United States Patent

Millis

[15] **3,662,211**

[45] **May 9, 1972**

[54] CATHODE CONSTRUCTION

[72] Inventor: **Walter T. Millis,** Owensboro, Ky.

[73] Assignee: **General Electric Company**

[22] Filed: **Jan. 15, 1970**

[21] Appl. No.: **4,167**

Related U.S. Application Data

[63] Continuation of Ser. No. 95,932, Mar. 15, 1961, abandoned.

[52] **U.S. Cl.** **313/340,** 313/45, 313/326

[51] **Int. Cl.** **H01j 1/24**

[58] **Field of Search** 313/45, 340, 326; 29/25.14, 29/25.17

[56] **References Cited**

UNITED STATES PATENTS

2,057,124 10/1936 Van Gessel et al. 313/340

1,872,359 8/1932 Sutherlin.....313/326 X

OTHER PUBLICATIONS

Kohl, " Materials and Techniques for Electron Tubes" Reinhold Publishing Co., N.Y. 1960, pgs. 557– 563, TK 6565, V3K65.

Primary Examiner—Roy Lake
Assistant Examiner—Lawrence J. Dahl
Attorney—Nathan J. Cornfeld, O. B. Waddel, John P. Taylor and Frank L. Neuhauser

[57] **ABSTRACT**

Structures and methods are disclosed for accelerating the warm-up time of an electron discharge device having an indirectly heated cathode either by coating the cathode with a high heat absorption material or by increasing the heat radiation properties of the heater.

5 Claims, 4 Drawing Figures

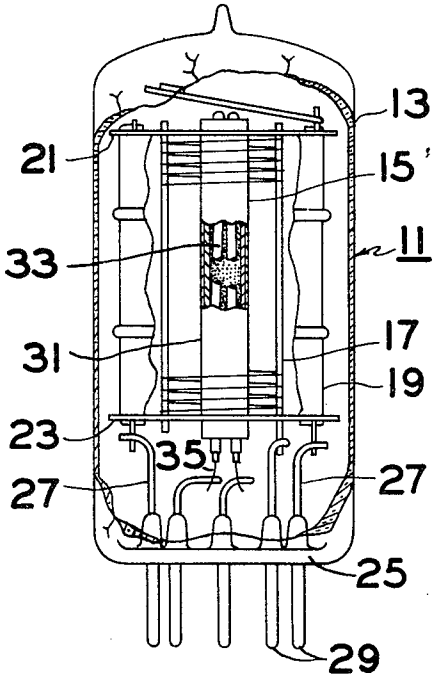


FIG. 1

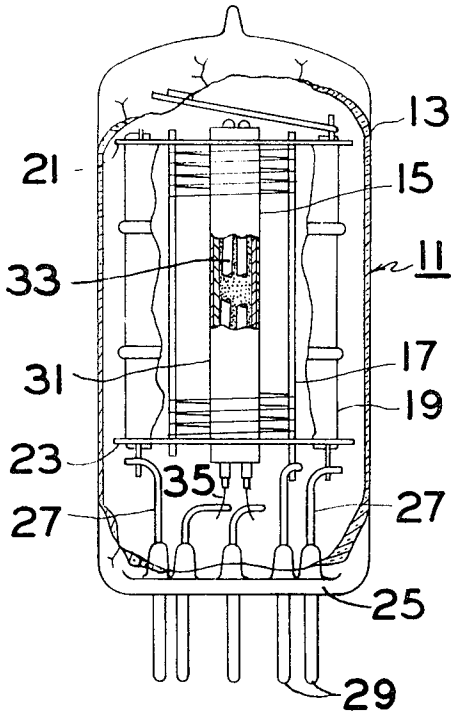


FIG. 2

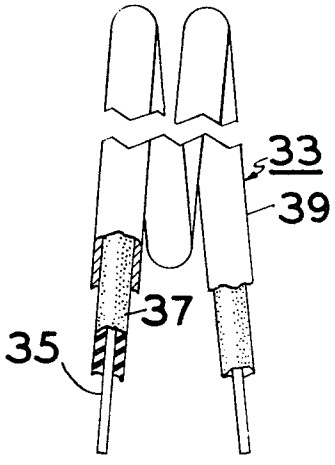


FIG. 3

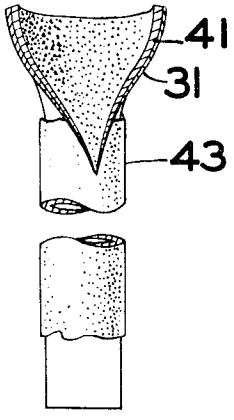
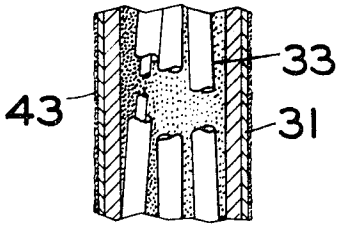


FIG. 4



INVENTOR.
WALTER T. MILLIS
BY
Nathan J. Compton
ATTORNEY

CATHODE CONSTRUCTION

"This application is a continuation of application Ser. No. 95,932, filed Mar. 15, 1961, and now abandoned."

This invention relates to electron discharge devices, and more particularly to indirectly heated cathodes utilizable in such devices.

Electron discharge devices are being used in applications in which extremely small warm-up times, so called, are required and while it has been recognized heretofore that reduction in warm-up time can be effected by arrangements which reduce the temperature differential between the heater and the cathode during the warm-up period, such expedients as have been proposed have not resulted in sufficiently reduced warm-up times to meet present requirements.

Constructions are known which would reduce the mass of the cathode, thus to reduce the time required for the cathode to reach effective electron-emission temperature, the so-called "warm-up" time. However, the mass of the cathode can be reduced only to a point at which its structural strength becomes so reduced as to adversely affect its rigidity. The corresponding warm-up time value has not been found to be adequate for many applications.

It is, therefore, a principal object of my invention to provide an indirectly heated cathode of improved thermal efficiency.

It is another object of my invention to provide a high thermal efficiency cathode of the indirectly heated type characterized in that the warm-up time therefor is reduced to a minimal value.

In accordance with the present invention, substantial reduction in warm-up time is accomplished by increasing the heat-radiating property of the heater or by increasing the heat-absorption characteristic of the cathode or by the combination of increased heat radiation by the heater and increased heat absorption by the cathode. Thus, the heater, according to the present invention, is formed with an outer surface coating which may be of a carbonaceous material overlying the insulative covering of the heater wire, or the coating may be of particulated or finely divided tungsten with similar results.

Further, in accordance with the present invention, the surface of the cathode adjacent the heater is formed with a high-heat absorbing material which may be in the form of a coating of carbonaceous material suitably affixed to the said cathode surface, or the coating may be of a suitable oxide, say of chromium.

Still further, in accordance with the present invention, a low warm-up time heater-cathode assembly is provided, characterized in that the temperature differential between the heater and the cathode is reduced to a relatively low value, which assembly comprises a heater having an outer coating of high-heat emissivity in combination with a cathode having high-heat absorption characteristics.

My invention possesses other objects and advantageous features, some of which together with those described above, will be set forth in the following description and accompanying drawing in which:

FIG. 1 is an elevational view, with parts broken away, illustrating an electron discharge device embodying the features of this invention;

FIG. 2 is an enlarged view, partly in cross-section, of a heater element usable with the cathode of the electron discharge device of FIG. 1;

FIG. 3 is an enlarged view, partly in cross-section, of the cathode; and

FIG. 4 is a fragmentary view in cross-section of the assembled heater-cathode assembly in accordance with this invention.

Referring now to the drawing, there is illustrated in FIG. 1 an electron discharge device 11 which may comprise an evacuated envelope 13, within which is supported a cage assembly including coaxially disposed electrodes which, in the illustrated embodiment, may include a cathode 15, a grid 17 and an anode 19. The cathode, grid and anode elements are supported between top and bottom insulative spacer elements or micas 21 and 23, respectively, the cage being supported

from the stem 25 of the envelope by stem supports as at 27. Connections from the electrodes to the stem supports may be effected in the usual manner and afford connections to the exterior pins 29.

While the invention is disclosed herein as embodied in a triode type of electron discharge device, it will, of course, be recognized that this type is exemplary only and that the features of the invention may readily be applied to other types of electron discharge devices, as for example, diodes, tetrodes, pentodes, et cetera, which in usual forms employ cathodes of generally cylindrical form and on the outer surfaces of which are deposited suitable electron emissive material which, upon being heated, are adapted to provide copious supplies of electrons.

Other types of electron discharge devices in which the features of the present invention may also be applied, include the planar-electrode devices wherein the cathode may be in the form of a substantially planar disk or, sometimes, a dished or cup-shaped member having on one surface thereof a coating of electron emissive material, the opposite surface of which is adapted to be heated by a heater in next adjacent spatial relation thereto.

The cathode 15, in accordance with the invention, may comprise a generally cylindrical, tubular sleeve 31, within which is disposed a heater 33 which, in turn, is adapted to be supplied with suitable heating current from a source (not shown). The heater 33, as shown more clearly in FIG. 2, may comprise a filamentary conductor 35 which may be of tungsten or other suitable refractory metal, which is coated with an insulative coating 37 which may be of a conventional variety consisting of a mixture of aluminum oxide and aluminum nitrate, or any other suitable insulative composition which may be applied to the conductor 35, as by drag coating, spray coating, or by any suitable cataphoretic process. Overlying the insulative coating 37, and for enhancing the heat radiating properties of the heater, I provide an electrically conductive, high-heat emissive coating 39 which comprises finely divided carbon in the form of lamp black or micronized graphite. To apply the heat-emissive coating 39, a quantity of finely divided carbon may be intimately mixed with a mixture of aluminum oxide and aluminum nitrate of the kind used for forming the insulative coating 37 and in proportions ranging from about 1 per cent to about 20 per cent carbon, by weight, and in a suitable vehicle for use with a drag-coating apparatus such as that disclosed and claimed in U.S. Pat. No. 2,943,598 to W. H. Newton, patented July 5, 1960. The heat-emissive coating may also be applied cataphoretically or it may be applied by spraying, in which case the carbonaceous mixture would be suspended in a suitable binder such as nitrocellulose.

The heater resulting from the just-described processing is characterized by a relatively blackened exterior appearance and provides a substantial reduction in time required to transfer heat from the conductor 35 to the cathode sleeve 31.

In another embodiment of my invention, a blackened outermost coating 39 is provided by mixing, with the aluminum oxide and aluminum nitrate, finely divided or pulverized tungsten instead of the carbon of the foregoing example, in proportions of from about 1 per cent to about 40 per cent tungsten, by weight, and applied to the insulative coating 37 as by drag coating, spray coating or cataphoretically, to provide a coating having the desired blackened high-emissive exterior.

It will be noted that the heater constructions described above not only provide the desired high-heat transfer characteristics but also operate to eliminate a defect found in heater-cathodes heretofore employed. Conventional heater-cathode arrangements used in electron discharge devices which are employed in tuned-circuit arrangements have been found to present a heater-to-cathode electrostatic capacitance which may actually form part of the tuned circuit. In such circumstances, relative movement of the heater and cathode resulting, say from mechanical shock or other vibration-producing disturbances causes undesired variations in the heater-cathode capacitance which, in turn, causes unwanted varia-

tions in the tuned-circuit characteristics. It will be seen, therefore, that in the heaters as above described, the outer coating is electrically conductive and when the heater is snugly fitted within the bore of a cathode sleeve, an electrical connection between the outer coating of the heater and the cathode sleeve is effected. Accordingly, the outer coating of the heater and the sleeve are at the same potential, thus rendering the capacitance between the cathode sleeve and the heater constant, independent of any relative movement therebetween. Thus, undesired capacitance variations between heater and cathode and the unwanted variations in the tuned-circuit characteristics noted above are eliminated.

In accordance with another feature of this invention, the cathode **31**, as shown more clearly in FIG. **3**, may be a tubular sleeve that is rendered highly heat-absorbent by providing a darkened interior coating **41** thereon. Such darkened coating may be provided by cladding on the inner surface of the sleeve a relatively thin layer of aluminum. The cladding is preferably performed prior to formation of the sleeve by a pressure cladding operation in which flat stock cathode nickel material and aluminum sheet material are tightly pressed together in sheet form under high mechanical pressure conditions. The composite metal is thereafter formed into tubular sleeve members interiorly clad with aluminum, and which may be provided with butt, lock, or lap seams, as desired, and cut to any desired length. The exterior surface of the sleeve is coated in any conventional manner with an electron-emissive material **43**. In operation, at the normal operating temperature of the cathode, the aluminum cladding is converted to an aluminum-nickel reaction product which presents a blackened interior surface having a high-heat absorption quality.

Another arrangement for providing the relatively darkened high-heat absorption coating **41** for the cathode sleeve **31** is to carbonize the inner surface of the sleeve. Such a carbonized coating may be applied in a manner similar to that employed in applying the finely divided carbon to the outer insulative coating **37** of the heater wire **35** described above. Or, the carbonized coating may be applied by preliminarily masking one surface of the nickel sleeve material and applying a carbonized coating to the other in accordance with a method described and claimed in the patent of Perl, U.S. Pat. No. 2,821,496 patented Jan. 28, 1958 and assigned to the assignee of the present application.

In accordance with another feature of the invention, a high-heat absorption coating is formed on the inner surface of the cathode sleeve by plating the cathode nickel sheet material, prior to forming the material into sleeves, with a relatively thin layer of chromium. In one operative embodiment, a thickness of chromium of about 0.0001 inch was found to provide, when oxidized in a wet hydrogen atmosphere at a temperature of approximately 700° C., a blackened oxide of chromium surface that was highly heat absorbent. The firing of the chromium plate at temperatures above 700° C. and up to about 1,100° C. produced equivalent high-heat absorbent surfaces in times substantially less than that described above for the firing at 700° C.

The chrome oxide layer has been found to be extremely stable at the normal operating temperatures of electron discharge devices and is sufficiently flexible to permit forming the sheet material into tubes of relatively small diameter without fracture or peeling of the oxide. It will be noted that during the firing operation described above, the nickel surface of the sleeve material is not adversely affected, this surface retaining its bright appearance, probably because nickel oxides are extremely unstable at the firing temperatures so that such oxides that may be formed are readily reduced down leaving a bright, highly reflective nickel surface suitable as the base for electron-emissive material.

In still another form of the invention, the heat absorptive surface **41** is formed on the interior coating of the sleeve **31** by cladding the cathode nickel alloy material, while in sheet form, with a coating of "Inconel," which is a brand of chrome-nickel-iron alloy available from the International Nickel Company and having approximately 15 per cent, by weight, chromium in an alloy containing components in the following approximate proportions:

Nickel	77.0%
Chromium	15.0%
Iron	7.0%
Copper	0.2%
Manganese	0.25%
Silicon	0.25%
Carbon	0.06%
Sulphur	0.007%

An alloy having similar composition and as effective as the above-mentioned "Inconel" is obtainable from the Driver-Harris Company under the trademark "Nirex."

I have found that a cladding or pressure bond of the high-chromium content alloy onto standard cathode alloys, as, for example, No. 225 cathode nickel alloy or No. 449 cathode nickel alloy in a ratio of approximately 80 per cent chrome alloy to 20 per cent cathode alloy, yields a well-blackened high-heat absorptive chromic oxide surface when the composite metal is fired in a wet hydrogen atmosphere at a temperature of about 1,000° C. for approximately 10 minutes. The operation of converting the chrome alloy to form a dark chrome oxide is a time-temperature process so that if the firing is carried out at temperatures above the noted 1,000° C., the time cycling can be correspondingly less than the indicated 10 minutes. Again, the cathode nickel alloy component of the composite material is virtually unaffected by the firing operation, because any nickel oxide that may be produced is unstable and reduced down readily at the firing temperature.

Electron discharge devices constructed in accordance with certain of the features of the present invention have demonstrated a substantial reduction in warm-up time resulting from the high-heat transfer characteristics provided thereby. In a series of tests conducted with commercially available types and utilizing a conventional heater, e.g., one not coated with the externally blackened high-heat emissive material but used to heat a cathode sleeve having a darkened interior surface of chromic oxide, the novel cathode assembly demonstrated reductions in warm-up time of approximately 30 to 38 per cent as compared to cathodes of conventional construction. Thus, with cathode sleeves having a wall thickness of 0.0035 inch, an average warm-up time of 31 seconds is observed with a conventional cathode alloy sleeve. This time was reduced to a value of 19 seconds when a cathode sleeve in the form of the composite metal of this invention is used in which the ratio of cathode nickel alloy to "Inconel" was 20 to 80. In another embodiment in which the cathode sleeve with a wall thickness of 0.0021 inch was used, the warm-up time of approximately 23 seconds for a conventional cathode alloy sleeve was reduced to approximately 16 seconds when a cathode sleeve of cathode alloy clad with "Inconel" in the ratio of 20 to 80 was used. In both embodiments, the chromium-alloy cladding was oxidized, prior to formation of the cathodes, in accordance with the above-described process.

Further reduction in warm-up time can be obtained through the use of a heater-cathode assembly as shown in FIG. **4**, wherein a high-heat radiating heater **33** of the type described above is employed to heat a high-heat absorptive cathode sleeve **31**.

There has thus been described arrangements for reducing the warm-up time of electron discharge devices by increasing the heat transfer characteristic between the heater and the cathode of an indirectly heated cathode assembly. While the invention has been described in connection with cathode constructions utilizing substantially cylindrical sleeve members, it will be understood, as noted above, that the features of the invention are not limited to employment in such cathode constructions, it being apparent that the heat radiating and heat absorptive features can readily be applied to relatively planar and cup-shaped or dished cathodes, the side thereof adjacent

the heater being blackened in the manner and by the means described above and disposed in next adjacent relation to a heater of which the insulative coating is provided with a black high-heat emissive material.

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

1. A cathode support for an indirectly heated cathode for electron discharge devices, comprising a base element of cathode nickel alloy, and a cladding on one surface of said element, said cladding consisting of a selectively oxidized alloy comprising chromium, nickel, and iron having an oxide of chromium thereon to provide a relatively high heat-absorptive means, said element being adapted to support on an opposed surface thereof an electron-emissive material.

2. The cathode support as defined in claim 1 wherein said base element is a tubular member having electron-emissive material on the outer surface thereof and wherein the chromium, nickel, and iron alloy further comprises an oxide of chromium on the inner surface of said tubular member as said heat-absorbing means.

3. A process for forming a cathode support for an indirectly heated cathode for electron discharge devices comprising:

a. cladding a cathode nickel sheet with a chrome-nickel-iron alloy;

b. forming the clad sheet into a cathode support; and

c. selectively oxidizing in a wet hydrogen atmosphere the chrome metal portion of said alloy on said support at an elevated temperature to form an oxide of chrome on said alloy, said wet hydrogen atmosphere inhibiting the oxidation of nickel.

4. The process of claim 3 wherein said support is selectively oxidized at a temperature of about 1,000° C.

5. A process for forming a cathode support for an indirectly heated cathode for electron discharge devices comprising:

a. cladding a cathode nickel sheet with a chrome-nickel-iron alloy

b. forming the clad sheet into a cathode support; and

c. selectively oxidizing the chrome metal portion of said alloy on said support at an elevated temperature to form an oxide of chrome on said alloy.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,662,211 Dated May 9, 1972

Inventor(s) Walter T. Millis

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Delete Claim 5, Column 6, Lines 12-19.

Signed and sealed this 12th day of September 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334