April 29, 1969 D. R. KERSTETTER 3,441,767

TENSIONED DIRECTLY HEATED CATHODE HAVING IMPROVED TEMPERATURE CHARACTERISTICS

Filed Feb. 1, 1967 Sheet 1 of 2

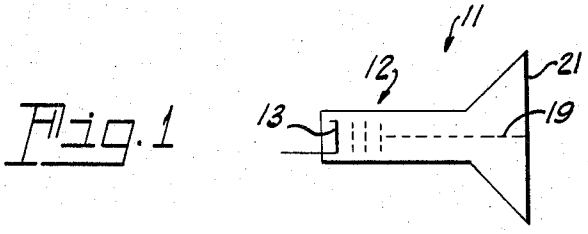


Fig. 1

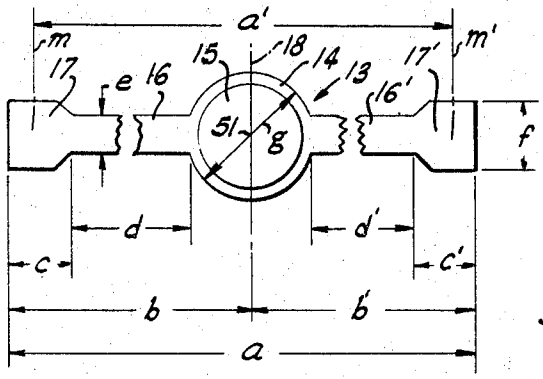


Fig. 3

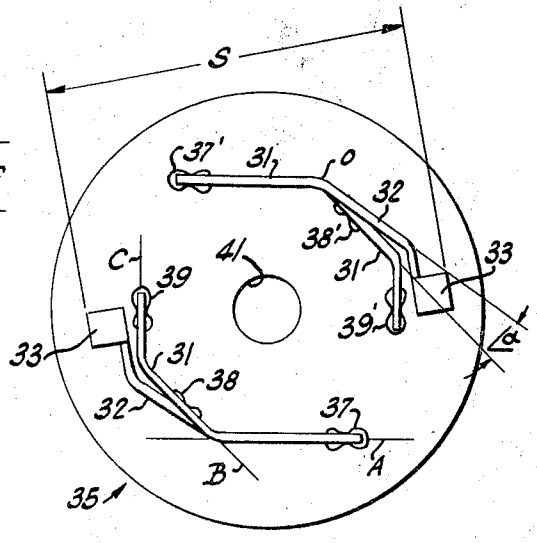


Fig. 4

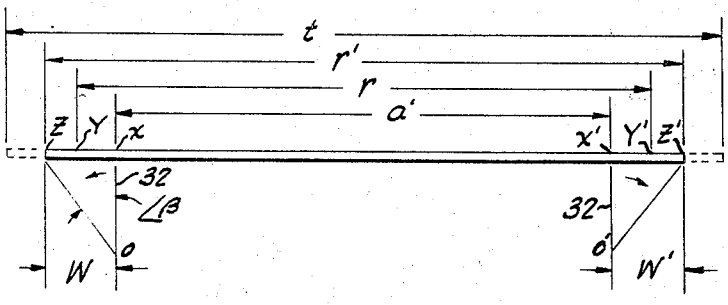


Fig. 5

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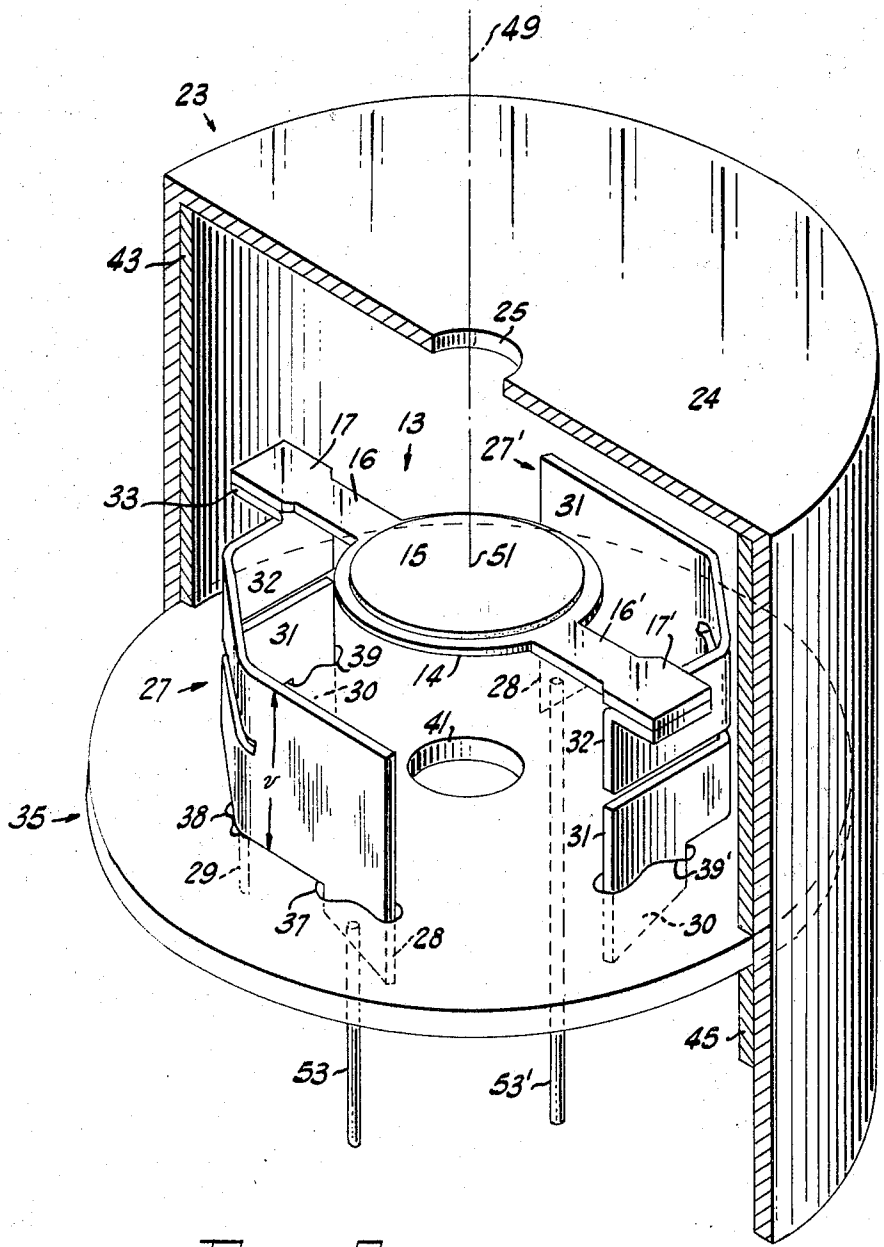


Fig. 2

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TENSIONED DIRECTLY HEATED CATHODE HAVING IMPROVED TEMPERATURE CHARACTERISTICS

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U.S. Cl. 313—37 3 Claims

ABSTRACT OF THE DISCLOSURE

A directly heated cathode for use in a cathode ray tube whereof the cathode is a rapid warm-up structure in the form of a substantially planar metallic formation of continuous uniform thickness and differential widths tensioned in a free suspension manner between supporting means. The cathode is formed to have a defined high temperature section in the shape of a substantially circular central portion with an electron emissive coating disposed on one surface thereof. Extending in a substantially radial manner in diametrical opposition from the central high temperature portion, to effect reduced heat loss therefrom, are two heat loss deterrent sections of reduced width each having a cross sectional area to provide predetermined limited heat conduction therethrough.

BACKGROUND OF THE INVENTION

This invention relates to cathode emission means for a cathode ray tube and more particularly to a rapid warm-up directly heated cathode for use in a cathode ray tube electron gun structure.

In electronic equipment utilizing thermionic electron discharge devices, the time required for heater warm-up has long been recognized as an important factor in determining the interim existent between equipment turn-on and operational response. With the advent of substantially instantaneously responsive solid state ancillary components in the circuitry of cathode ray tube display equipment, the warm-up time of the cathode ray tube heater-cathode combination became the main deterrent to a shortened initial warm-up interim. In an attempt to shorten this interim, various ribbon type low power directly heated cathodes were devised and utilized in association with costly and intricately shaped ceramic supports and tensioning means. The broad temperature gradients manifest in these cathodes failed to produce the rapid concentration of heat required for the desired time improvement in initiating tube operation.

OBJECTS AND SUMMARY OF THE INVENTION

It is an object of the invention to reduce the aforementioned disadvantages and to provide an improved directly heated rapid warm-up cathode for use in a cathode ray tube electron gun structure. A further object is to provide an improved directly heated cathode having a defined optimized high temperature section at its emissive portion with means for reducing heat losses therefrom.

The foregoing objects are achieved in one aspect of the invention by the provision of a substantially planar directly heated cathode of continuous uniform thickness and differential widths and being formed to have a defined high temperature section in the shape of a substantially circular central portion with an electron emissive coating disposed on one surface thereof. It is within this section that the major part of the input power applied to the cathode is converted to thermal energy and substantially confined thereto. Extending substantially in a radial manner in diametrical opposition from the central portion are two heat loss deterrent sections of reduced widths. These provide electrical connection and suspension support for the central high temperature section and effect reduced radiation losses therefrom. The smaller cross sectional areas thereof afford limited heat conduction and increased resistance thereby effecting greater IR drop thereacross. The increased power dissipation results in localizing most of the temperature differential to these sections and contributes to realizing a higher and uniform temperature in the central portion.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a sectional view of a cathode ray tube utilizing the invention;

FIGURE 2 is a perspective view of one embodiment of the invention showing the improved cathode supported within the electron gun;

FIGURE 3 is a plan view of the directly heated cathode;

FIGURE 4 is a top plan view of the cathode positioning and support means prior to cathode attachment thereto; and

FIGURE 5 is a diagrammatic view showing the expansion and tensioning of the cathode.

DESCRIPTION OF THE PREFERRED EMBODIMENT

For a better understanding of the present invention, together with other and further objects, advantages and capabilities thereof, reference is made to the following specification and appended claims in connection with the aforedescribed drawings.

With reference to the drawings, there is shown in FIGURE 1 a cathode ray tube **11** having in the neck portion thereof an undetailed electron gun **12** which incorporates an electron generating source **13**. The electron beam **19** emanating from the gun is directed to a cathodoluminescent screen, not shown, suitably disposed within the tube relative to the viewing panel **21**.

In referring to FIGURE 2, there is shown an enlarged view of the G_1 structure of the gun **12** wherein the electron generating source or directly heated cathode **13** is oriented on and between support means **27** and **27'**.

In greater detail and with reference to FIGURES 2, 3, and 4, the directly heated cathode **13** is a substantially planar metallic formation having substantially continuous uniform thickness and differential widths. It is formed from sheet or strip material of a cathode metal, alloy, or metallic laminated medium. Such materials are generally denoted as filament materials having high temperature strength, controlled resistance, and freedom from impurities detrimental to electron emission. As example of a suitable material is a cobalt-nickel alloy known as "Cobanic," manufactured by the Wilbur B. Driver Company, Newark, N.J. The cathode is formed to provide a defined high temperature section substantially shaped as a circular central portion **14** having a diameter larger than that of the aperture **25** in the associated G_1 electrode structure. Disposed on the surface of the central high temperature

portion, proximal to the G_1 aperture, is a conventional electron emissive coating **15** comprising materials such as two or more alkaline earth salts, including for example barium and strontium, which, when subsequently heated during tube processing, are chemically converted to forms capable of emitting electrons during tube operation. It is necessary that the area of emissive coating be of a size larger than the G_1 aperture to effect proper diametrical size to the electron beam to facilitate the focusing thereof by sequential gun elements, not shown. The cathode has an advantage over conventional structures in that lower power input is required due to its improved thermal efficiency whereby a major part of the thermal energy is concentrated in the central portion. Also, its resistive aspects permit the use of a higher voltage and lower current rating.

To achieve the improved feature of defined heat concentration there is a first heat loss deterrent section in the form of a first reduced width portion or first longitudinal leg portion **16** extending in a radial unbroken manner from the central portion to effect one electrical path and a first half of the suspension support therefor. The cross sectional area thereof is of a value to also provide limited heat conduction and defined resistance. In a similar manner, a second heat loss deterrent section in the form of a second reduced width portion or second longitudinal leg portion **16'** also extends radially from the central portion in diametrical opposition to the first reduced width portion to effect a second electrical path and a second half of the suspension support therefor. The cross sectional area of the second reduced width portion is of a value equalling that of the first reduced width portion to also provide defined heat conduction and resistance. Both legs are of substantially uniform longitudinal widths to minimize heat loss radiation therefrom. Each of the first and second heat loss deterrent portions have like distal terminal portions or tabs **17** and **17'** of increased widths to facilitate placement on and jointure with a compatible supporting structure. The larger tab areas effect heat sink characteristics at the extremeties of the cathode and make the actual positioning of the securement welds less critical.

The dimensional features of the directly heated cathode **13**, as generally noted in FIGURE 3, are substantially divided I.e., the transverse axis **18** of the central portion **14** has like metallic structures dimensioned as b and b' extending diametrically from either side thereof to achieve a concentration of heat in the central portion of the cathode having an overall longitudinal dimension of a wherein $a=b+b'$.

The heat loss deterrent sections or reduced width portions **16** and **16'**, which are longitudinally dimensioned as d and d' respectively, are designed as continuous integrations extending from the central high temperature portion to provide predetermined limited heat conduction therethrough and limited radiation therefrom.

It has been found that an example of an improved directly heated planar cathode, having a warm-up period of less than two seconds at electrical conditions of .5 volts and 500 milliamperes, may have dimensions (not to be considered limiting) substantially in the order of:

	Inches
Material thickness	.001
Overall length a	.230
Diameter of central portion g	.040
Leg portions **16**, **16'**: lengths d, d'	0.65
Leg portions **16**, **16'**: width e	.010
Terminal portions **17**, **17'**: lengths c, c'	.030
Terminal portions **17**, **17'**: width f	.040

The cathode being free of burrs, bows, ripples and twists is tautly mounted in a plane parallel with the closed end **24** of G_1 structure **23** at a predetermined spacing relative to the aperture **25** therein. In the improved cathode as described, the emissive covered central portion operates at approximately 800 degrees centigrade which is achieved as a rapid thermal rise. Since the cross sectional areas of the heat loss deterrent sections limits the conduction of heat therefrom, the thermal drop in the adjacent dimensionally reduced leg portions is indicated by a markedly sharp temperature gradient therein which is evidenced as being substantially below the color temperature. In addition to better warm-up the optimizing of the temperature in the central portion enhances complete conversion of the emissive materials thereon during tube processing without approaching the danger of overprocessing.

Suitably formed metallic means **27** and **27'** for supporting the aforedescribed cathode relative to the associated G_1 structure have been developed as shown in FIGURES 2 and 4. These are secured to a planar insulative positioning means **35** which is spaced from the apertured end **24** of the G_1 electrode to provide the proper operational K–G_1 spacing.

More specifically, as illustrated, the substantially planar insulative positioning means is dimensioned to fit within a cup-like G_1 electrode. This is not to be construed as limiting since the to-be-described cathode positioning and supporting means is also applicable to separate mounting orientation for usage with a disc-like or shallow thimble G_1 electrode. As shown, the insulative means is substantially formed as a wafer and may be, for example, of mica or ceramic material of a thickness such as at least .010 inch to provide rigid positioning support.

Secured to one surface of the insulative wafer are first and second metallic support members **27** and **27'** comprising like upstanding fixed portions **31** which are oriented in a spaced and substantially opposed manner relative to one another. One means of securement comprises a plurality of projections **28**, **29**, and **30** protruding from one side thereof to mate with and extend through commensurate perforations **37**, **38**, and **39** in the insulative wafer, whereupon the projections may be bent or twisted to effect seated securement of the member. As illustrated, both upstanding members comprising the support means are of like fabrication being vertically formed in a horizontal plane to provide securement to the positioning wafer along more than one plane perpendicular thereto as depicted by planes A, B, and C in FIGURE 4. Thus, rigid seated placement of the upright member **31** on the wafer is effected in a manner that is free of horizontal shifting and vertical rocking. Other vertical formings are also applicable including arcuate and additional angular manifestations.

In the embodiment illustrated, the support members are fabricated from nonmagnetic Type 305 stainless steel of substantially .005 inch thickness. In this instance the vertical height v of each member is in the order of .095 inch.

Each support member has an integral resilient portion **32** extending therefrom with a cathode attachment means **33** formed to accommodate a cathode terminal portion. Thus, means for jointure are provided for the two terminal portions by a first and a second cathode attachment means respectively. Since tube processing temperatures, to which the cathode and supporting members are subsequently subjected, are in the order of 500–600 degrees centigrade, the metallic composition of the members is such that the flexure of the resilient portions is not effected thereby.

Each cathode attachment means or shelf is formed with a surface area shaped in a manner commensurate with the shape and area of a cathode terminal portion or tab to facilitate rapid and accurate superimposing of the tab on the shelf.

After the two support members are secured to the insulative wafer, the integral resilient portion **32** of each upstanding support member is positioned or set in a manner to provide a definite bending moment thereto whereof a small predetermined angle of flexure $\angle\alpha$ of less than 3 degrees exists between the resilient portion **32** and the adjacent fixed portion **31**. This in turn defines an initial variable span s between the two cathode attach-

ment means; this span being greater than the given cathode length *a*. By jigging means, not shown, the two resilient portions are temporarily flexed in an equal manner toward each other to reduce the span therebetween to equal the cathode length *a*; whereupon the cathode terminal portions are superimposed on the cathode attachment means and welding jointures effected thereat. Release of the jigging means permits the resilient portions to exert a bending moment and initiate potential flexure in opposed directions to provide free suspension tensioning of the cathode and maintain tautness thereof during operation. The term "tension" as used herein does not connote permanent extension or elongation of the cathode material. It is a force value less than the hot yield strength of the cathode material at the smallest cross-sectional region thereof. The cathode length should remain consistent in accordance with the normal thermal expansion and contraction characteristics of the material.

In referring to FIGURE 3, the cathode **13** is joined to the respective cathode attachment means of each support member as by welding the terminal portion **17** and **17'** thereto, whereby one or more welds are applied substantially in relation to the two terminal transverse axes *m* and *m'* respectively. Being thus joined in a tensioned manner, the cold suspension length of the cathode is substantially denoted by the dimension *a'* between axes *m* and *m'*. The tensioning of the cathode is illustrated diagrammatically in FIGURE 5 wherein *a'* represents the cold length of the cathode as defined between the regions of jointure substantially along the transverse axes *m* and *m'* of the cathode terminal portions. The lines *ox* and *o'x'* represent the resilient portions **32** of each support member **27** and **27'** between which the cathode is mounted in free suspension at *x* and *x'*. As the cathode is heated, it expands to the length *r* as defined between *y* and *y'*. The bending moments of the resilient members **32** are equal and keep the cathode taut as it thermally expands. Since each member assumes half of the tensioning responsibility, for purposes of clarity the tensioning characteristics of only one end will be described. As illustrated in FIGURE 4, the predetermined initial angle of flexure $\angle\alpha$ of the resilinet member **32** is established prior to cathode jointure thereto and is greater than the angle of movement $\angle\beta$ of the resilient member consummated during cathode tensioning, i.e., $\angle\alpha > \angle\beta$. The movement of the resilient member **32** from position *ox* to *oz* exerts sufficient tension on the cathode to achieve a tensioned or taut length of *r'* which is slightly in excess of the normal expansion *r*, but significantly less than *t* which represents the hot yield-strength length of the cathode at the threshold of permanent elongation. Thus, the longitudinal tensioning movement of the cathode experienced during the thermal operational cycle is of a nature to keep the cathode taut in a planar position relative to the associated electrode and is represented by a *w* and *w'*. The relationship of *w* or *w'* to cathode length can be described as

$$w > \frac{r-a'}{2} \text{ or } w < \frac{t-a'}{2} \text{ or } w = \frac{r'-a'}{2}$$

The supported cathode-insulative wafer assembly is thence oriented within the G_1 electrode **23** against a tubular spacer **43** internally telescoped within the electrode and abutted against the closed end thereof. The spacer is of a height to provide the proper spacing between the cathode and the G_1 aperture **25** with the cathode being in a plane parallel therewith. Being thus positioned, the axis **49** of the aperture **25** intersects the central emissive portion **14** at substantially the center point **51** thereof.

A retainer **45**, fitted within the electrode in seated peripheral engagement with the bottom of the insulative wafer, fixes placement of the cathode support assembly.

Electrical connections **53** and **53'** for the directly heated cathode are made to respective projections on each of the support members.

Since the cathode is confined in the restricted space between the positioning wafer and the end of the electrode, the inclusion of an aperture **41** in the wafer has been found expeditious to facilitate subsequent exhausting of the outgassed products resultant from cathode activation and tube processing.

While the described embodiment of cathode support utilizes a resilient portion on each of the support members, it is within the scope of the invention to use resilient cathode attachment on one support member and nonresilient attachment on the opposing member.

Thus there is provided an improved directly heated cathode and supporting means for use in a cathode ray tube. The cathode has optimum temperature at its emissive portion and the structure is such that heat losses are reduced on either side thereof. Both the cathode and its associated support means are facilely fabricated and assembled. The rapid warm-up of the cathode achieves marked improvement in accelerating initial tube operation.

While there has been shown and described what is at present considered the preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the scope of the invention as defined by the appended claims.

I claim:

1. In a cathode ray tube, an improved directly heated rapid warm-up cathode oriented in free suspension on a support structure within the electron gun thereof with the high temperature portion positioned relative to the aperture of an associated electrode, said cathode having means for applying input power to the supported ends thereof to provide a cathode structure having improved performance in the form of a substantially integral planar metallic formation of differential widths comprising:

a defined high temperature section in the form of a substantially circular central portion wherein the major part of said input power is converted to thermal energy and substantially confined thereto; said central portion being of a diameter larger than said aperture of said electrode;

a first heat loss deterrent section in the form of a first reduced width portion extending radially in an unbroken manner from said central portion to effect one electrical path and a first half of the suspension support therefor, the cross sectional area thereof being of a value to also provide defined resistance therein and limited heat conduction therethrough from said high temperature section;

a second heat loss deterrent section in the form of a second reduced width portion extending radially from said central portion in diametrical opposition to said first reduced width portion to effect a second electrical path and a second half of the suspension support for said central portion, said second reduced width portion being substantially dimensionally equal to that of said first reduced width portion and having a like cross sectional area of a value to provide like defined resistance and limited heat conduction therethrough; said planar cathode being of substantially uniform thickness throughout said multiple integral sections; and

an electron emissive coating disposed on one surface of said central high temperature portion.

2. A directly heated cathode according to claim **1** wherein said first and said second reduced width portions each have like distal terminal portions of increased widths formed to facilitate placement on and jointure with said support structure.

3. A directly heated cathode according to claim **2** wherein each of said first and said second reduced portions are formed as substantially longitudinal leg portions having substantially uniform longitudinal widths to pro-

vide limited heat radiation therefrom, limited heat conduction therethrough, and defined resistance therein.

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U.S. Cl. X.R.

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