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METHOD OF FORMING DISTORTION RESISTANT TUBULAR ELEMENTS

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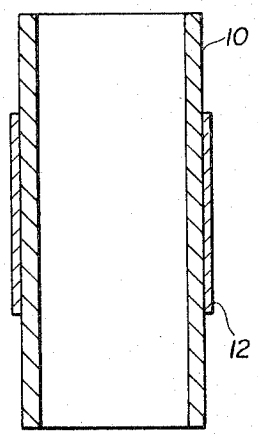

Fig. 1

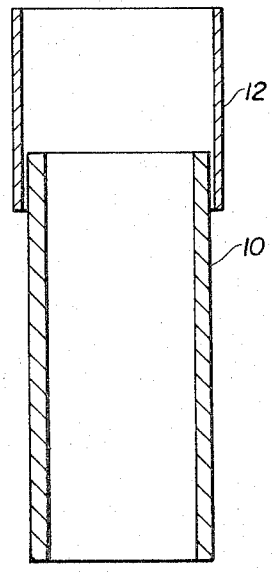

Fig. 2

INVENTOR.
WILLIAM R. STUART

BY Harry M. Weiss
Robert W. Dillon

ATTORNEYS

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METHOD OF FORMING DISTORTION RESISTANT TUBULAR ELEMENTS

William R. Stuart, San Carlos, Calif., assignor, by mesne assignments, to Varian Associates, a corporation of California

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This invention relates generally to a method for forming tubular metal elements resistant to distortion during variations in temperature of the tubular metal elements and more specifically relates to a method for forming thin walled, distortion resistant, cylindrical cathode elements for use in an electron tube.

In the past, electron tube manufacturers had been unsuccessful in developing a thin walled, distortion resistant, cylindrical cathode element to which a current could be directly applied for quick heating applications.

Quick heating electron tubes are essential in portable push-to-talk communication systems where delay in tube warm up of even as much as one second will result in the loss of a portion of the message being transmitted. Such quick heating electron tubes require directly heated, thin walled, distortion resistant, cathode elements which are capable of functioning during thousands of cycles of operation. Directly heated, thin walled, cylindrical cathode elements of an electron tube must maintain sufficient rigidity to prevent bowing due to temperature variations which results in undesirable noise and possibly shorting between the cathode and grid electrodes.

This problem of having a thin walled, directly heated, cylindrical cathode element maintain its rigidity and roundness during tube operation becomes even more severe if the cylindrical cathode element is perforated to increase the electron path which results in an increase in the electrical resistance of the cylindrical cathode element.

It is an object of this invention to provide a method for forming tubular metal eelments which are distortion resistant during variations in temperature of the tubular metal element.

It is a further object of this invention to provide a method for forming a thin walled, cylindrical cathode which can be directly heated and not have its cylindrical shape distorted due to temperature variations.

Briefly described, this invention relates to a method for making a thin walled, tubular metal element resistant to distortion under variations in temperature. A mandrel, which is located within a thin walled, tubular metal element, is heated to a temperature and for a time sufficient to increase the outer diameter of the mandrel. The mandrel is made of a material having a coefficient of thermal expansion greater than the coefficient of thermal expansion of the thin walled, tubular metal element. The thin walled, tubular metal element and the mandrel are cooled to separate the thin walled, tubular metal element, which is now distortion resistant, from the mandrel.

Other objects and advantages of the present invention will become apparent from the following description and drawing taken in connection with the appended claims.

In the drawing:

FIGURE 1 is a cross-sectional view of a mandrel located within a tubular element which element is to be made distortion resistant in accordance with the method of this invention; and

FIGURE 2 is a cross-sectional view of the mandrel and tubular element after the heating and cooling steps in the distortion resistant treatment of the tubular element.

Referring to FIGURE 1, a mandrel **10** is provided within a thin walled, tubular metal element **12**. The thin walled, tubular metal element is preferably formed

undersized having a diameter smaller than the diameter desired.

The assembly of both the mandrel **10** and the tubular metal element **12** is placed in a furnace and heated for a time and at a temperature sufficient to increase the outer diameter of the mandrel **10**. The mandrel **10** is formed of a material having a coefficient of thermal expansion which is greater than the coefficient of thermal expansion of the thin walled, tubular metal element **12**. Hence, the thin walled, tubular metal element **12** is radially expanded beyond its normal expansion due to the expansion characteristics of the mandrel **10**.

The assembly is then cooled and the outer diameter of the mandrel **10** returns to its original size (FIGURE 2). However, the thin walled, tubular metal element **12** does not return to its original size, but has a slightly increased diameter and is now precipitation hardened or distortion resistant.

In making a cylindrical cathode element, the thin walled, tubular metal element **12** is preferably formed from .0005-inch thick Hastelloy B metal, which is a trade name of a nickel based alloy comprising small amounts of molybdenum, iron and carbon. The Hastelloy B metal cylinder is preferably made by rolling a section of a sheet of Hastelloy B metal into a cylindrical configuration about the mandrel **10** and then the ends are spot welded together.

In one example, the mandrel **10** which was cylindrical had an outer diameter of .335 inch and the diameter of the Hastelloy B metal cylinder was between .335–.336 inches. The mandrel **10** which is preferably formed of 300 series stainless steel need not be hollow, but in this example a $\frac{3}{16}$ inch diameter hole was formed in the mandrel **10**. To increase electrical resistivity, the Hastelloy B metal cylinder was photoetched to form a plurality of small perforations each of which is vertically offset with respect to the others. Approximately one-third of the Hastelloy B metal material was removed in the photoetching step.

The assembly of both the stainless steel mandrel **10** and the Hastelloy B metal cylinder **12** is placed in a furnace, preferably, in a reducing atmosphere, such as hydrogen, and fired at a temperature of 850° C., preferably, for a period of 30 minutes. The assembly was then cooled and the resultant Hastelloy B metal cylinder had a diameter of about .339 inch. The resultant cylinder **12** of Hastelloy B metal is found to be truly cylindrical and remarkably durable during tube lifetime.

Since many changes could be made in the above method and many apparently, widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matters contained in the above description or shown in the accompanying drawing should be interpreted as illustrative and not in a limiting sense.

I claim:

1. The method of making a hollow, cylindrical, hardened, distortion resistant, thin walled structure of Hastelloy B metal comprising the steps of forming a strip of Hastelloy B metal into a cylindrical configuration about a cylindrical mandrel made of 300 series stainless steel and securing the ends of said strip together, heating the assembly of said Hastelloy B metal cylinder and said 300 series stainless steel mandrel in a furnace in a reducing atmosphere at a temperature of about 850° C. for a period of about 30 minutes and then cooling said assembly.

2. The method claimed in claim **1** wherein said reducing atmosphere is hydrogen.

3. The method of making a hardened, hollow, distortion resistant, thin walled structure of Hastelloy B metal comprising the steps of placing the hollow thin walled

metal structure about a closely fitted mandrel made of a 300 series stainless steel, said mandrel having a coefficient of thermal expansion greater than the coefficient of thermal expansion of said hollow thin walled metal structure, heating the hollow thin walled metal structure together with said mandrel located therein to a temperature of about 850° C., said temperature being below the annealing temperature of said hollow thin walled metal structure, continuing said heating for a period of about 30 minutes, said period being sufficient to precipitation harden said hollow thin walled metal structure, and cooling said hollow thin walled metal structure with said mandrel contained therein to separate the hardened, hollow, distortion resistant, thin walled metal strucure from said mandrel.

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JOHN F. CAMPBELL, *Primary Examiner.*

WHITMORE A. WILTZ, *Examiner.*

W. I. BROOKS, *Assistant Examiner.*