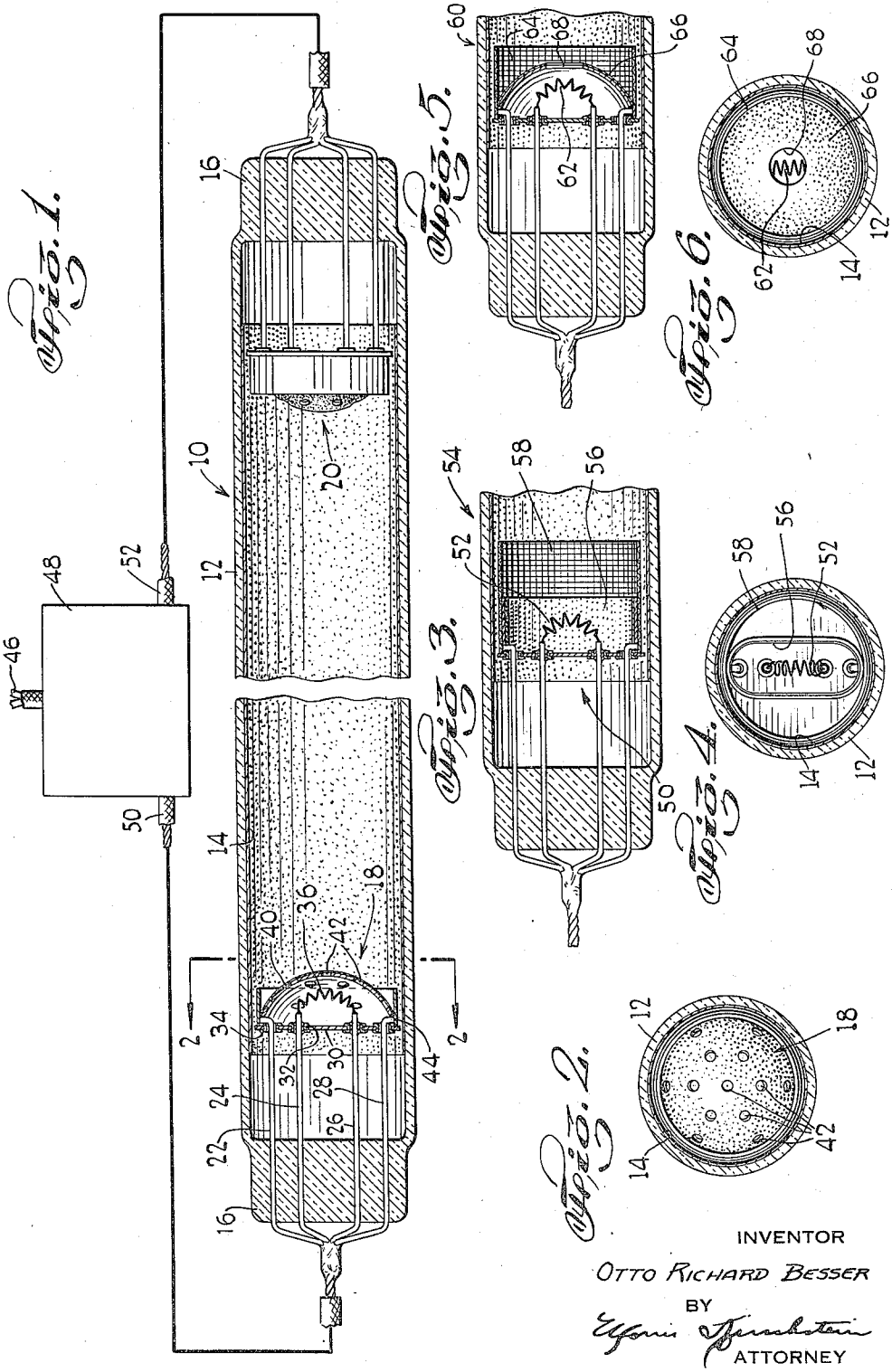
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ELECTRODE FOR FLUORESCENT TUBES

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ELECTRODE FOR FLUORESCENT TUBES

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This invention relates to fluorescent electric lighting devices and to electrodes for use therewith. More particularly the invention is concerned with cold cathode fluorescent tubes, i. e., tubes whose electrodes are not heated prior to striking an arc discharge.

At the present time two types of fluorescent electric discharge tubes are known. They are the preheated or hot cathode fluorescent discharge tube and the cold cathode fluorescent discharge tube.

Hot cathode tubes have a satisfactory light output but their life is short. They must be preheated to incandescence before they will start and an impulse voltage is usually required to initiate the arc discharge. This necessitates auxiliary equipment which adds to the cost of installation and maintenance.

Cold cathode tubes, on the other hand, whose life is long, do not have a satisfactory light output. If their light output is increased by increasing power consumption, their life is greatly shortened. Cold cathode tubes require an extremely high starting voltage unless they employ starting devices. Such devices must be cut out once the tube is in operation or else they deteriorate rapidly. Thus, the cold cathode tubes also need auxiliary apparatus for starting which is idle while the tubes are in operation.

It is an object of the present invention to provide an improved fluorescent electric discharge tube in which the advantages of the present day hot and cold cathode tube are combined, and their drawbacks eliminated.

More particularly, it is an object of the invention to provide an electric discharge tube which has a long life and satisfactory light output, which will start with its electrodes cold but which will heat the same during operation, and which does not require an excessively high starting voltage.

Another object of the invention is to provide an electric discharge tube having as part of an electrode a starting element which is not cut out of operation when the tube is running.

Another object of the invention is to provide an electric discharge tube which does not operate at the high temperatures of the present day hot cathode tube and whose electrodes do not become brittle during operation so that the tube may be safely subjected to severe impact.

A further object of the invention is to provide an electric discharge tube which, although capable of attaining the foregoing objects, comprises relatively few and simple parts and is inexpensive to manufacture.

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In general these and other objects of the invention are accomplished by providing in the tube an electrode which comprises at least two elements having different striking voltages and different electron-emitting capacities at room temperature; but which elements, when the tube is running, have electron-emitting capacities of the same degree. These two elements are fabricated from such substances and are so designed with relation to the rated wattage of the tube that neither element during operation carries a current which would be equal to its rated current if the element were used by itself in a hot or cold cathode electric fluorescent discharge tube.

Thus, the elements share the operating current load and neither carries its full rated load. They both operate at temperatures beneath that at which they would operate singly in a hot or cold cathode tube, and at this lowered temperature the electrode elements have a much longer life and much greater resistance to shattering under impact.

Other objects of this invention will in part be obvious and in part hereinafter pointed out.

The invention accordingly consists in the features of construction, combinations of elements, and arrangements of parts which will be exemplified in the constructions hereinafter described, and of which the scope of application will be indicated in the claims.

In the accompanying drawings, in which are shown various possible embodiments of this invention,

Fig. 1 is a sectional view through an electric fluorescent lighting tube embodying my invention, the electric supply circuit for the same being diagrammatically illustrated;

Fig. 2 is a sectional view taken substantially along the line 2—2 of Fig. 1;

Fig. 3 is a fragmentary sectional view through one end of a fluorescent tube embodying a modified form of my invention;

Fig. 4 is a view similar to Fig. 2 of said modified tube; and

Figs. 5 and 6 are views similar to Figs. 3 and 4 of a fluorescent tube embodying another modified form of my invention.

Referring now to the drawings, and more particularly to Figs. 1 and 2, 10 denotes a cold fluorescent electric lighting tube embodying my invention. Said tube comprises an elongated pellucid, vitreous envelope 12 which is internally coated with suitable substances 14, such as phosphors, which are luminously activated upon the passage of an arc discharge through a gaseous

ionizable medium contained within the envelope. This medium may be of any suitable type well known to this art (argon, neon, krypton), and is maintained at a pressure such as is ordinarily used in fluorescent electric discharge tubes (ten to forty mm. of mercury). The leads from the various elements of the two electrodes 18, 20 are sealed in the pinched ends 16 of the envelope.

To simplify manufacture the electrodes may be of identical construction and, therefore, only the electrode 18 need be described, the electrode 20 being identical therewith.

The electrode 18 is supported by a plurality of electrically conductive, heavy mount wires 22, 24, 26, 28, which, as indicated, are sealed in the tube ends 16 and serve to supply current to the electrode. The portions of these wires extending from the tube are twisted together as shown.

Said electrode 18 has a mounting base comprising a disc 30 of electrically non-conductive material such as mica and is of approximately the same diameter as the inside of the envelope 12. This base is provided with apertures 32 reinforced by eyelets 34 through which the mount wires 22—28 pass. To make the electrode construction rigid it is desirable to secure the eyelets 34 to the mount wires and I may therefore weld each mount wire to the eyelet through which it passes or employ any other equivalent expedient, as for example pinching the eyelet shanks against the mount wires.

The two central mount wires 24, 26 have attached to the ends thereof which project through the disc 30 an electrode element comprising a coil 36 which may be in the form of a curved helix of convoluted tungsten wire, such as is customarily employed for electrodes in a hot cathode electric fluorescent tube. This wire electrode element is heavily coated with an electron-emissive material such as strontium or barium oxide, deposited in the form of a carbonate, as well known to the art, and activated by heating the wire coil. It is for this purpose that the several mount wires 22—28 are brought through the pinched tube ends.

The coated wire electrode 36 is capped with a dome-shaped shell 40 which comprises the second electrode element and is provided with a plurality of perforations 42. The shell is made from a suitable electrically conductive material such as is customarily used as an electrode in cold cathode tubes. An example of this material is Swedish metal, commonly known as "Swe-metal," which is practically pure iron. This second electrode element is also coated with an electron-emissive material such as that employed for the wire electrode 36, although the shell 40 need not be coated on all faces thereof, as is the wire, but only on the outer surface which faces the opposite electrode 20. The shell should be disposed in close proximity to the wire electrode so as to receive heat therefrom but should not touch the same. I have found that a spacing between the nearest portions of the two electrode elements of about one thirty-second of an inch, plus or minus one sixty-fourth of an inch, will give satisfactory results when the shell and wire have the electrical and physical measurements hereinafter described. The shell 40 is connected in the electric circuit by means of the mount wire 22.

Both the shell and wire may be shielded by a circumscribing collar 44 of electrically conductive material, such as iron, which need not be as pure as the Swe-metal shell 40 so that said collar will have a lower electron-emitting capacity. The collar is not coated with an electron-emissive substance and is of such diameter that it is spaced a short distance from the inner surface of the pellucid envelope 12.

Electrical energy is supplied to the tube from a source of alternating current 46 through a transformer 48 of any type well known to the art but preferably such that when the secondary circuit is open, a high potential will be applied thereto, which potential drops as the impedance of the secondary circuit decreases. Current is transmitted from the transformer to the tube through lead wires 50, 52.

In the operation of the tube an arc initially will be struck between the tungsten coil electrode elements 36 of the two electrodes 18, 20 at about 350 volts, which is the voltage at the terminals of the transformer secondary when the secondary circuit is open. After the initial arc is struck an arc discharge continues to take place between said coils 36. These coils quickly heat to an operating temperature later described. After ionization has once been initiated by striking of the initial arc, discharge will also take place between the shell elements 40 of the two electrodes 18, 20. Since there is no cut-out for the coil elements 36, they will continue to operate when the tube is running and will share the current load with the shell elements.

In accordance with my invention I cause the current passing through the tube during operation thereof to be so shared between the two electrode elements that each carries a substantial portion of the load. Also the electrode elements 36, 40 are of such size that each element will carry a smaller current than it would be required to carry if used alone in a present day hot or cold cathode tube. To these ends the physical and electrical measurement of electrode elements bear certain relative proportions to each other and to the rated current of the tube in which they are employed.

Acccrdingly in my improved tube the coil and shell electrode elements are so proportioned that they will each carry from about 50% to 90% of their rated currents. "Rated current" as used herein denotes the normal current carrying capacity of an electrode element (coil or shell) which, heretofore, it was arbitrarily required to carry in practice when employed by itself in a present day hot or cold cathode tube. For example, a double coil electrode element, such as the element 36, having a resistance of about six ohms when used in a present day hot cathode tube is required to carry a normal current of from one hundred eighty to two hundred ma. (milliamperes). For example, in a twenty watt tube I can use a coil electrode element having a current rating of two hundred ma. in parallel with a shell electrode element having a current rating of one hundred ma. From the proximity of these ratings it is obvious that the two electrode elements have electrode emitting capacities of the same degree. The coil element will be required to carry one hundred and thirty ma. or about 65% of its rated current, and the shell electrode element seventy ma. or about 70% of its rated current. In this manner the temperatures of both electrode elements would be kept low, much lower than that at which they would operate if used alone in a present day hot or cold cathode tube. Due to the lower temperature, the life of the electrode elements is greatly increased and the resistance, particularly of the coil electrode

element, to shattering under impact, substantially enhanced. Although electrodes operating within the foregoing sub-rated capacity ranges will give satisfactory results, the best results are obtained when the tungsten electrode is of such dimensions that during operation of the tube it will be at a dull cherry red heat, and the shell electrode is so dimensioned that during operation of the tube it will be slightly below the heat at which it will first emit light, hereinafter referred to as "black heat." At these temperatures the life of both electrode elements is very long and yet they pass sufficient current to give the tube a highly satisfactory light output.

By way of example, and without limiting my invention thereto, the two electrode elements **36**, **40** may be of the following specific physical and electrical measurements: the tungsten coiled helix wire **36** may have a resistance of six ohms and a rated current of one hundred eighty to two hundred ma.; the shell electrode element used in conjunction with this coil electrode element has an area of two hundred and fifty-six square mm., a thickness of one-half mm., and a rated current of one hundred ma. This high rating is due to the shape and construction of the shell above described. The electrode comprising these two elements can be used in a twenty watt tube embodying my invention.

I have found that for the thickness of Swe-metal and the size of wire coil used, the surface area of the Swe-metal must be controlled within rather close limits, i. e., if but eight square mm. are added to the shell electrode, the lamp starts to flicker and if the area is decreased by three square mm., the Swe-metal starts to turn red. When Swe-metal turns red it pits and its life is very much shortened. With a tungsten coil wire of the type described, and a Swe-metal shell of the thickness indicated, the ratio between the ohmage of the tungsten wire and the area of the shell in square mm.—6:256—remains substantially constant over a range of tube wattages from three to one hundred and sixty watts.

In general, I have found that when the shell electrode **40** has too large an area the operating voltage of the tube is undesirably increased and when its area is too small its temperature rises beyond that desired. Likewise, when the resistance of the tungsten electrode is too small, its life will be shortened and it will cause the shell electrode to operate at too high a temperature and shorten the life of the latter electrode too. When the resistance of the tungsten coil is too high, it does not generate enough heat to raise the shell to an efficient electron-emitting temperature and the shell will not carry its proper share of the load.

The function of the collar **44** is to prevent either of the electrode elements **36**, **40** from sputtering on to the phosphor coating **14** adjacent the electrodes **18**, **20**. Because this collar has a lower electron-emissive capacity than either of the electrode elements it will confine emission from the two electrode elements in a direction generally longitudinal of the envelope **12**.

In Figs. 3 and 4 I have shown a modified form of my invention differing from that shown in Figs. 1 and 2 only in the shape of the shell electrode and collar. The electrode supporting structure **50** and tungsten electrode **52** of this tube **54** are similar to those shown and described with reference to the tube **10**. However, the shell electrode element consists of a flattened, open-ended tube **56** of uncoated Swe-metal. The major axis of the cross-section of the tube lies in a plane including the wire coil electrode element **52**, so that when viewed from an end (Fig. 4) the two electrode elements are symmetrically disposed.

The anti-sputtering collar comprises a metallic wire screen **58** which circumscribes the two electron-emitting elements. Said wire is fabricated from an electrically conductive material of lower electron-emitting capacity than the Swe-metal shell **56**, so that electron-emission will be concentrated in the shell electrode and tungsten electrode elements, and sputtering from the latter on to the tube will be inhibited by said screen.

In Figs. 5 and 6 I have shown another modification of my invention generally similar to the first two forms of tubes hereinabove described. The tube **60** embodying this modified form differs from the first two forms chiefly in the construction of the shell electrode element. In this tube the tungsten electrode element **62** is the same as the elements **36** and **52** of the earlier described forms and the anti-sputter collar **64** is of an electrically conductive wire gauze of relatively poor electron-emitting capacity such as the collar **58** shown in Figs. 3 and 4. The Swe-metal shell electrode element **66** is dome-shaped, but instead of a plurality of small apertures it has only one relatively large central aperture **68**.

It will thus be seen that I have provided devices in which the several objects of this invention are achieved, and which are well adapted to meet the conditions of practical use.

As various possible embodiments might be made of the above invention, and as various changes might be made in the embodiments above set forth, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

Having thus described my invention, I claim as new and desire to secure by Letters Patent:

1. An electric discharge device comprising an elongated sealed envelope containing a gaseous ionizable medium, leads sealed in said tube at opposite ends thereof, electrodes at each end of said tube connected to said leads and facing each other, each of said electrodes comprising a bare ferrous shell electrode element and a tungsten coil electrode element coated with an electron-emissive oxide and having a striking voltage lower than that of the bare electrode, both of said elements during running operation of the tube having electron-emitting capacities of like degree and each carrying a substantial portion of the current passing through said electrode during operation of the tube.

2. An electric discharge device comprising an elongated sealed envelope containing a gaseous ionizable medium, leads sealed in said tube at opposite ends thereof, electrodes at each end of said tube connected to said leads and facing each other, each of said electrodes comprising a bare ferrous shell electrode element and a tungsten coil electrode element coated with an electron-emissive material and having a striking voltage lower than that of the bare electrode, both of said elements during running operation of the tube having electron-emitting capacities of like degree and each carrying a substantial portion of the current passing through said electrode during operation of the tube, said coil running at a dull cherry red heat and said shel running just below red heat during operation of the tube.

3. An electric discharge device comprising an

elongated sealed envelope containing a gaseous ionizable medium, leads sealed in said tube at opposite ends thereof, electrodes at each end of said tube connected to said leads and facing each other, each of said electrodes comprising a bare thin ferrous shell electrode element and a tungsten coil electrode element coated with an electron-emissive material and having a striking voltage lower than that of the bare electrode, the ratio between the surface of said shell in square mm. and the ohmage of said coil being substantially as 256 is to 6, both of said elements during running operation of the tube having electron-emitting capacities of like degree and each carrying a substantial portion of the current passing through said electrode during operation of the tube.

4. An electric discharge device comprising an elongated sealed envelope containing a gaseous ionizable medium, leads sealed in said tube at opposite ends thereof, electrodes at each end of said tube connected to said leads and facing each other, each of said electrodes comprising a bare thin ferrous shell electrode element and a tungsten coil electrode element coated with an electron-emissive substance and having a striking voltage lower than that of the bare electrode, said shell being of Swe-metal of approximately ½ a mm. thickness and the ratio between the surface of said shell in square mm. and the ohmage of said coil being substantially as 256 is to 6, both of said elements during running operation of the tube having electron-emitting capacities of like degree and each carrying a substantial portion of the current passing through said electrode during operation of the tube.

5. An electric discharge device comprising an elongated sealed envelope containing a gaseous ionizable medium, leads sealed in said tube at opposite ends thereof, electrodes at each end of said tube connected to said leads and facing each other, each of said electrodes comprising a bare metal cold cathode electrode element and an electron-emissive coated hot cathode electrode element electrically connected in parallel and disposed in juxtaposition, and so dimensioned that during operation of said tube they will each carry a substantial portion of the load, the hot cathode electrode element comprising a tungsten coil coated with an electron-emissive substance and said cold cathode electrode comprising a dome-shaped shell covering said coil and having a plurality of small apertures therethrough.

6. An electric discharge device comprising an elongated sealed envelope containing a gaseous ionizable medium, leads sealed in said tube at opposite ends thereof, electrodes at each end of said tube connected to said leads and facing each other, each of said electrodes comprising a bare metal cold cathode electrode element and an electron-emissive coated hot cathode electrode element electrically connected in parallel and disposed in juxtaposition, and so dimensioned that during operation of said tube they will each carry a substantial portion of the load, the hot cathode electrode element comprising a tungsten coil coated with an electron-emissive substance and said cold cathode electrode comprising a dome-shaped shell covering said coil and having a large central aperture therethrough.

7. An electric discharge device comprising an elongated sealed envelope containing a gaseous ionizable medium, leads sealed in said tube at opposite ends thereof, electrodes at each end of said tube connected to said leads and facing each other, each of said electrodes comprising a bare metal cold cathode electrode element and an electron-emissive coated hot cathode electrode element electrically connected in parallel and disposed in juxtaposition, and so dimensioned that during operation of said tube they will each carry a substantial portion of the load, the hot cathode electrode element comprising a tungsten coil coated with an electron-emissive substance and said cold cathode electrode comprising a flattened open-ended tube surrounding said coil.

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