July 12, 1938. J. A. SPENCER 2,123,686

TUBULAR CATHODE FOR ELECTRON DISCHARGE DEVICES

Filed March 4, 1936

FIG. 1.

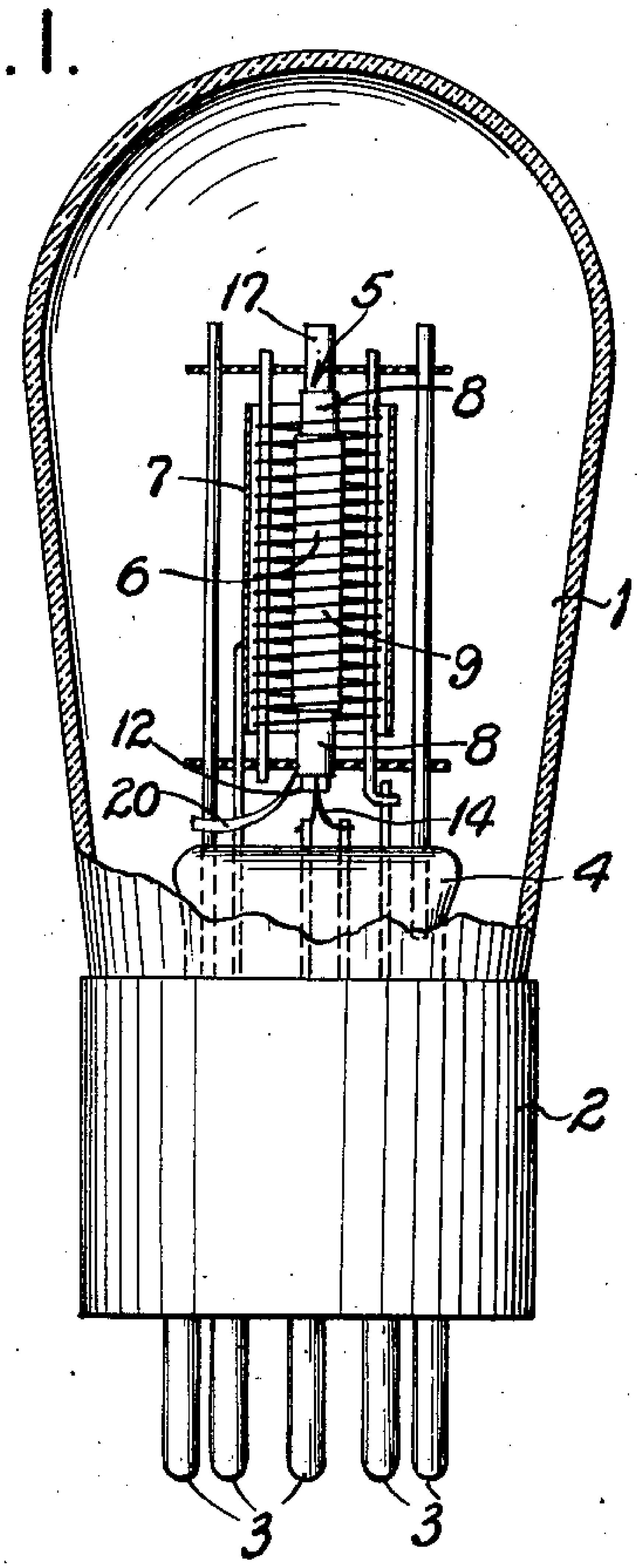


FIG. 2.

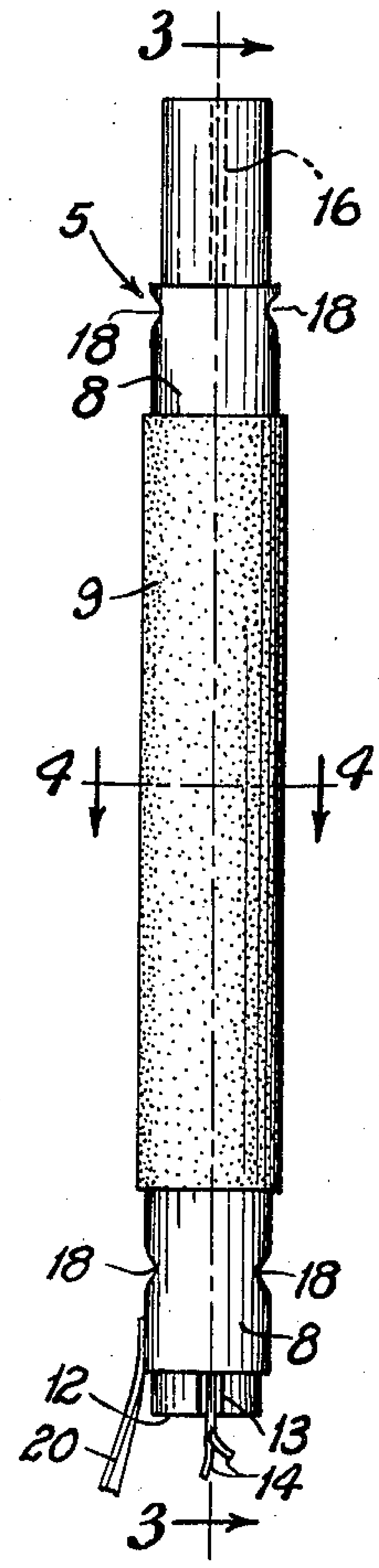


FIG. 3.

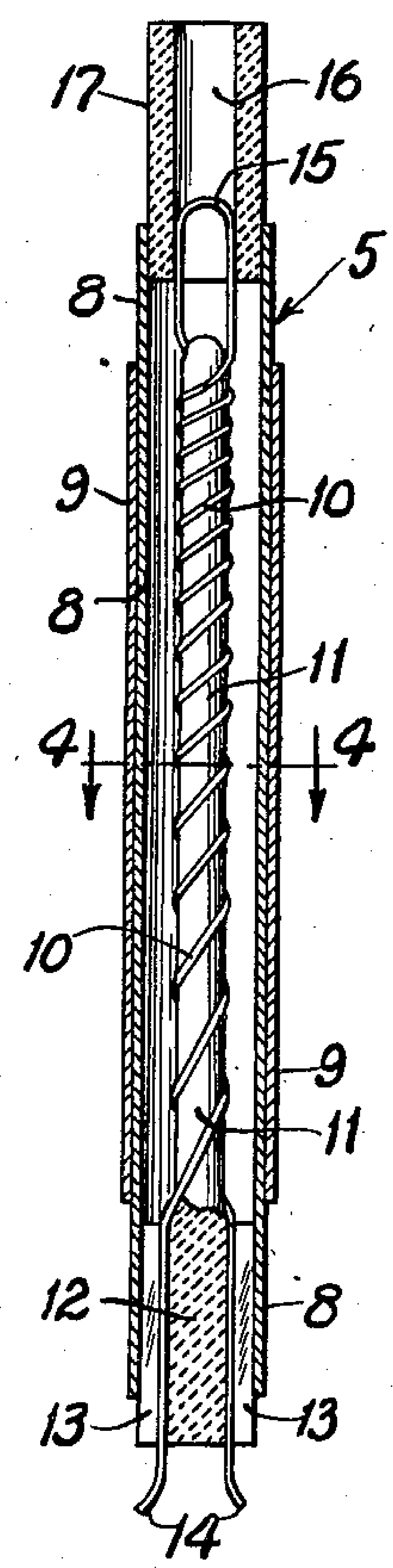


FIG. 5.

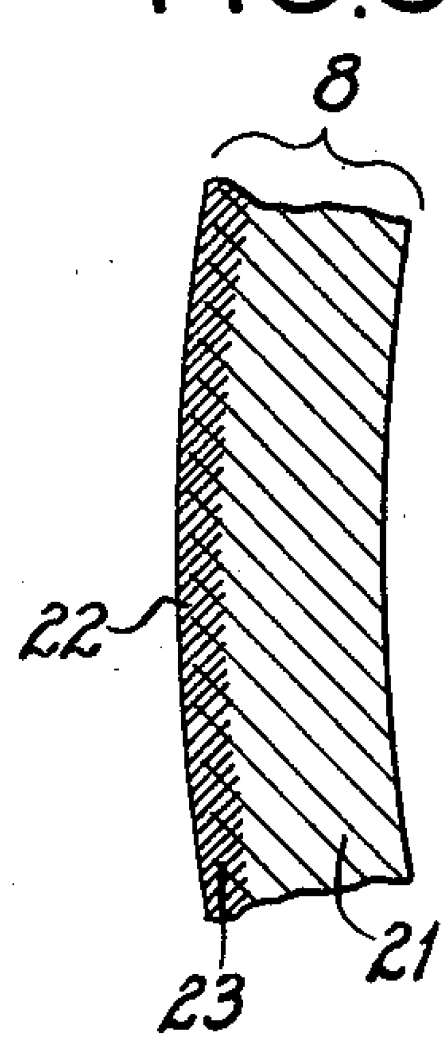
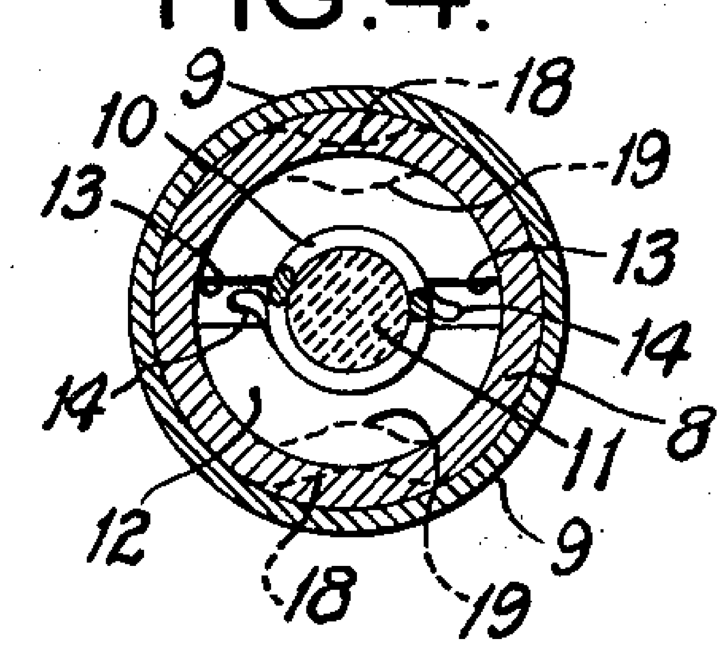


FIG. 4.



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2,123,686

TUBULAR CATHODE FOR ELECTRON DISCHARGE DEVICES

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Application March 4, 1936, Serial No. 67,006

1 Claim. (Cl. 250—27.5)

This invention relates to tubular cathodes for electron discharge devices, and with regard to certain more specific features, to cathodes of the class described having improved electron emissivity.

Among the several objects of the invention may be noted the provision of a cathode of tubular type for electron discharge devices which is so constructed that its electron emissivity is improved over a considerable length of time; and the provision of a tubular cathode of the class described which may be economically manufactured from readily obtainable materials. Other objects will be in part obvious and in part pointed out hereinafter.

The invention accordingly comprises the elements and combinations of elements, features of construction, and arrangements of parts which will be exemplified in the structures hereinafter described, and the scope of the application of which will be indicated in the following claim.

In the accompanying drawing, in which is illustrated one of various possible embodiments of the invention,

Fig. 1 is a side elevation, partly broken away, of a typical electron emission device;

Fig. 2 is an enlarged side elevation of a tubular cathode;

Fig. 3 is a vertical section of the cathode of Fig. 2, taken substantially along line 3—3 of Fig. 2;

Fig. 4 is a cross-section taken substantially on line 4—4 of Figures 2 and 3; and,

Fig. 5 is a greatly enlarged fragmentary cross-section of a tube.

Similar reference characters indicate corresponding parts throughout the several views of the drawing.

Referring now more particularly to Fig. 1, there is shown an electron emission device of substantially standard construction. This comprises an envelope 1, which, according to present practice, may be either glass or a metal, an insulating base 2, and connecting prongs 3 extending from the base 2. A stem of insulating material 4, usually glass, is rigidly mounted inside the envelope 1, and serves to support the "elements" of the device.

The number of these so-called "elements" depend upon the use to which the device is to be put, and varies widely in accordance with present engineering practice. Fig. 1 shows a so-called "three element" device, the three elements comprising a cathode 5, a grid 6, and a plate or anode 7. A heater 10 is also provided, but since it has an indirect function it is not ordinarily considered as an "element". These elements are supported in a manner well-known in the art upon the stem 4, and the specific details of their mounting need not be described herein.

The present invention is concerned more particularly with the construction of the cathode 5. Functionally, the cathode 5 is the portion of the device which is provided for the purpose of emitting electrons. It comprises a tube 8, to be described in greater detail hereinafter, which has a coating 9 provided on the outside thereof. The coating 9, as is known in the art, comprises substances having the characteristics of emitting large quantities of electrons when suitably heated. A mixture of barium and strontium oxides is frequently employed for this purpose.

In order to emit electrons, the coating 9 must be heated. For this purpose there is mounted centrally in the tube 8 a heater 10 (see Fig. 3). The particular heater 10 shown in Fig. 3 is of the twisted hairpin type, which is well-known in the art. The heater 10 is twisted about a refractory rod 11, which is enlarged at one end into a circular plug 12 fitting closely into the tube 8. The plug portion 12 is provided with diametrically opposite slots 13 in the bottom of which fit the ends 14 of the heater 10. The closed or hairpin end of the heater 10, indicated by numeral 15, is received in a flat slot 16 formed in a refractory material plug 17 that fits tightly into the upper end of the tube 8.

The plugs 12 and 17 are held in position in the tube 8 by indentations 18 (see Figures 2 and 4) in the tube 8 which fit into corresponding depressions 19 in said plugs 12 and 17.

The heater 10, it will be seen, is electrically insulated from the tube 8. In order to connect the tube 8 into the circuit, a metal strip or tab 20 (see Figures 1 and 2) is connected to the bottom end of said tube 8.

The structure as thus far described is known in the art, and no claim is made to it, except in the following connection:

In prior practice, the tube 8 has usually been made of nickel. I have discovered that if the tube 8, instead of being made of nickel, is made of nickel with an exterior surface impregnation of aluminum, then the electron emissivity of the coating 9 is considerably enhanced. This cathode tubing so treated with aluminum, which will hereinafter be termed "aluminized" tubing, may be prepared in the following manner:

A length of stock nickel tubing is first procured. This is usually of a considerably heavier nature than the ultimate cathode tubing, both as to diameter and as to wall thickness. The outer surface of this nickel tubing is thoroughly cleaned, and metallic aluminum is then sprayed, by methods known in the metal coating art, onto this cleaned surface. Thereafter, the large piece of coating nickel tubing is swaged or drawn down in size until the cathode tubing dimensions are achieved. Following these general principles, the details of the invention have been carried out successfully in the following manner:

A piece of commercially pure nickel tubing about 30 inches long and one inch in outside diameter, which has a wall thickness of about 0.065 inch, is sand blasted in order to clean it and to provide a roughened outer surface. Onto this roughened surface metallic aluminum is sprayed to a thickness of about 0.005 inch, after which the tube is swaged. The swaging tends to drive the aluminum well into the roughened texture of the nickel surface. The swaged piece is then preferably heated in a hydrogen atmosphere furnace to about 760 to 870° C., at which temperature it is believed that some of the aluminum coating infuses into the nickel, the former probably filling the pores of the latter. The heated swaged tube is then subjected to a series of drawing operations, according to ordinary tubing manufacturing practice, which reduces the diameter and wall thickness of the large tube to dimensions suitable for cathodes of the class concerned. From this stock the individual cathodes may be cut and coated and manufactured into electron discharge devices by methods well-known in the electron discharge device art.

Otherwise identical electron discharge devices, one of which has the aluminized nickel cathode tube of the present invention, while the other has ordinary nickel tubing, show electron emissivity, for example, of 110 milliamperes for the aluminized tubing, and 80 to 85 milliamperes on the ordinary nickel tubing.

Fig. 5 is a greatly enlarged cross-section of an aluminized surface tube, and is believed to correspond to the structure of the tubing, the manufacture of which has just been described. Numeral **21** indicates the pure nickel backing of the tube. Numeral **22** indicates the sprayed aluminum coating on the surface. Numeral **23** indicates a region of infusion or impregnation of the two metals **21** and **22**.

If the heating step in the hydrogen furnace is omitted, tubing is obtained which still has improved electron emissivity characteristics. In this event, the infusion of the nickel and aluminum is not believed to take place, at least to as great an extent.

While the spraying procedure has been determined to be the preferred one for providing the aluminum coating on the nickel tubing, other procedure well-known in the art may likewise be used. For example, the aluminum may be electroplated onto the nickel tubing base. Or, aluminum may be mechanically plated, by means of welding or soldering, on the nickel base, or put on by the calorizing process. All of these methods are considered to be comprehended within the scope of the invention.

From the foregoing it will be seen that the present invention is most particularly concerned with the structure and composition of the cathode tube, and is not concerned with the particular structure of the electron discharge device in which the cathode tube is used. Nor is it important, for purposes of the present invention, how the cathode heater is constructed and mounted in the cathode tube.

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

As many changes could be made in carrying out the above constructions 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.

I claim:

In an electron discharge device, a tubular cathode, a coating of a substance having a high electron emissivity on the outer surface of said cathode, and a heater within said cathode, said cathode comprising a nickel tube having a coating of aluminum less than .005 inch thick on its working surface, said emissive coating surmounting said coating of aluminum.

JOHN A. SPENCER.