Feb. 6, 1940. F. W. LYLE 2,189,638

HOT CATHODE VACUUM TUBE

Filed June 16, 1938

Fig. 1.

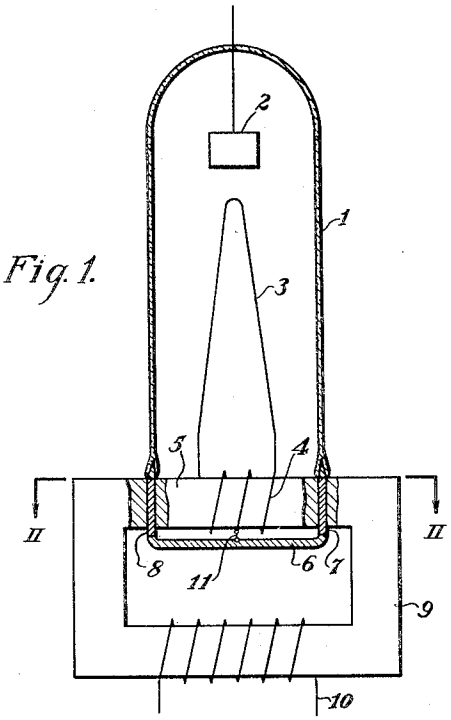


Fig. 4.

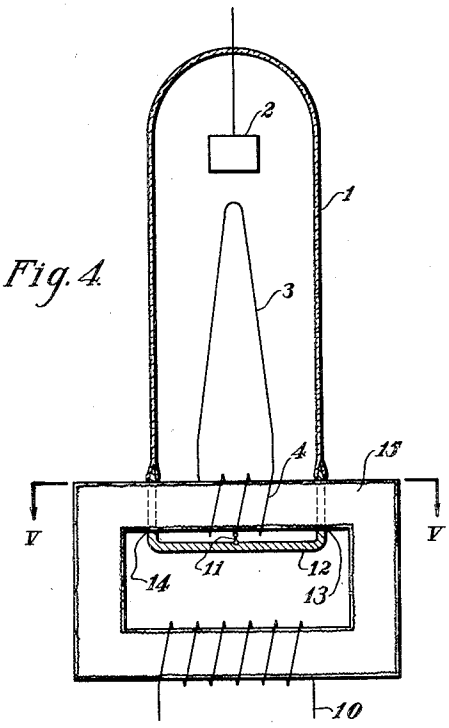


Fig. 2.

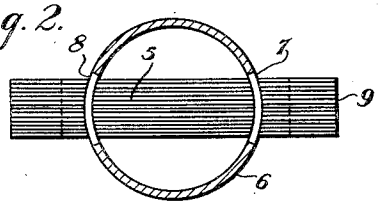


Fig. 5.

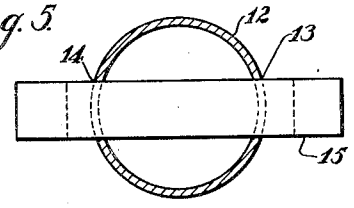


Fig. 3.

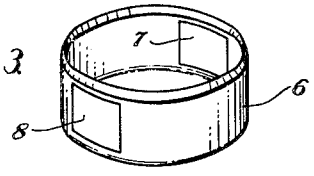
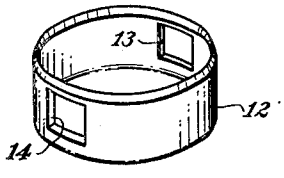


Fig. 6.



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UNITED STATES PATENT OFFICE

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HOT CATHODE VACUUM TUBE

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2 Claims. (Cl. 250—27.5)

My invention relates to electrical discharge devices and especially to the structure of such devices for embodying circuits for maintaining one or more of their electrodes at elevated temperature.

One object of my invention is to avoid the employment of inleading conductors of relatively large current carrying capacity sealed through insulating material for heating the electron-emissive cathodes in hot cathode electrical discharge devices.

Another object of my invention is to minimize the number of seals of electrical conductors through insulating material in electrical discharge devices which are required to enclose conductors carrying currents of large magnitude.

Another object of my invention is to facilitate the construction of hot cathode electrical discharge devices having cathodes heated by relatively large heating currents.

Still another object of my invention is to make it possible to construct electrical discharge devices with electron-emissive cathodes designed to be maintained in operating condition by relatively large currents of low voltage.

Other objects of my invention will become apparent upon reading the following specification taken in connection with the drawing in which:

Figure 1 is a view, partly in section and partly in elevation, of one embodiment of my invention;

Fig. 2 is a sectional view taken on the plane II—II in Fig. 1;

Fig. 3 is a perspective view of the construction of a portion of the tube of Fig. 1;

Fig. 4 is a view, partly in elevation and partly in section of another modification of my invention;

Fig. 5 is a sectional view taken along the plane V—V of Fig. 4; and

Fig. 6 is a detailed view illustrative of the method of constructing a portion of the tube in the Fig. 4 modification.

For numerous reasons, it is usually desirable that the cathodes of electrical discharge tubes of the hot cathode type shall be heated by currents which are large compared with the main output current of the tube. One reason for this is that it is desirable that the cathode should operate at a fixed and definite temperature and that this could not be even approximately attained if the current flowing from the principal anode to the cathode were of a size equal to or greater than the normal cathode heating current; if the latter condition existed, the cathode temperature would fluctuate largely whenever the load underwent considerable variations. Since in tubes of ordinary construction it is necessary to provide two seals through the container wall to carry the inflowing and outflowing heater current, and each of these seals is of large capacity compared with the seal for the current conducted to the anode, it results that the seals to convey the heater current are the most difficult to manufacture of any which are embodied in the structure of the tube. Furthermore, the difficulty of making seals of large carrying capacity makes it impossible to design a cathode of given heating-power requirements to operate with a very large current at very low voltage; and this is a limitation on the cathode life, inasmuch as voltage drop between the ends of the cathode tends to cause concentration of current at one terminal. In contrast to this, cathodes which approximate a uni-potential condition exhibit greater life at a given operating temperature than do cathodes with even a relatively moderate potential difference between their ends.

In accordance with my invention, I provide a tube structure in which the cathode is supplied with heating current by means of a transformer core of continuous metal which passes directly through a metallic portion of the tube wall. The cathode is then heated by current generated in a secondary winding contained within the tube walls and positioned on this transformer core. In this way, the only seal through insulating material which is necessary in a two-electrode tube is a single one to the insulating material intervening between the anode lead and the metallic portion of the tube wall through which the transformer core passes. By making the secondary winding connected to the cathode heater of a small number of turns, the cathode heating current may be made as large as is desired without difficulty from large capacity seals, inasmuch as the cathode heating current does not pass through insulating seals at all.

With the foregoing principles in mind, Fig. 1 of my application shows a container 1 which may be of glass or other insulating material, having an anode 2 sealed through its wall by methods well known in the art. The device is provided with a cathode 3 which may be of nickel coated with oxides of the alkali earth metals, which cathode 3 is directly connected to a winding 4 positioned within the container 1 on a portion 5 of a magnetic transformer core. The core-por-

tion 5 may be of laminated silicon steel or other conventional transformer-core material, the ends of which fit closely against the walls of a cup portion 6 of the container wall. The cup portion 6 is illustrated in detail in Fig. 3 and preferably consists of a non-magnetic metal having two inserts 7 and 8 of magnetic material welded or otherwise held vacuum tight at diametrically opposite portions of its walls. The inserts 7 and 8 are slightly larger in area than the cross-section of the magnetic core-portion 5, and the ends of the latter fit as closely as possible against the inserts 7 and 8. At least the upper edge of the cup 6 comprises a material which is adapted to form a vacuum-tight seal with the wall portion 1. For example, this material may be the alloy of approximately 24% to 34% nickel, 10% to 25% cobalt, less than 1% manganese, and the remainder iron, which is known to form a vacuum-tight seal with borosilicate glass known under the trade-name of G702P, the chemical analysis of which is given in application Serial No. 106,798 of Walter E. Bahls, filed October 21, 1936 and assigned to the Westinghouse Electric & Manufacturing Company. Alternatively, the edge of the wall portion 6, which is expected to form a vacuum-tight seal with insulating material, may be of platinum or may be of chrome-iron or may be of the composite structure comprising nickel steel coated with copper which is well known in the sealing art as Dumet. In the case of the three materials last mentioned, the insulating wall portion 1 may be of lead glass. Any combination of insulating material and metal or alloy known to form a vacuum-tight fused seal therewith may, in fact, constitute the seal at the upper edge of the wall portion 6.

The ends of a transformer core 9, which may be of laminated silicon steel or any desired suitable transformer-core material, are arranged to fit tightly against the outer faces of inserts 7 and 8, thereby forming a virtually complete magnetic circuit of ferro-magnetic material for the transformer core. A primary winding 10 may be positioned on the core 9 and may be supplied with alternating current from any suitable source. When this is done, the cathode heater 3 may be raised to any desired operating temperature and there maintained. The main load current of the above-described tube will flow from the anode 2 to the cathode 3 and then through a connection 11 between the heating circuit of cathode 3 and wall portion 6, from which it may be conducted by means well known in the art to any desired external circuit.

While I have described the cathode 3 as being of the directly-heated type, it will be recognized that the heater of an indirectly-heated type of cathode may be connected to the winding 4 when desired. It is also within the purview of my invention that the cathode heater 3 should form but a single turn embracing the core-portion 5, and this single turn may, in fact, constitute the entire cathode surface, being coated all over with thermionically-emissive oxides when such construction is suitable. Such a cathode should, of course, be spaced far enough away at all points from the transformer core 5 to avoid unduly heating the latter. The use for core-portion 5 of a magnetic material which retains the ferro-magnetic properties at elevated temperatures may be desirable. When a cathode comprising a single turn about the core-portion 5 is employed, it will be found that, if this single turn is made absolutely symmetrical relative to core 5, the currents flowing in the single turn will produce no potential-difference between any two points therein; in other words, a uni-potential cathode which is directly heated will have been attained.

While I have described the inserts 7 and 8 as being continuous plates, it will be recognized that they may be formed as composite structures in which vertical strips of magnetic material equal in number to the laminations of the cores 5 and 9 are fused vacuum tight to each other by intervening layers of some insulating or high resistance alloy or other material. For example, such a material may be an enamel or a glass capable of forming a vacuum-tight joint with the magnetic material or with an alloy such as that described as constituting the upper edge of the wall portion 6, said alloy forming a thin surface on each said vertical strip of magnetic material.

In order to illustrate another embodiment of my invention, I have shown in Fig. 4 an electrical discharge device in which similar structural elements to those in Fig. 1 are designated by the same reference numerals. The arrangement of Fig. 4 differs from that in Fig. 1 in that the metallic wall portion 12, instead of having inserts 7 of magnetic material, is provided with notches 13 and 14 of the same size as the cross-section of the magnetic core 15. A detailed view of the cup 12 provided with such notches appears in Fig. 6. The transformer core 15 is then made of continuous magnetic material. It is provided with windings 4 and 10 similar to those in Fig. 1. In many cases, it will be desirable to form the core 15 of laminations of sheet steel in the way well known in the art, and in such cases the outermost laminations on the two opposite sides may be made slightly wider than the others. Vacuum-tight coatings of some suitable material may then be used to seal the entire surface over the ends of the intermediate laminations, thereby forming what is, in effect, a vacuum-tight box containing the laminations of the transformer core. The coating material may, for example, be enamel such as lead borate or zinc borosilicate capable of forming a vacuum-tight seal with transformer iron; or it may be of glass and sealed to the edges of the outside laminations by seals like that described for the upper edge of the wall portion 6. As still another alternative, the layers covering the ends of the laminations may be of metal, preferably of high resistance, welded to the edges of the two outside laminations.

The transformer core thus constructed may be placed in position in the wall portion 12 and welded vacuum tight thereto around the periphery of the notches 13 and 14. The remainder of the device of Fig. 4 being similar to that of Fig. 1 needs no further description.

It is within the principles of my invention to divide the parts 6 of Fig. 3 and 12 of Fig. 6 in halves as if by a vertical plane passing through the middle of the magnet core 5 and 15 and to put the two halves together by fusing their plane edges to opposite sides of a strip of insulating or high-resistance material sandwiched between them.

While I have described two specific embodiments of my invention in order to comply with the patent statutes, it will be recognized by those skilled in the art that the principles thereof are of broader application in ways which will be readily evident. I, therefore, desire that the following claims shall be given the broadest inter-

pretation of which their terms are reasonably capable.

I claim as my invention:

1. An electrical discharge device comprising a container having a wall portion of metal, an electrode, an inleading conductor therefor, said conductor being sealed vacuum tight to said wall portion by glass insulation fused thereto, said metal wall portion being of non-magnetic metal and having two opposite sections of its wall composed of magnetic material, a first core of magnetic material inside said wall portion extending between said sections, a second core of magnetic material forming a continuous bridge outside said container and interconnecting said sections, a primary winding on said second core, and an electrode within said discharge device connected to a secondary winding linking said first core portion.

2. An electrical discharge device containing at least two electrodes and having a vacuum-tight enclosing wall, a substantially continuous ferromagnetic core extending through said enclosing wall so that one portion of said core is inside said enclosing wall and another portion is outside said enclosing wall, a circuit within said device linking said one portion and supplying power to an electrode, and a circuit outside said device linking said other portion.

FREDERICK W. LYLE.