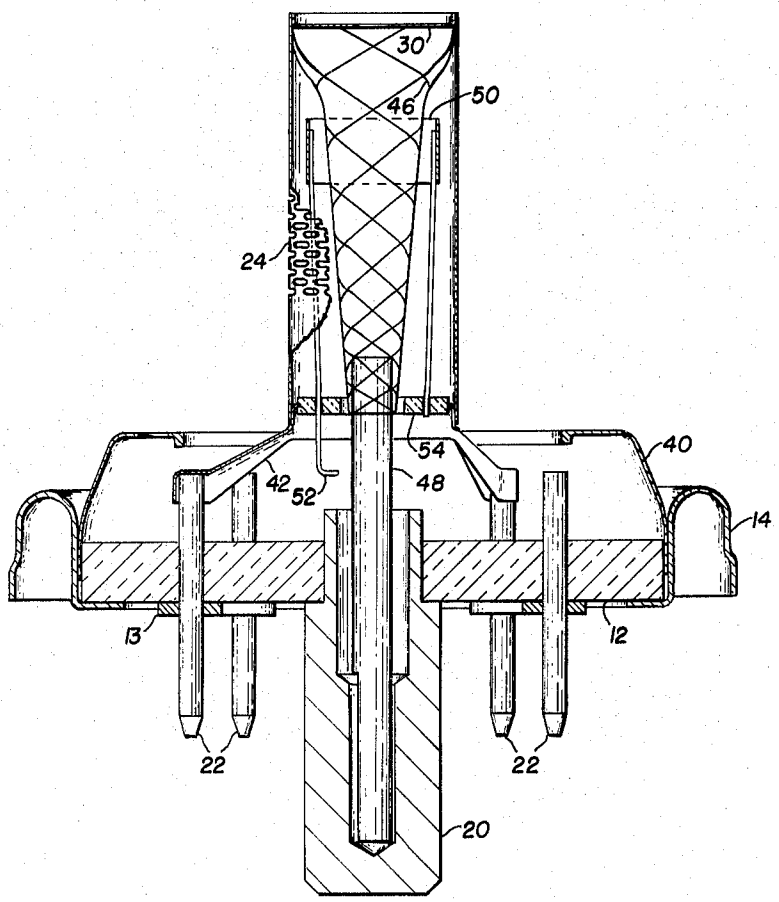


Fig. 2

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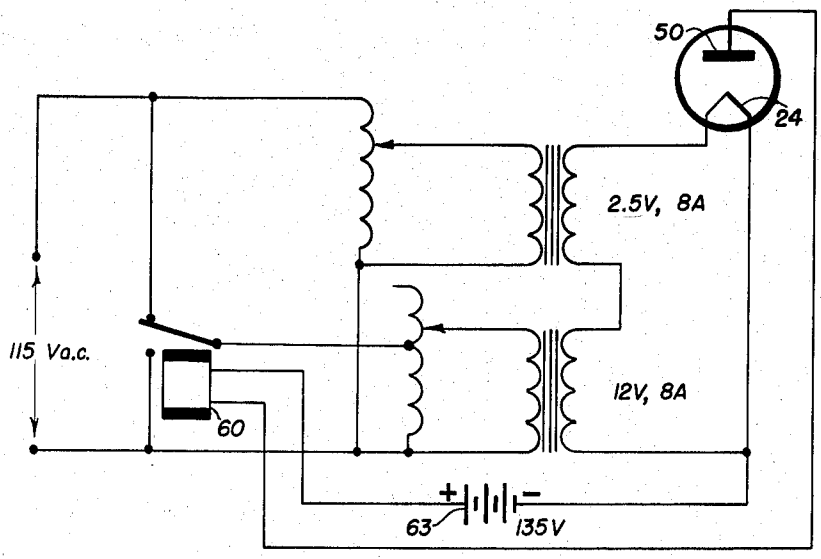


Fig. 3

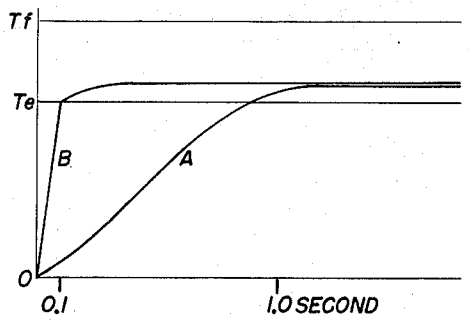


Fig. 4

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ELECTRON TUBE AND COMBINATION FOR SENSING AND REGULATING THE CATHODE TEMPERATURE THEREOF

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8 Claims. (Cl. 313—293)

This invention relates to an electron tube and more particularly to a quick heating cathode structure for an electron tube including means for sensing and regulating the cathode temperature thereof in combination with appropriate circuitry.

A portable push to talk transmitter and other similar devices require tubes having low power consumption combined with quick warm up operation for the efficiency and long lifetime of the device. In this type of electronic equipment and also in other electrical systems utilizing tube components in cooperation with transistor components, it is essential for the tube to have the features of low power consumption, long on-off cycle lifetime, and also have warm up time occur within approximately a tenth of a second. The tube of this invention has all of the above enumerated essential features and can be used in quick operating electrical systems.

Cathodes have been made before using the principle of directly heating the cathode by a current source. However, most of the prior art arrangements generally were operated with the consumption of a great deal of power since the current to the cathode was left on continuously so that immediate cathode operation could be achieved.

Besides high power consumption, previous directly heated cathodes had other disadvantages, such as complicated assembly, vibration problems, poor voltage-current relationship, i.e. high current at low voltage, short life time due to inability to be cycled on and off repeatedly, and mechanical difficulties in the expansion and contraction of the cathode.

In other forms of directly heated cathodes, an overvoltage or high potential was applied to the cathode for the quick heating thereof and timing devices were utilized to switch on and off the high potential applied to the cathode. However, this type of arrangement was not adequate in the past since the cathode did not always reach its coldest temperature before the equipment user activated the circuit supplying the overvoltage to the cathode. Hence, the use of a timing mechanism was inadequate since the tube was easily destroyed due to overheating of the cathode.

Other directly heated cathode devices, using an initial overvoltage for quick heating, required complicated mechanical and electrical arrangements associated with the tube to switch the overvoltage on and off. The overvoltage had to be applied directly to the cathode for only a short period of time, and the prior art was concerned with complex mechanical and electrical arrangements to cope with the problem of switching the overvoltage on and off and the associated cathode expansion and contraction problem. A need existed for a tube having low power consumption, quick warm up, long on-off cycle lifetime, and simple construction from a mechanical and electrical view.

Accordingly, the main object of this invention is to provide an electron tube which will heat up to operating temperature in a very short period of time and which incorporates structure for sensing the temperature of the cathode of the electron tube.

A further object of this invention is to provide an electron tube which can be quickly brought to operation and use low amounts of power to maintain operation.

A still further object of this invention is to provide a cathode which will have a long on-off cycle lifetime.

A further object of this invention is to provide a simply constructed quick heating cathode arrangement which will permit the cathode to repeatedly expand and contract during on-off cycling.

Another object of this invention is to provide a cathode which is initially directly heated and subsqeuently heated directly and indirectly.

A further object of this invention is to provide a cathode which will have a cathode temperature sensing arrangement to control voltage applied directly to the cathode so as to prevent destruction of the cathode.

Briefly described, the invention resides in a cathode heating arrangmeent which comprises a cathode member and a support for the cathode member. Current carrying means are provided in the cathode heating arrangement and are permanently connected in series with the cathode member. The current carrying means serve as a current path for the alternate application of a high and low voltage to the cathode member. The current carrying means also serve as a heat source for the cathode member. The current carrying means is also a flaccid element which permits the cathode member to expand and contract in response to temperature variations. Cathode temperature sensing means are also provided to cooperate with the cathode assembly so as to control the amount of voltage which is supplied to the cathode member. The cathode temperature sensing means comprise an anode member adapted to receive electrons emitted from the cathode member and means cooperating with the anode member for switching the high and low voltage applied to said cathode member depending on the current in the anode member which is a function of the temperature of the cathode member.

In addition, an electron tube having an envelope enclosing electrodes including a cathode is described. The electron tube contains the current carrying means permanently connected in series with the cathode to serve as a current path and as a heat source for the cathode. The cathode temperature sensing means to control the voltage applied to the cathode are also defined in the description of the electron tube.

A diode is also described which comprises a cathode cylinder, a heat source within the cathode cylinder for radiantly heating the cathode cylinder, and an anode within the cathode cylinder.

A means for sensing the temperature of a cathode alone or within an electron tube is also described. The means requires that a readily emitting electron source be applied to two surfaces of the cathode. An auxiliary anode is placed in the vicinity of one of the surfaces of the cathode. The amount of current in the auxiliary anode is used to gauge the temperature of the cathode.

These and other features of this invention will become more clearly apparent upon review of the following description when taken in conjunction with the accompanying figures in which:

FIGURE 1 is an elevational view in section of a tube illustrative of this invention;

FIGURE 2 is an elevational view in section of the cathode assembly of the tube of FIGURE 1;

FIGURE 3 is a schematic diagram of one type of switching circuit acutated by the anode of FIGURE 2; and

FIGURE 4 is a graph showing the temperature vs. time characteristics for cathode warm up.

Referring now to FIGURE 1 of the drawing, a tetrode is shown to illustrate the invention. Electron tube **8** has an anode **10** which is a cylindrical or cup shaped metal element mounted on a ceramic base **12** by means of U-shaped metal flange **14**, L-shaped metal flange **15**, ceramic

cylinder section 16 and curved metal flange 18. A metal flange 17 is brazed to the outside of the anode and a cup shaped metal contact member 19 is heliarced to the flange 17 so as to provide an anode terminal. The metal contact member 19 also provides a protective cap for anode tubulation 21 which is pinched and sealed at 23 after exhausting contaminants from the tube. Assembly of the various metallic and ceramic elements mentioned herein is done pursuant to well known ceramic metallizing and brazing techniques used in joining metal to ceramic.

Referring to FIGURES 1 and 2, a copper index pin 20 is mounted in the center of the ceramic base 12. Eight contact pins 22, only four of which are shown in the sectional views of FIGURES 1 and 2, are also mounted in the ceramic base 12 by metallizing the ceramic and brazing washer 13 thereto. The pins 22 provide leads for the electrodes of the tube 8.

As shown in FIGURE 1, cathode cylinder 24, control grid cylinder 26, and screen grid cylinder 28 are mounted in concentric alignment in the electron tube 8. An electron emitting oxide coating is applied to the exterior surface of the cathode cylinder 24. The cathode cylinder 24 is composed of a thin foil, preferably having small holes 25 aligned diagonally. The holes 25 are formed by etching. The electrical resistance of the cathode cylinder 24 is raised by making the cylinder thin and also by providing the holes 25 which create a longer electron path. The cathode cylinder 24 is composed of high electrical resistance metal material, such as a one mil thick Hastelloy B metal which is a trade name of a nickel based alloy comprising small amounts of molybdenum, iron and carbon. Metal caps 30, 32 and 34 connect the cathode cylinder 24, the control grid cylinder 26 and the screen grid cylinder 28, respectively, to an insulated support pin 36. The screen grid cylinder 28 is brazed to a curved metal flange 38 at its lowest end. A support flange 40 is bolted by bolt 41 to the curved metal flange 38 so as to support the screen grid assembly comprising the screen grid cylinder 28 and the curved metal flange 38. The support flange 40 is connected at its lowest end to the ceramic base 12 by metallizing the ceramic and then brazing the support flange thereto. The support flange 40 is also joined to the U-shaped flange 14 by brazing.

Referring to FIGURES 1 and 2, a four-pronged cathode cylinder metal support member 42 is mounted on four of the pins 22. Current can be supplied directly to the cathode cylinder 24 through electrical connection with the four pins 22 on which the cathode cylinder metal support member 42 is mounted. The cathode cylinder 24 is connected to the cathode cylinder metal support member 42 by spot welding. Leads for the control grid 26 are made through connections 44 to two of the pins 22. A molybdenum wire braid 46 comprising forty to fifty .003 inch diameter molybdenum wires is formed in a hollow substantially cylindrical configuration. The braid 46 is mounted on metal pin 48 the bottom portion of which is located with and brazed to the copper index pin 20. The molybdenum wire braid 46 has one end of each of the .003 inch diameter wires spot welded to the metal pin 48 and the other ends of the wires are spot welded between the cap 30 and the cathode cylinder 24. Thus, the braid 46 is permanently connected in series with the cathode cylinder 24 and provides a current path for the cathode cylinder 24. The end of the braid 46 which is located between cathode cylinder 24 and the end cap 30 has a larger diameter than the end of the braid 46 which is spot welded to the pin 48. This is achieved by cutting and stretching the end of the molybdenum braid 46 to achieve the wide configuration necessary for connection between the cathode cylinder 24 and the end cap 30. The molybdenum braid 46 is a flaccid member or a member which yields readily and thus permits the cathode cylinder 24 to expand and contract in its longitudinal direction without stress. The molybdenum braid 46 has a high electrical resistance when hot and a low electrical resistance when cold, thus permitting large amounts of current to initially surge through the braid 46 to heat the cathode directly. After the initial high current surge through the braid 46 the braid 46 becomes hot and its electrical resistance becomes high. The braid 46, when hot, has a lower amount of current passing through it and heats the cathode cylinder 24 directly with this current. The braid 46 also heats the cathode cylinder 24 indirectly due to its high electrical resistance when hot.

An auxiliary anode 50 is supported within the cathode cylinder 24 by a pair of molybdenum wires 52 connected to an insulated disk 54. The insulated disk 54 is connected to and supported by the cathode cylinder metal support member 42. One of the wires 52 is a lead for the auxiliary anode 50 and is connected to one of the pins 22. The cathode cylinder 24 is provided with an electron emitting oxide coating on the inside of the cylinder by either spraying such a coating directly to the inside of the cylinder or by applying a coating to the outside of a perforated cylinder. A portion of the electron emitting oxide coating will pass through the perforations of the cathode cylinder 24 and will form a readily emitting electron source on the inside of the perforated cathode cylinder 24. Thus, current from auxiliary power source 63 (battery) will flow to the cathode cylinder 24, when hot, to auxiliary anode 50 and then through the coil of a relay 60 (FIGURE 3), thereby causing operation of the relay 60.

The circuit of FIGURE 3 comprises a conventional switching relay 60 which, when energized, removes the overvoltage supplied to the cathode cylinder 24 and only the low heater voltage is supplied to the series circuit comprising the cathode cylinder 24 and the wire braid 46.

Curve A of FIGURE 4 depicts the warmup time of a cathode in relation to temperature. T_e on the ordinate indicates the temperature for electron emission by the cathode. T_f indicates the cathode burn out temperature or the temperature at which the cathode is destroyed. Curve B of FIGURE 4 is illustrative of the warm up characteristic of the quick heat cathode of this invention. In order to bring the temperature of the cathode up to where electrons are emitting in one tenth of a second, it is necessary to use an overvoltage.

However, there is only a small temperature difference between the temperature for the cathode to emit electrons (T_e) and its burn out temperature (T_f). Therefore, control of the temperature of the cathode is extremely important when using an overvoltage applied directly to the cathode. This cathode temperature control is achieved by the mechanical and electrical arrangements of this invention.

It will thus be seen that the objects set forth above, among those made apparent from the preceding description, are efficiently attained, and since certain changes may be made in the above construction without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

I claim:

1. An electron tube having an envelope comprising a main anode and a first terminal means electrically connected with said main anode, a cathode within said envelope, said cathode being made of high electrical resistance material and having a generally cylindrical configuration, a second terminal means extending through said envelope and electrically connected to one end of said cylindrical cathode, a third terminal means extending through said envelope, current carrying means electrically connected between said third terminal means and

the other end of said cylindrical cathode, an auxiliary anode located within said cylindrical cathode, and a fourth terminal means extending through said envelope and electrically connected to said auxiliary anode.

2. An electron tube as claimed in claim 1 in which said current carrying means extends through said cylindrical cathode and is adapted to provide both an electrical current path for the alternate application of high and low voltage to said cathode and a source of radiant heat for heating said cathode.

3. An electron tube as claimed in claim 2 in which said auxiliary anode is located between said current carrying means and said cathode member.

4. An electron tube as claimed in claim 1 in which said cathode cylinder is a thin perforated foil of high electrical resistance material and the outer surface thereof is coated with electron emissive material some of which extends through the perforations.

5. In combination, an electron tube comprising an envelope, a cathode and a main anode within said envelope, a current carrying means in said envelope electrically connected in series with said cathode for heating said cathode by providing both an electrical current path for the passage of electrical current through said cathode and a source of radiant heat for heating said cathode, and an auxiliary anode spaced from said anode in said envelope and adapted to receive electrons emitted by said cathode; and means for utilizing the electron flow between said cathode and said auxiliary anode to regulate the temperature of said cathode by varying the current passed through said cathode.

6. The combination as claimed in claim 5, in which the cathode is cylindrical and adapted to emit electrons from both its exterior and interior surfaces and said auxiliary anode is located within said cylindrical cathode.

7. The combination as claimed in claim 6, in which said current carrying means passes axially through said cylindrical cathode, and said auxiliary anode comprises a cylindrical member of smaller diameter than said cathode and surrounding said current carrying means.

8. The combination as claimed in claim 6, in which said cathode comprises a thin perforated foil of high resistance material coated with electron emissive material some of which extends through the perforations.

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