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ELECTRON DISCHARGE DEVICES AND MATERIALS THEREFOR

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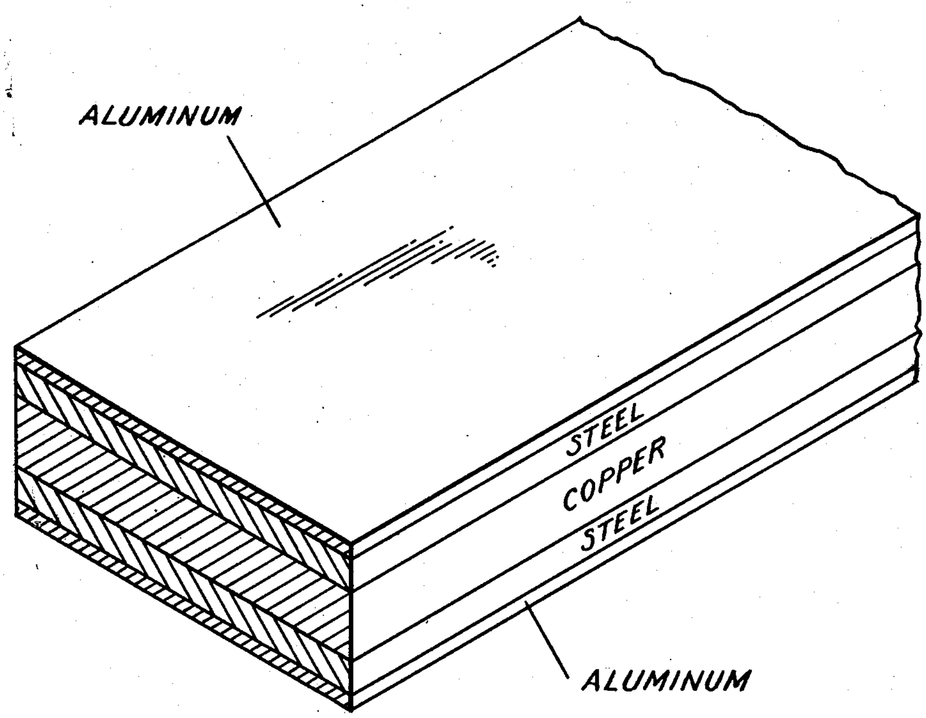

Inventors:
Frederick C. Ochsner,
Edwin A. Miller,
by Harold Levine
Att'y.

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ELECTRON DISCHARGE DEVICES AND MATERIALS THEREFOR

Frederick C. Ochsner and Edwin A. Miller, Attleboro, Mass., assignors to Texas Instruments Incorporated, Dallas, Tex., a corporation of Delaware

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The instant invention relates to electronic discharge devices and materials therefor, and more particularly, to amplifier tubes and anodes therefor.

It is an object of the instant invention to provide an electronic tube having a new and improved anode which affords an increased power output life of the tube.

It is another object of the instant invention to provide an electronic tube having a new and improved anode which affords substantially uniform heat distribution over the entire area of the anode, along with a substantial reduction of the hot area operating temperature of the anode.

It is yet another object of the instant invention to provide an electronic tube having an anode which is of high electrical conductivity and exhibits markedly improved tensile characteristics and affords markedly improved anode re-radiation characteristics.

It is yet another object to provide a receiving tube having a new and improved anode which exhibits markedly improved gas evolution characteristics when heated in a vacuum.

It is yet another object of the instant invention to provide a receiving tube having a new and improved anode which exhibits markedly improved thermal radiation properties, and which does not have undesirable inherent thermal deflection characteristics.

It is yet another object of the instant invention to provide a receiving tube having a new and improved anode which affords substantially reduced plate operating temperature.

It is yet another object of the instant invention to provide a receiving tube having a new and improved anode which accords a reduced temperature differential between the hot and cool portions thereof in operation and which also affords a reduction in temperature of hot portion.

It is yet another object of the instant invention to provide a receiving tube having a new and improved anode which exhibits improved grid emission characteristics.

It is yet another object to provide a receiving tube having a new and improved anode which provides the aforementioned improved characteristics and which is formed of a relatively thin multilayer composite material.

It is yet another object of the instant invention to provide a new and improved composite material having improved thermal conductivity properties, which composite materal is particularly useful, for example, as anode material in an electronic tube.

Among the further objects of the instant invention may be noted the provision of a receiving tube having a new and improved anode which affords miniaturized tube construction, increased power output life and improved thermal and emissive characteristics and lower production costs.

Other objects will be in part apparent and in part pointed out hereinafter.

The invention accordingly comprises the elements and combinations of elements, steps and sequence of steps, features of construction and manipulation, and arrangements of parts, all of which will be exemplified in the structures and methods hereinafter described, and the scope of the application of which will be indicated in the following claims.

The accompanying drawing illustrates the five-layered

composite material, of which the new and improved anode of the instant invention is formed.

Recent trends in the receiving tube art, particularly for amplifier tubes, have resulted in increased requirements for further miniaturization of these tubes along with increased electrical performance. Such increased requirements have created problems, among which one of the most significant is that of temperature, particularly that of the anode since it is this component of the tube wherein most of the heat therein is generated. Since the anode is required to re-radiate the heat generated to the other components of the tube such as, for example, the grid, cathode and envlope, it is important that the anode does not operate at an excessive temperature. Excessively high anode temperature can cause excessive grid and cathode temperature and result in the development of excessive grid emission during the life of the tube. Further, such excessive temperature, and particularly "hot spots" or localized areas of heat generation, can create excessive gas evolution from the anode which can severely reduce the power output life of the tube. The instant invention successfully solves these and other problems and affords a number of advantages as will be more fully described below.

It has been discovered that an anode formed of a five-layed composite material such as that shown in the drawing will successfully solve the above-mentioned problems and provide a number of unique and unobvious advantages. The five-layered composite material in cross section comprises two layers of aluminum each adhered or bonded to a respective one of two layers of steel with said layers of steel being bonded to and sandwiching therebetween a layer of copper as shown in the drawing. The five-layered composite strip may be bonded by the methods set forth in detail in the patent to Boessenkool, No. 2,691,-815, granted October 19, 1954. It is preferred though not absolutely essential, that the aluminum layer be an Alcoa C–22 aluminum alloy (which includes 1.0–1.5% silicon) and that the steel be a low carbon steel (0.08% carbon maximum) and that the copper be an OF (oxygen-free) copper. The OF copper is preferred to any of the deoxidized coppers so as to afford a maximum electrical and thermal conductivity and a low residual gas content. The low carbon content of the steel affords a low-springback characteristic, which is advantageous in forming the parts. The copper layer affords the advantage of providing the composite material with high thermal conductivity as well as high electrical conductivity. The steel layer also serves to add strength to the composite strip and to compensate for the fact that the strength of the copper layer might be low in view of the high temperatures at which many of the tubes operate. The aluminum surface layer combines with the adjacent steel layers during the final firing of the tube to form a dark grey surface layer of very high thermal emissivity. The anode generally does not operate at uniform temperatures over its entire area because of its peculiar geometric configuration and localized areas of heat generation. As mentioned above, these "hot spots" create most of the gas evolution from the anode and cause temperature increase of other components of the tube. Several attempts have been made to reduce the temperature of the anode such as, for example, incorporating radiating fins and increasing the radiation area of the anode. For example, materials such as carbonized nickel have been extensively used because of their radiation properties. Increasing the radiation of the anode will tend to increase the size of the tube rather than afford further miniaturization. The anode of the instant invention formed of the five-layed composite material described above serves to afford a more effective use of the radiation area of the anode and to reduce the hot spots or hot area temperature, and affords a material of both good thermal conductivity properties as well as good radiation properties.

Due to the fact that the anode of the instant invention is formed of a material having a relatively large percentage thereof which is of substantially gas-free material (the OF or oxygen free copper), the overall gas content of the anode is considerably lower than that which would obtain with anodes formed of conventional anode materials. This advantageously facilitates quicker and more complete out-gasing and affords less gas evolution during the operating life of the tube.

Tests wherein tubes with anodes according to the instant invention were compared to tubes with anodes formed of other materials such as, for example, carbonized nickel, show that tubes with anodes of the instant invention have the following improved characteristics.

(1) The tube with the anode of the instant invention affords considerably reduced gas evolution in a vacuum when the materials are heated.

(2) A substantially reduced temperature difference between the hot and cool portions of the tube and also some reduction in temperature of the hot portion are effective in increasing the power output life of the tube.

(3) The greater uniform temperature distribution advantageously affords faster and more complete out-gasing.

(4) The anode of the instant invention affords greater uniform temperature distribution over the entire area of the anode with no deleterious effects on the thermal radiation properties.

(5) The anode of the instant invention, in reducing its high temperature and consequently avoiding excessive grid and cathode temperatures, serves also to avoid the development of excessive grid emission during life.

The anode of the instant invention, which is formed of the five-layered composite material as described above, is further advantageous in that it does not have undesirable inherent thermal deflection characteristics. The three materials which constitute the composite strip, namely, aluminum, steel and copper, have different coefficients of thermal expansion. Ordinarily, if the composite strip were of asymmetrical construction, this would give rise to a thermal deflection or a curvature of the composite material which would be induced by heating. Since the composite material of the instant invention is of asymmetrical construction, the problem of undesirable inherent thermal deflection is advantageously obviated.

The anode of the instant invention, with its lower temperature differential between the hot and cool portions of the anode, affords a more uniform and greater amount of total surface emission which serves to advantageously reduce back emission, and more uniform heat distribution over the entire area of the anode also advantageously affords greater thermal emission and serves to considerably reduce gas evolution by elimination of hot spots which also advantageously serves to provide a greater power output life of the tube. Further, the anode of the instant invention, by affording a more uniform heat temperature distribution over its entire area and substantially eliminating hot spots, serves to reduce the ambient temperature and reduce filament burnout and affords a longer tube life, and because of the substantially increased and more uniform thermal emission properties, affords miniaturization of the tube construction.

It was first thought that an anode formed of the five-layered composite material as described above could be made only in .007" minimum thickness, wherein the copper layer comprised a minimum of 40% of the thickness of the composite cross section. It was believed that a minimum of 40% copper would be required to afford the advantages and necessary thermal emissive properties and the other advantages described above. Providing materials thinner than .007" and yet maintaining the 40% minimum copper material requirement proved to be unfeasible in view of fabrication problems and the fact that the composite material had a low strength because of the substantial copper inclusioin.

The unexpected result was then discovered that as little as 16%–20% (or an average of 18%) copper could be employed in a .005" thick, composite material, which would provide substantially all of the desirable results afforded by .007" and thicker 40% copper minimum composite materials and would provide additional advantages thereover. The following comparison table indicates the relative thicknesses of the copper, aluminum and steel layers for a .005" thick, 18% average copper composite material and a .007" and .010" thick, 40% copper material.

Five-Layered Composite Material	Copper Thickness Range	Aluminum Thickness Range	Steel Thickness Minimum
.005" 18% Cu	0.0010 0.0008	0.00025 0.00060	0.0015
.007" 40% Cu	0.0032 0.0025	0.0003 0.0008	0.0017
.010" 40% Cu	0.0035 0.0045	0.0003 0.0008	0.0025

It was discovered that the .005" thick, with less than 40% copper material, with an 18% copper composite material taken as an example, provided a number of advantages over the .007" and thicker, 40% copper minimum five-layered composite material, which include:

(1) Greater strength to withstand distortion at high operating temperatures;

(2) The .005" thick, 18% copper material afforded greater miniaturization over the thicker 40% copper material and afforded further cost reduction;

(3) The .005" thick, 18% copper composite material permits simpler production assembly and facilitates production and tube processing by requiring less out-gasing time;

(4) The greater proportion of steel in the cross section of the .005" composite material facilitates welding and reduces fabrication time;

(5) The thinner .005" material, because of the greater proportion of steel in the cross section, affords improved dimensional stability characteristics in that it maintains a more substantially constant dimension during operation; and

(6) The thinner .005", 18% copper composite material, in addition to providing the advantages listed above over that of the .007" and thicker, 40% copper material, additionally provides substantially all of the advantages and the improved performance characteristics of the thicker materials.

In view of the above, it can be seen that the several objects of the invention are achieved and other advantageous results attained.

As many changes could be made in the above constructions and methods without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings, shall be interpreted as illustrative and not in a limiting sense, and it is also intended that the appended claims shall cover all such equivalent variations as come within the true spirit and scope of the invention.

We claim:

1. An electron discharge device comprising an anode formed of a five-layered composite material, said material in cross section comprising two layers of aluminum each metallurgically bonded to a respective one of two layers of steel and said layers of steel metallurgically bonded to and sandwiching therebetween a layer of copper, said copper layer having a thickness comprising less than 40% of the thickness of said five-layered composite material, and said composite material being approximately .005 of an inch in thickness.

2. An electron discharge device comprising an anode formed of a five-layered composite material, said material in cross section comprising two layers of aluminum

each metallurgically bonded to a respective one of two layers of steel and said layers of steel metallurgically bonded to and sandwiching therebetween a layer of copper, said copper layer having a thickness comprising less than 40% and at least 16% of the thickness of said five-layered composite material, and said composite material being approximately .005 of an inch in thickness.

3. Composite anode material comprising a plurality of metallurgically bonded metallic layers at least five of which layers comprise aluminum, iron, copper, iron and aluminum, in that order; said composite anode material being aproximately .005 of an inch in thickness, and said copper layer having a thickness comprising less than 40% and at least 16% of the thickness of said composite anode material.

4. The electron discharge device as set forth in claim 3 and wherein each of said aluminum layers are exposed outer layers.

5. Anode material for an electron discharge device comprising a five-layered composite material, said material in cross section comprising two layers of aluminum each metallurgically bonded to a respective one of two layers of steel and said layers of steel metallurgically bonded to and sandwiching therebetween a layer of copper, said copper layer having a thickness comprising less than 40% and at least 16% of the thickness of said five-layered composite material, and said composite material being approximately .005 of an inch in thickness.

References Cited in the file of this patent

UNITED STATES PATENTS

1,077,977	Fuller	Nov. 11, 1913
1,656,892	Shover	Jan. 17, 1928
2,490,700	Natchman	Dec. 6, 1949
2,558,093	Kinney	June 26, 1951
2,859,158	Schaer	Nov. 4, 1958
2,916,337	Fike	Dec. 8, 1959
2,947,069	Carlson	Aug. 2, 1960
2,952,904	Hann	Sept. 20, 1960