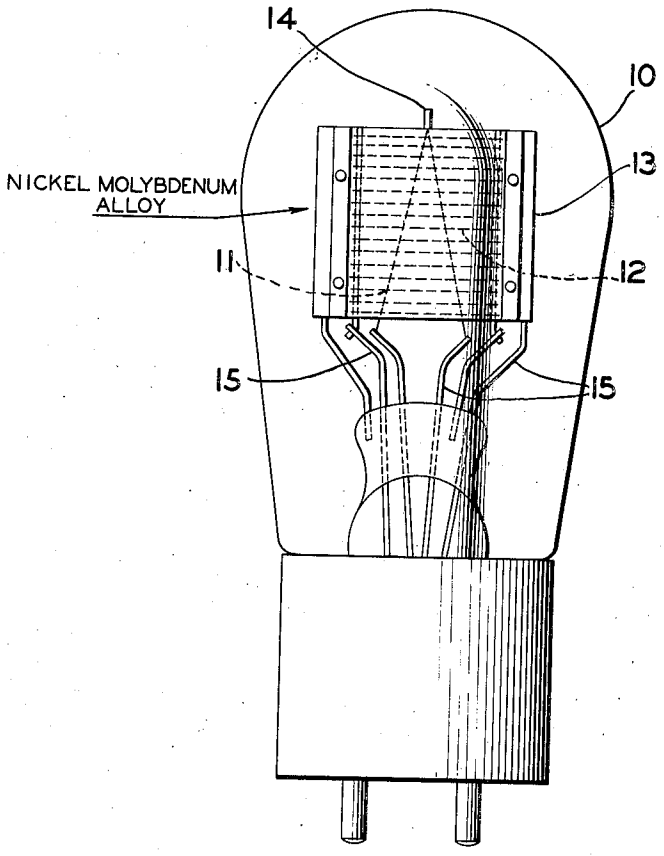
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THERMIONIC DEVICE

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THERMIONIC DEVICE

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The invention relates to metallic parts of thermionic and similar devices. It is directed especially to grid electrodes of thermionic valves or radio tubes, but is applicable to other metallic parts of radio tubes and thermionic devices generally. The chief object of the invention is to provide parts for such devices fabricated from a group of alloys having the mechanical, chemical and electrical properties which render them adaptable to such application.

One type of thermionic devices to which the invention is applicable is illustrated in the sole figure of the accompanying drawing, in which are shown an envelope 10 containing elements consisting of an electron emitting cathode 11, an anode 13, a grid 12 located between the cathode and anode, a hook-wire 14 for supporting the cathode, and supporting wires 15 for supporting the cathode, anode, and grid within the envelope 10.

In the present state of the art it cannot be predicted in advance of actual trial whether or not a hitherto untried metal or alloy will be suitable for the manufacture of the metallic elements of radio tubes; this is especially true of metals to be used for grid electrodes. All radio tube elements must be non-corroding and relatively non-tarnishing under the conditions of manufacture, storage and use, relatively free from occluded gas, and possess at least a moderate degree of ductility. Grid wires must have, in addition to these properties, a high melting point, and a large number of special characteristics required for easy manipulation in manufacture, which include: springiness or resilience, stiffness, a high tensile strength and high elongation under tensile test, and uniformity of properties throughout the length of the wire. The wires must not deform when used in a tube. Furthermore, the completed tube elements must have suitable electrical characteristics and a long life in use.

In my Patent 1,963,844, issued June 19, 1934, I have disclosed that alloys which comprise chiefly nickel, molybdenum and iron within certain limits of composition, may successfully be fabricated into grid electrodes and other operating elements of radio tubes and similar devices, and that elements so fabricated have the mechanical, chemical and electrical properties essential for satisfactory performance in such devices.

The alloys described in my said patent comprise those which contain at least 40% of nickel, from about 15% to about 40% of molybdenum, and from about 10% to about 30% of iron. The presence of vanadium in amounts of about 0.3% is beneficial, but not essential. Small amounts of carbon and metals such as manganese and silicon may also be present, but large amounts of these materials are undesirable. For instance, up to about 2.5% of manganese improves the workability of the alloy, but the manganese content should not exceed about 4%. The silicon content should preferably be below about 0.5%, and the carbon content below about 0.3%. Such impurities as sulfur and phosphorus are detrimental, and should be present only in very low quantities. Cobalt may be substituted in whole or in part for the nickel, and tungsten may be substituted at least in part for the molybdenum.

Alloys of the above description possess the requisite properties for fabrication into and use as various structural parts of electronic tubes, of both the vacuum and the gas-filled types, and the tubes produced by assembly of these structural parts function in a satisfactory manner chemically, electrically, and mechanically.

Since the issue of the above mentioned Letters Patent, the methods of manufacture of radio tubes, as well as the devices themselves, have undergone considerable alteration due to advances in the art. The changes have imposed increasingly severe conditions upon the required properties of the materials used in the manufacture of such devices. This is especially true of the fine wire used in the making of the grid element. The tendency has been to decrease the size of the devices as well as to introduce, in some cases, three or even more of the grid elements, and this has created a demand for wire of considerably smaller diameter than that ordinarily used before. The use of such thin wire has increased the difficulty of obtaining and retaining the desired mechanical and electrical properties of the wire during fabrication and use of the device.

It is the chief object of this invention to provide improved alloy parts and wire for such devices, having the mechanical, chemical, and electrical properties which render them adaptable, to an extent even greater than that attained by the parts and wire described in my earlier patent, to the more exacting and severe conditions imposed by the more advanced state of the art.

I have now discovered that alloys which comprise chiefly nickel and molybdenum within certain limits of composition, and alloys composed substantially of nickel and molybdenum but modified as hereinafter stated, may be successfully fabricated into grid electrodes and other operat-

ing elements of radio tubes and similar devices and that elements so fabricated have the mechanical, chemical, and electrical properties required to meet the exacting specifications and needs of such devices as are made at the present time.

The alloy thermionic elements included in this invention contain between 15 and 40% of molybdenum, the balance being substantially all nickel. The nickel may be replaced by one or more of the metals of the group containing cobalt and iron, but the iron content must be less than 10%, and is preferably not over 5%, of the final alloy. As in the alloy described in my above-mentioned patent, the presence of vanadium is beneficial, but not essential; and small amounts of carbon and metals such as manganese and silicon may also be present, but large amounts of these elements are undesirable. For instance, up to about 2.5% manganese improves the working properties of the alloy, but in general the manganese content should not exceed 5%. The silicon content should preferably be below about 0.5% and the carbon content below about 0.3%. Such impurities as sulphur and phosphorous are detrimental, and should be present in no more than very small quantities. Cobalt and iron may be substituted for nickel, as explained, and tungsten may be substituted in part for the molybdenum. Zirconium may be used, in addition to or in place of manganese, to deoxidize the alloy, and it has been found that small additions of magnesium also improve the working characteristics of the materials.

The alloys just described possess the requisite properties for fabrication into wire of the size employed in the manufacture of thermionic valves and the like provided that in the fabrication the reduction be taken in reasonably small stages with intermediate annealing periods.

Thermionic wire elements of the present invention possess great stiffness, even when hot, a high tensile strength, and a high surface work function, and these properties are retained even at temperatures in the range of 700° to 800° C. The wire has excellent winding properties and may be formed on a mandrel to produce grids of uniform dimensions.

Due to the low emissivity and great stiffness while hot, these alloys have been found highly useful, not only for use as main grid elements but also in those parts of the tube subjected to less stringent conditions, such as control grids, support rods, and other parts of the tube construction.

The advantages of the alloy structural elements of the present invention include: stiffness and elasticity, resistance to corrosion, freedom from distortion when heated and cooled, a high melting point (about 1330° C.), and relative cheapness. Furthermore, the alloy has a high tensile strength for a given elongation. It is possible to control the elongation within close limits over a wide range.

In test it has been found that those alloys which as wire show a wide spread between the yield point (which must not be unduly low) and the ultimate strength are, in general, most satisfactory for use in the manufacture of grids. In the production, grids are stretched on a mandrel and are given the desired stretch by a sharp shock. Wire which does not have a satisfactory spread between yield point and ultimate strength, when subjected to this severe test, is apt to break or otherwise render difficult the operation. The alloy wire elements of the present invention are, by actual test, vastly superior in this respect to molybdenum wire. Furthermore, the tensile strength of the alloy wire of this invention is considerably greater than the tensile strength of pure molybdenum wire of equal size.

It is to be emphasized that the particular properties most desired in grid wire are different for different types of grids, and vary also according to the methods and machines used in fabrication. For example, different practices in such operations as swaging, stripping, annealing and stretching of the grids in process require correspondingly different characteristics in the grid material for successful manufacture. Probably the greatest advantage in the alloys of the invention is the fact that they possess in addition to the peculiar set of properties required for grid manufacture the ability to change their physical properties over wide ranges under suitable control of the mechanical treatment imposed upon them.

The wire grid elements of this invention are superior in many respects, not only to the elements described in my Patent 1,963,844, but also to pure molybdenum elements. For instance, the elements of the invention are more resistant to oxidation, which feature is important because an oxidized surface has a relatively higher electron emissivity than an unoxidized one. Another important characteristic in which the grid elements of the invention excel is in the comparatively greater ease with which they may be removed from a winding mandrel without deformation of the grid. Moreover, the grid elements of the invention have, when drawn and annealed to impart optimum ductility and stiffness, a considerably higher breaking strength, a considerably higher elastic limit, and a considerably higher ratio of breaking strength to elastic limit.

A preferred composition for use according to this invention is approximately 30% molybdenum, 4% iron, remainder substantially all nickel.

While the application of my invention to radio tube grid wires has herein been stressed in the description and examples, it wil be understood that a material which will meet the difficult requirements of this application will also meet the less difficult requirements of many other elements of electronic devices, such for example as support wires, core wire for certain coated filaments, filament hook support wires, plates and the like.

I claim:

1. A thermionic device comprising an envelope; elements consisting of an electron emitting cathode, an anode, at least one grid electrode located between the cathode and anode, and means for supporting said cathode, anode and grid electrodes within said envelope; at least one of the elements within said envelope being composed of an alloy having the composition of from about 15% to about 40% molybdenum, less than 10% iron, and the balance nickel.

2. A grid electrode suitable for use in a thermionic valve which comprises an alloy having substantially the following composition: from about 15% to about 40% molybdenum, less than 5% iron, and the balance nickel.

3. A grid electrode suitable for use in a thermionic valve which comprises an alloy having substantially the following composition: 30% molybdenum, not over 5% iron, remainder nickel.

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