March 15, 1966 W. E. BUESCHER 3,240,569

CATHODE BASE STRUCTURE

Original Filed Aug. 26, 1959

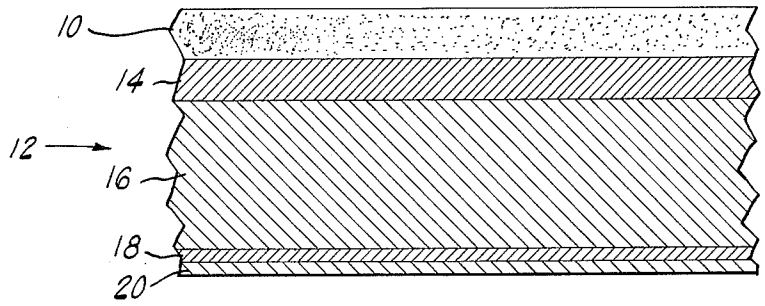


Fig. 1

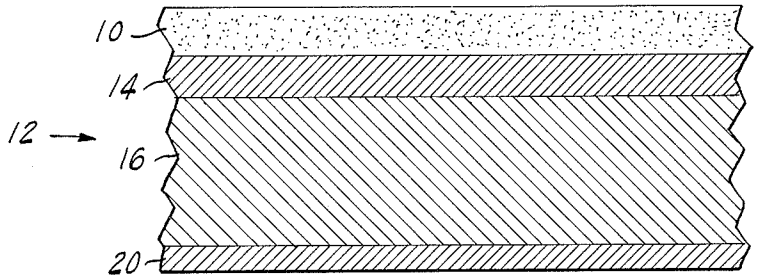


Fig. 2

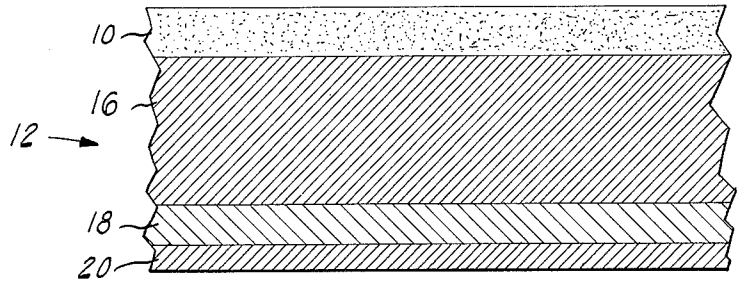


Fig. 3

INVENTOR
WILLIAM E. BUESCHER
BY
Robert E. Strauss
ATTORNEY

United States Patent Office 3,240,569 Patented Mar. 15, 1966

3,240,569

CATHODE BASE STRUCTURE

William E. Buescher, Emporium, Pa., assignor to Sylvania Electric Products Inc., a corporation of Delaware

Continuation of abandoned application Ser. No. 836,278, Aug. 26, 1959. This application Aug. 21, 1964, Ser. No. 391,275

7 Claims. (Cl. 29—183.5)

This invention relates to a cathode base structure utilizable in an electron discharge device such as a radio receiving tube and is a continuation of Serial No. 836,278, filed August 26, 1959.

In one method used in the production of cathodes or electron emitters the base structure is coated with a mixture of alkaline earth metal carbonates comprising, principally, the carbonates of barium, strontium, and calcium. During cathode activation the carbonates are broken down into their oxides by the application of high temperatures to the base as by energizing the heater to temperatures above its normal operating temperatures. Further, prolonged heating of the oxides with moderate positive potential applied to an adjacent electrode renders the oxides electron emissive, with concomitant reduction of some of the oxide material to the earth metal.

During tube use the emissive characteristic of the coating is dependent upon the rate at which the alkaline earth oxides are reduced to free metal. One of the primary causes of this reduction is the migration of reducing materials contained within the cathode base to the interface between the base and the emissive coating and their reaction therewith. The life characteristic of the tube is dependent in part upon the activity of these reducing agents. It has been necessary heretofore to exclude certain materials from the cathode base that are particularly useful as reducing agents. These materials have been excluded because they are known to sublimate at the processing temperatures employed during the conversion of the carbonates contained in the coating to the oxides and thus to produce leakage paths between the electrodes. Sleeve type cathode bases, fabricated from homogenous base materials by previous techniques, were weakened by the effect of the tube processing and operating temperatures upon their structure. This resulted in poor shock and vibration characteristics of the finished tube.

It is an object of this invention to reduce interelectrode leakage due to sublimation of constituents of the cathode base.

It is another object of this invention to reduce hum encountered in the completed tube which is due to leakage between the heater and cathode.

It is another object of this invention to increase the stiffness of cathode bases without the introduction of materials deleterious to cathode life.

It is still another object of the invention to reduce sublimation of reducing agents from the cathode base during tube processing.

The foregoing objects are achieved in one aspect of the invention by the provision of a laminated cathode base structure having lamina which cooperate with one another to give the desired characteristics. In one aspect of the invention a lamina is provided to delay the migration of the alkaline earth oxide reducing agents contained in the active cathode base material to the interface between the cathode structure and the coating applied thereto until the end of the cathode coating activation process. In a second aspect of the invention a lamina is provided within the cathode base structure to increase the high temperature-strength characteristic of the base structure. In yet another aspect of the invention an inner lamina is provided to inhibit the sublimation of the constituents of the active cathode base material and which forms a thermally efficient insulating coating on the interior of the base when employed in an indirectly heated cathode.

For a better understanding of this invention, reference is made to the following description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a fragmentary cross-section of a laminated cathode employing a base structure fabricated according to one aspect of this invention;

FIG. 2 is a cross-section of a cathode embodying another aspect of the invention; and

FIG. 3 is a fragmentary cross-section of yet another laminated cathode base.

Heretofore, cathode base structures have been fabricated, primarily from a homogenous active cathode base material. These active materials are generally selected from the class of alloys of nickel or cobalt containing various alkaline earth oxide reducing agents. The active cathode base materials are so designated due to the activity of their reducing components in converting the oxides of the coating to their constituent metals. The reducing agents are employed to produce and sustain the emissive characteristics of the cathode during the life of the tube. The reducing agents migrate through base structure to the interface between the oxide coating and the base at which place the necessary reduction takes place. The migration or diffusion of the reducing agents through the base is dependent in part upon the temperature of the base structure. During that portion of the tube processing in which the emissive materials are activated, the cathode is heated to a temperature of approximately 1000° C., which is above its normal operating level (700°–800° C.) to speed up the reduction.

It is believed that the pure metals, formed by the reduction of the oxides contained in the coating, migrate from the interface through the oxide coating to the outer surface of the coating where they function as an electron source. Both the reducing agents and the reduced metals are susceptible to vaporization at the elevated temperatures employed during tube processing and activation. Therefore, interelectrode leakage problems are encountered due to the deposition of these materials on the insulating spacers in the tube. Further, undesired secondary emission from other electrodes in the tube is due to the condensation deposits of emitting material.

When the aforementioned homogenous cathode base structures were employed, it was also found that the completed tubes were susceptible to vibration and shock which distorted the cathode. At the operating temperature of the cathode, approximately 700–800° C., the base structure was easily caused to bow, thus causing a change in the interelectrode spacing, and if severe enough, causing interelectrode contact.

FIGS. 1, 2, and 3 illustrate completed unipotential cathodes which have an alkaline earth oxide coating 10 applied to a laminated cathode base 12. While the illustrations show a unipotential cathode, the teaching of the invention is equally applicable to filamentary or ribbon type cathodes.

In the embodiments shown in FIGS. 1 and 2, the laminated base 12 is provided with an outer lamina 14 composed primarily of substantially pure nickel with a minimum of extraneous ingredients. For example, the silicon content of the lamina 14 should be in the vicinity of .01% or less, and the magnesium content should be in the same range. This lamina may be conveniently applied to the active cathode base material 16 forming the inner lamina of the base structure by well-known techniques such as cladding.

The substantially pure nickel lamina 14 clad over the active cathode base material lamina 16 extends the time,

at the processing temperature, before an appreciable migration of the reducing agents contained in the active lamina to the interface between the oxide coating **10** and the nickel lamina **14** occurs. When sufficient thickness of nickel is employed, the sublimation of the reducing agents during the processing operation is reduced since they are encased by the lamina. Additionally, since reducing agents cannot appreciably convert the alkaline earth oxides to their constituent metals during the actual tube processing, the problem caused by the sublimation of the emitting metals is also alleviated.

An active cathode base material **16** may be selected from any of the many alloys known to be useful for this purpose. As an example, the alloy described in United States Patent 2,837,423, which is assigned to the same assignee as the present invention, may be used. This alloy contains the following ingredients in the stated quantities:

	Composition, percent	Range, percent
Aluminum	.04	.04-.10
Tungsten	2.0	1.5-5.0
Titanium	.006	.0-.05
Cobalt	.5	.0-1.0
Manganese	.05	.02-.20
Copper	.006	.0-.015
Chromium	1.0	.2-2.25
Silicon	.005	.0-.05
Carbon	.01	.0-.03
Magnesium	.04	.01-.10
Iron	.04	.0-.08
Nickel	Balance	Balance

In one embodiment of the invention a cathode base structure **12**, which was .020" thick, was fabricated with a nickel lamina approximately 20% of the total thickness and an active cathode base material lamina of the above-described alloy comprising approximately 70% of the total thickness. A marked reduction in sublimation and interelectrode leakage was noted in life tests of tubes employing such cathodes.

As previously indicated, the thickness of the nickel lamina as an outer layer **14** may be varied, depending upon the materials employed and the tube processing temperatures encountered. It has been found that a layer ranging from 5% to 50% is particularly effective. The upper limit of the nickel lamina is, of course, dependent upon the amount of reducing agents present in the active cathode base material lamina.

In the embodiments shown in FIGS. 1 and 3, an intermediate lamina **18** is provided to strengthen the base structure. Metals which are employed in this lamina have a high temperature-strength characteristic up to 1100° C., thus stiffening the base by the lamina's characteristic resistance to bow at tube processing temperatures and operating temperatures. The multi-lamina technique of base construction, by methods such as cladding, allows the use of many materials heretofore considered unsuitable for use in electrodes. Metals having the desired characteristic may be used singly or in combination as alloys. The following tables are illustrative and not exclusionary in that other metals having the desired characteristic may be employed without departing from the spirit of the invention.

(I) Refractory metals (those having a melting point above 1600° C.):

Molybdenum	Columbium
Tungsten	Vanadium
Tantalum	Thorium
Titanium	Chromium
Zirconium	Hafnium

(II) Metals of the platinum group:

Platinum	Indium
Rhodium	Osmium
Ruthenium	Palladium

(III) Rare earth metals as exemplified by the yttrium group, erbium family:

Yttrium	Holmium
Erbium	Thulmium
Dysprosium	Lutetium

(IV) Metal selected from the group comprising:

Uranium	Cobalt

(V) Iron alloys:

Constituents	Percent by weight			
	Nickel chromium steels	Stainless steels	Nickel chromium molybdenum steels	Chromium vanadium steels
Nickel plus cobalt	0.25-5.30	0-22.0	.20-3.50	
Chromium	.55-1.80	11.50-27.00	.30-9.0	.60-1.20
Iron	Balance	Balance	Balance	Balance
Carbon	.08-.70	.12-1.20	.08-65	.15-53.
Manganese	.45-1.00	1.0-1.50	.45-1.05	.60-1.00
Molybdenum		0-4.00	.08-.30	
Vanadium				[1] 10.0
Sulfur				.20-.35
Others	[2] 1.0	[2] 2.0	[2] 1.0	[2] 1.0

[1] Minimum. [2] Maximum.

(VI) Nickel-cobalt alloys:

	Percent by weight								
	Illium*		Duranickel*	Inconel*		Incolloy*		Hastelloy* Type X	D-Nickel*
	Type G	Type R		Standard type	Type X	Standard type	Type 901		
Nickel and cobalt	56	64	[1] 93.0	[1] 72.00	[1] 70.00	30.00-34.00	43.0	Bal	95.2
Copper	6.5	2.5	[2] .25	[2] .50	[2] .20	[2] .50		[2] .50	.05
Iron	6.5	6.0	[2] .60	6.0-10.0	5.00-9.00	Bal	35.0	17.0-20.0	.15
Manganese	1.25	0.3	[2] .50	[2] 1.00	.30-1.00	[2] 1.50	.48	[2] 1.00	4.5
Silicon	.65	.15	[2] 1.00	[2] .50	[2] .50	[2] 1.00	.22	[2] 1.00	.05
Chromium	22.5	22.0		14.0-17.0	14.00-16.00	19.00-22.00	12.8	20.5-23.0	
Molybdenum	6.4	5.0					5.7	8.0-10.0	
Carbon	.2	.05	[2] .30	[2] .15	[2] .08	[2] .10	.05	.015-.15	.10
Aluminum			4.00-4.75		.40-1.00				
Titanium			.25-1.00		2.25-2.75		2.4		
Sulfur			[2] .01	[2] .015	[2] .01	[2] .030			.005
Cobalt				[3]	[2] 1.00			.50-2.50	[3]
Columbium and tantalum					.70-1.20				
Tungsten								.20-1.00	

[1] Minimum. [2] Maximum. [3] Small amount. *Trade name of commercially available alloy.

(VII) Alloys of the above-identified metals, i.e.:

(a) 10 percent platinum in ruthenium
(b) 0.1 percent zirconium, 2 percent tungsten in a nickel base.

Cathode sleeve-type bases, fabricated according to the invention, having an intermediate lamina **18** of molybdenum, resulted in an increased cold strength of 48 percent and an increased strength of 65 percent after firing for two minutes at a temperature of 1025° C. in a wet dissociated ammonia atmosphere. In this instance, the molybdenum lamina was 20 percent of the total thickness of the base **12**. Cathode bases having a lamina **18** wherein the thickness is 5 percent of the total thickness of the base will also give increased strength characteristics.

The use of an intermediate lamina is believed to reduce the migration of the constituents of the alloy employed in the inner lamina **20**. This barrier effect allows a greater latitude in the choice of materials to be employed in the interior of the completed sleeve.

In the embodiments shown in FIGS. 1, 2, and 3, the inner lamina **20** comprises an alloy of nickel and aluminum. This alloy, at the high temperature employed in tube processing and aging, forms a complex nickel-aluminum oxide on its exterior surface. This complex nickel-aluminum oxide functions as a sublimation barrier, insulative coating, and due to the dark color of the oxide formed, as a means for making the indirectly heated cathode more thermally efficient. Tests performed on tubes employing a cathode having an aluminum-nickel inner lamina **20** have indicated marked reductions in heater cathode leakage and interelectrode leakage.

The ingredients of the nickel-aluminum alloy used in the lamina **20**, depend to a large extent upon the constituents of the remainder of the cathode structure with which it is to be employed. In cathodes such as the one shown in FIG. 2, the aluminum content of the alloy must be limited to twice the difference between the total aluminum content of the active cathode base material and the total amount of aluminum acceptable in the entire cathode base since the aluminum diffuses throughout the structure without hindrance due to the absence of a barrier lamina. This high a percentage is allowable since it is believed that 50% of the aluminum in the lamina **20** will form the aforementioned complex aluminum-nickel oxide. In cathode structures such as that shown in FIGS. 1 and 3, the intermediate high temperature-strength lamina **18** serves as a barrier for the aluminum in the alloy of the inner lamina **20** and relatively higher percentage of aluminum may be employed without adversely affecting the characteristics of the completed cathode.

An aluminum bearing nickel-cobalt alloy having the following composition has been found satisfactory as the inner lamina **20** of plural lamina cathode bases:

	Percent
Aluminum	4.40
Titanium	0.40
Manganese	0.30
Copper	0.05
Iron	0.35
Carbon	0.17
Silicon	0.005
Nickel	93.70

It is particularly adapted to be used in the base shown in FIG. 2. Base structures of this type wherein the lamina **20** was 10% of the total thickness of the base have achieved the desired results. Adequate properties may also be obtained where the lamina **20** was only 2% of the total thickness utilizing the above-described aluminum-nickel alloy.

As previously indicated, when the bases of FIGS. 1 and 3 are constructed, greater amounts of aluminum may be present in the inner lamina **20** since the high temperature-strength lamina **18** acts as a barrier to contain the aluminum in the inner lamina.

As shown in FIGS. 1, 2, and 3, the advantages of the multi-lamina base may be obtained in various combinations without departing from the scope of the invention as defined by the above specification and the appended claims.

What is claimed is:

1. A cathode base structure adapted to be employed with an oxide containing electron emissive coating having a plurality of lamina comprising in order, an outer lamina consisting essentially of nickel formed to receive the emissive coating, an adherent next adjacent lamina of active cathode base metal formed to reduce the oxide emissive coating, an adherent next adjacent high temperature strength metal lamina, and an adherent next adjacent lamina of a nickel alloy having a predominant aluminum alloying constituent, said alloy providing a nickel-aluminum oxide insulating barrier upon oxidation.

2. A cathode base structure adapted to be employed with an oxide containing electron emissive coating having a plurality of lamina comprising in order, an outer lamina of active cathode base metal having said coating thereon and formed to reduce the oxide emissive coating, an adherent next adjacent high temperature strength metal lamina, and an adherent next adjacent lamina of nickel alloy having a predominant aluminum alloying constituent, said alloy providing a nickel-aluminum oxide insulating barrier upon oxidation.

3. A cathode base structure adapted to be employed with an oxide containing electron emissive coating having a plurality of lamina comprising in order, an outer lamina consisting essentially of nickel formed to receive the emissive coating, an adherent next adjacent lamina of active cathode base metal formed to reduce the oxide emissive coating, and an adherent next adjacent lamina of a nickel alloy having a predominant aluminum alloying constituent, said alloy providing a nickel-aluminum oxide insulating barrier upon oxidation.

4. A cathode base structure adapted to be employed with an oxide containing electron emissive coating having a plurality of lamina comprising in order, an outer lamina of active cathode base metal having said coating thereon and formed to reduce the oxide emissive coating and an adherent next adjacent lamina of a nickel alloy having a predominant aluminum alloying constituent, said alloy providing a nickel-aluminum oxide insulating barrier upon oxidation.

5. A cathode base structure adapted to be employed with an oxide containing electron emissive coating with the structure having a plurality of lamina comprising in order, an outer lamina consisting essentially of nickel formed to receive the emissive coating, an adherent next adjacent lamina of active cathode base metal formed to reduce the oxide emissive coating, and an adherent next adjacent lamina of a nickel alloy having a predominant aluminum alloying constituent, said outer lamina of nickel having a thickness in the range of about 5 to 50% of the combined thickness of the nickel lamina and the active base metal lamina and said nickel alloy providing a nickel-aluminum oxide insulating barrier upon oxidation.

6. A cathode base structure adapted to be employed with an oxide containing electron emissive coating with the structure having a plurality of lamina comprising in order, an outer lamina of active cathode base metal having said coating thereon and formed to reduce the oxide emissive coating and an adjacent lamina of a nickel alloy having a predominant aluminum alloying constituent, said alloy including not more than twice the difference between the aluminum content of the active cathode base metal and the total amount of aluminum in the cathode base structure.

7. A cathode base structure adapted to be employed with an oxide containing electron emissive coating with the structure having a plurality of lamina comprising in order, an outer lamina of active cathode base metal having said coating thereon and formed to reduce the oxide emissive coating and an adjacent lamina of a nickel alloy having a predominant aluminum alloying constitu-

ent, said alloy having a thickness in the range of about 2–10% of the cathode base structure.

References Cited by the Examiner

UNITED STATES PATENTS

2,878,410 3/1959 Millis ---------- 29—195

3,141,744 7/1964 Couch ---------- 29—195

DAVID L. RECK, *Primary Examiner.*

HYLAND BIZOT, *Examiner.*