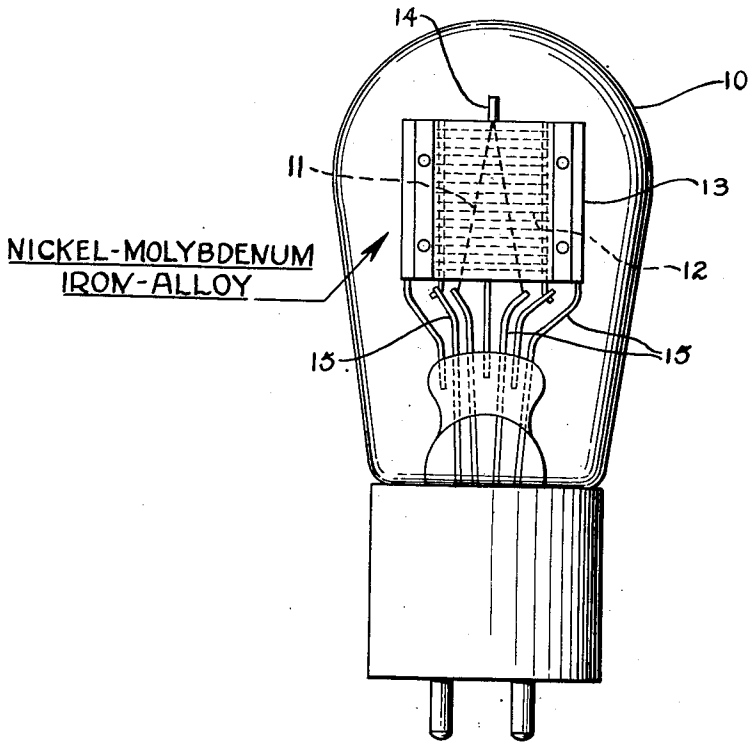
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THERMIONIC DEVICE

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INVENTOR:
James A. Holladay,
By Potter, Pierce & Schaffler,
ATTORNEYS.

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THERMIONIC DEVICE

James A. Holladay, Douglaston, N. Y., assignor to Kemet Laboratories Company, Inc., a corporation of New York

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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.

I have discovered 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 included in my invention 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.

The following description of one application of my invention, to radio tube grid electrodes, serves as an example. An alloy having approximately the following composition: 58% of nickel, 20% of molybdenum, 2.25% of manganese, 0.30% of vanadium, 0.20% of silicon, 0.10% of carbon, and the remainder iron was drawn down to wire having a diameter of about 0.005 inches. Samples of this wire were annealed at several different temperatures between about 900° C. and 1200° C. This heat treatment was found to provide a control of the stretch of the wire between about 5% and 30%, with a corresponding range of yield points between about 140,000 and 100,000 pounds per square inch, and of ultimate tensile strengths between about 170,000 and 115,000 pounds per square inch. The higher the annealing temperature, in general, the higher the resulting stretch of the wire will be, and the lower the yield point and ultimate strength. The above stretch figures were obtained on ten-inch samples of wire stretched to rupture. The stretch figures may be taken as indicative in a qualitative way of the elongation of the metal under standard elongation test conditions.

The heat treated wire samples were than made into radio tube grids. About five hundred grids were made during this experiment, including various types of flat, rectangular and round structures. During the manufacture of these grids it was observed that the wire was strong, stiff, had a good surface finish, handled well on the automatic machinery, and responded properly to the various operations such as winding, swaging,

stripping, stretching, annealing and assembling. There was no difficulty in manufacturing a uniform product to meet strict mechanical specifications. Tubes of the commonly known types containing these experimental grids, together with cathodes and anodes, were found to possess good electrical characteristics and to have a long life in use.

The advantages of the alloy structural elements of my 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, and this ratio is controllable not only by change in the composition of the alloy, but also by subjecting the alloy to varying degrees of cold working. While drawing wire for grids, for example, a severe cold working by rapid reduction of cross section tends to give a brittle material with a high tensile strength. A more gradual reduction in cross section yields a less brittle material with a lower tensile strength. Intermediate annealing during the drawing lessens the brittleness of the final material, and lowers the tensile strength considerably. I prefer to draw the wire by rapid reductions of area and at the most only slight intermediate annealing, and to impart the necessary stretch characteristics to the finished wire by one anneal after drawing is completed. This procedure gives a satisfactory wire for grid-wire. It is possible to control the elongation within close limits over a wide range by varying the annealing conditions as explained above.

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.

While the application of my invention to radio tube grid wires has herein been stressed in the description and examples, it will 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% of molybdenum, from about 10% to about 30% of iron, and the balance chiefly of 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, from about 10% to about 30% of iron, and the balance chiefly of nickel.

3. A grid electrode suitable for use in a thermionic valve which comprises an alloy having substantially the following composition: 20% of molybdenum, 58% of nickel, 2.25% of manganese, 0.30% of vanadium, 0.20% of silicon, 0.10% of carbon, and the remainder substantially iron.

4. A grid electrode suitable for use in a thermionic valve which comprises an alloy having the following composition: about 15% to 40% molybdenum, about 10% to 30% iron, approximately 0.3% vanadium, manganese in an amount not over about 2.5%, silicon in an amount not over about 0.5%, carbon in an amount not over about 0.3%, the balance substantially all nickel; the nickel being present in an amount at least 40% of the alloy.

JAMES A. HOLLADAY.