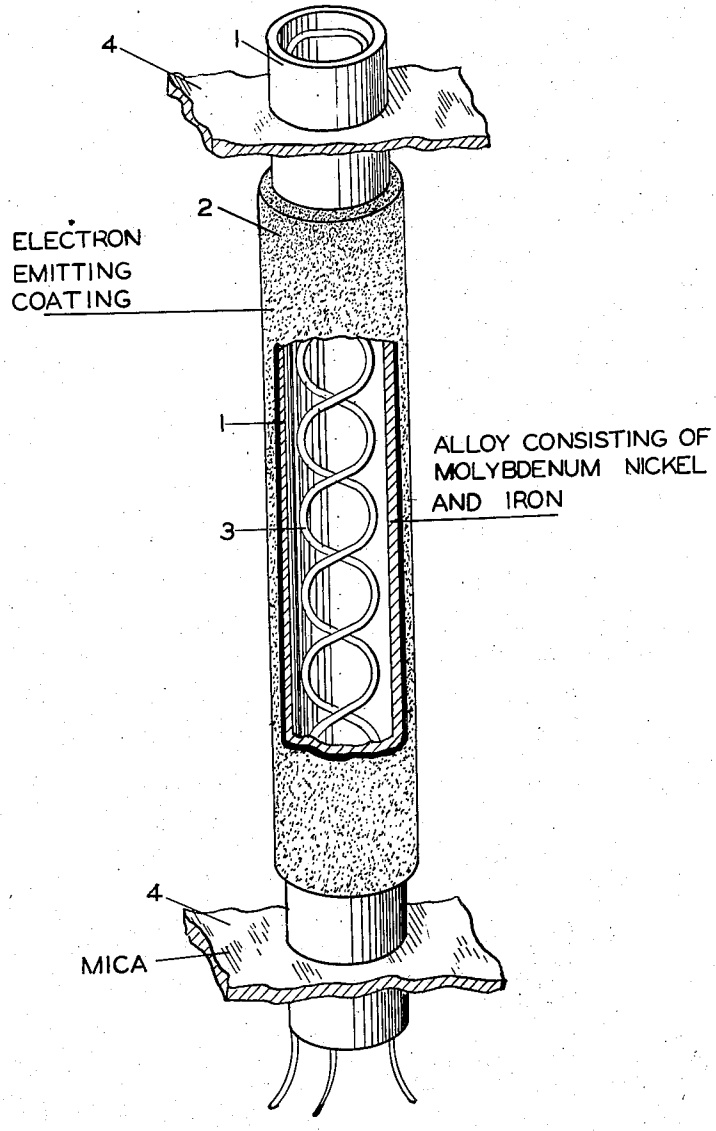
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CATHODE FOR ELECTRIC DISCHARGE TUBES

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CATHODE FOR ELECTRIC DISCHARGE TUBES

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1

This invention relates to cathodes for electric discharge tubes, particularly to alloys for cathodes heated either directly or indirectly. This application is a division of my copending United States application No. 480,099, filed March 22, 1943, now Patent No. 2,428,042.

One of the most important problems which arise in the construction of cathodes for electric discharge tubes is the loss of heat to the supports at the extremities of the cathode. Due to this heat loss, the temperature of the cathode at the extremities is always materially lower than that in the center. If the cathode temperature is plotted graphically as a function of length, a curve is obtained which shows a maximum in the center and which gradually decreases to a higher or lower extent at the extremities. Thus, the center receives an excessively high temperature, or if, on the other hand, the center is maintained at approximately the correct temperature, the ends remain below emission temperature.

It has already been suggested to reduce the difficulties involved by the use of particular constructions. Thus it is known to surround the extremities of an incandescent cathode to be heated directly by an independent heating coil, in order to compensate for the loss of heat due to dissipation by means of an additional supply of heat. Such a measure has been used with cathodes to be heated directly by arranging for the extremities to comprise per centimeter cathode length more wire material of this heating element than in the center. Consequently, the temperature at the surface of the cathode body is rendered more uniform. These constructions, however, have the disadvantage that the supply of energy from the incandescent body of the cathode has been rendered unequal and, in addition, in the case of cathodes to be heated indirectly, the undesirable condition arises that additional energy is supplied especially to the extremities which have remained uncovered with emissive material and do not assist in the emission, thus materially increasing the losses at those points.

Furthermore, it has been suggested that the cathode body of a cathode to be heated indirectly should be made from two layers, i. e. from an underlayer of a material having a small heat conductive capacity and an upper layer of a material having a low heat emissive capacity, which layer does not cover the extremities of the under layer, to which the support for the cathode is fastened. For the under layer use is made in this case of an iron-nickel alloy which may have chromium added to it, if desired; for the upper layer it is suggested to utilize copper.

2

Now, applicant has carried out a number of investigations on this subject and has found that very special materials are fit to be used for cathodes, with which the dissipation of heat at the extremities has to be very small. According to the invention, for this purpose a cathode to be heated directly, or a cathode sleeve to be heated indirectly, and having a fastening or current supply tab, consists of an alloy of tungsten or molybdenum on the one hand, and nickel, cobalt or iron on the other hand with, if desired, the addition of one or more other components, the percentage of tungsten or molybdenum atoms being at least 10 if alloys consisting of two components are concerned, such as tungsten or molybdenum with iron, nickel or cobalt, and at least 5 if use is made of alloys comprising more than two components. The upper limit to be maintained in both cases is for tungsten 25 per cent of atoms and for molybdenum 35 per cent of atoms.

The component to be added to these alloys preferably consists of one or more of the elements aluminum, silicon, manganese, magnesium, zirconium or thorium. As has been found by applicant, an alloy which is very suitable for the purpose of the invention consists of 16 per cent of tungsten atoms and 84 per cent of nickel atoms whilst very good results can also be obtained with a three-component alloy consisting of 9 per cent of aluminium atoms, 13 per cent of molybdenum atoms and 78 per cent of nickel atoms, or with an alloy composed of 16 per cent of iron atoms, 14 per cent of molybdenum atoms and 70 per cent of nickel atoms, since the alloys according to the invention may contain not only tungsten or molybdenum and one of the components iron, nickel or cobalt, but also two of the last mentioned elements.

As has been set out above, the conduction of heat of the material which enter into consideration is the most important factor; in connection therewith attention should also be paid to the wall thickness of the body made from this material, since with the use of the same material the conduction of heat may be reduced by choosing thinner material. The thickness is limited by the rigidity or hardness of the material while these properties in turn are limited by the more or less good workability. Especially the latter property makes it impossible to utilize alloys in which the percentage of atoms for tungsten or molybdenum are higher than 25 and 35 respectively.

A very important advantage of the alloys according to the invention is that, in addition to being properly workable, they exhibit great hardness so that an improvement is obtained not only

due to the conduction of heat itself being smaller than that of the materials so far used, but also because these materials, due to their great hardness which appears to be greatly heatproof under the influence of the high melting tungsten or molybdenum, may be thinner than the known materials when used for the same purpose. Also with different alloys according to the invention this means an important advantage over the alloys stated above as known, viz. chrome-nickel and nickel-iron. Thus it appears, for example, that the hardness of a tungsten-nickel alloy of which the percentage of tungsten atoms is 17 is heatproof and is approximately twice as great as that of an iron-nickel or chrome-nickel alloy, whilst the heat conductive capacity is of the same order of magnitude. Due to the materially greater heat-proof hardness, connected with good workability, this material may, according to the invention, be chosen considerably thinner than the nickel-iron or chrome-nickel, resulting moreover in an improvement of the heat conductive capacity. With an alloy containing 7 per cent of aluminium atoms, 16 per cent of tungsten atoms and 77 per cent of nickel atoms the hardness is almost thrice as great as that of an iron-nickel alloy of equal atom percentages whilst, in addition, the heat conductive capacity of the material itself is already smaller than that of iron-nickel and chrome-nickel. During working with this aluminium-tungsten nickel alloy it appears, however, that for definite purposes the limit of good workability is almost attained. For the alloys aluminium-molybdenum-nickel and iron-molybdenum-nickel which are mentioned above, the hardness is approximately one and a half times as great as that of iron-nickel or chrome-nickel alloys whilst the heat conductive capacity is smaller. With regard to the iron-nickel and chrome-nickel alloys here mentioned, the materials according to the present invention have in addition the advantage that they give off less gas than the known alloys, such as iron-nickel and chrome-nickel.

The fact that literature does refer to the last-mentioned alloys and does not mention those according to the present invention, though tungsten and molybdenum themselves are used for cathodes to be heated directly and for heating elements of cathodes to be heated indirectly, as in all probability due to the circumstance that on the one hand the opinion prevailed that these alloys, due to their great hardness, would be workable with too great difficulty, and on the other hand it had been expected that the conduction of heat would be comparatively great since the heat conductive capacity of tungsten is at least ten times as great as that of iron-nickel and chrome-nickel whilst the hardness of tungsten is about 20 to 30 times greater than that of these known alloys. Consequently, it is evident that one will not rapidly decide to substitute these known alloys for alloys containing tungsten or molybdenum, if materials are wanted which exhibit good workability and have at the same time a low heat conductive capacity.

Now by means of the investigations made by applicant it has been found that the heat conductive capacity can be rendered very small and that, on the other hand, these materials are properly workable especially because they can be used as bodies of very small thickness. The workability particularly plays a part in the manufacture of cathode bodies for cathodes to be

heated indirectly which may be obtained from the material according to the present invention, for example by rolling. Thus, it is possible for indirectly heated cathodes to be advantageously made from a sleeve which is made from an alloy according to the present invention and covered with a layer of a material, for example nickel or copper, having a smaller capacity of radiation than the underlying body. The outer layer preferably does not extend the full length of the sleeve. The manufacture of such a cathode may be effected in a simple manner by using two thin plates which are laid on one another and subsequently rolled together until a tubular cathode body is obtained.

The combination of rigidity and small heat conductive capacity renders the above described materials also highly adapted to be used for bodies which serve at the same time as fastening and current supply members for a cathode to be heated indirectly. Most generally also the construction of this cathode is simplified by utilizing the materials according to the present invention, since under certain conditions the centering of the cathode may be effected without special means by introducing the cathode body itself through an aperture in a plate consisting of mica or similar material and supporting the cathode body in this mica without excessive loss of heat at the contact surface between the cathode and the mica. Also other modes of fastening are possible with the use of the cathode according to the invention.

What I claim is:

1. A thermionic cathode body comprising a heater element, a tubular body surrounding said element, said tubular body consisting of an alloy of molybdenum, nickel and iron, the molybdenum constituting from 5% to 35% of the atoms of the total alloy and the nickel constituting the major part of the balance, and a coating of alkaline earth metal oxides on and in contact with said body.

2. A thermionic cathode body comprising a heater element, a tubular body surrounding said element, and an electron emissive oxide forming a coating on said tubular body, said tubular body consisting of an alloy of molybdenum, nickel, and iron, the molybdenum constituting from 5 to 35 per cent of the atoms of the total alloy, the nickel constituting substantially 81 per cent of the atoms of the balance, and the iron constituting substantially 19 per cent of the atoms of the balance.

3. A thermionic cathode body comprising a heater element, a tubular body surrounding said element, and an electron emissive oxide forming a coating on said tubular body, said tubular body consisting of an alloy of molybdenum, nickel, and iron, the molybdenum constituting substantially 14 per cent of the atoms of the total alloy, the nickel constituting substantially 70 per cent of the atoms of the total alloy, and the iron constituting substantially 16 per cent of the atoms of the total alloy.

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