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METAL INSERT FOR VACUUM-TIGHT SEALING

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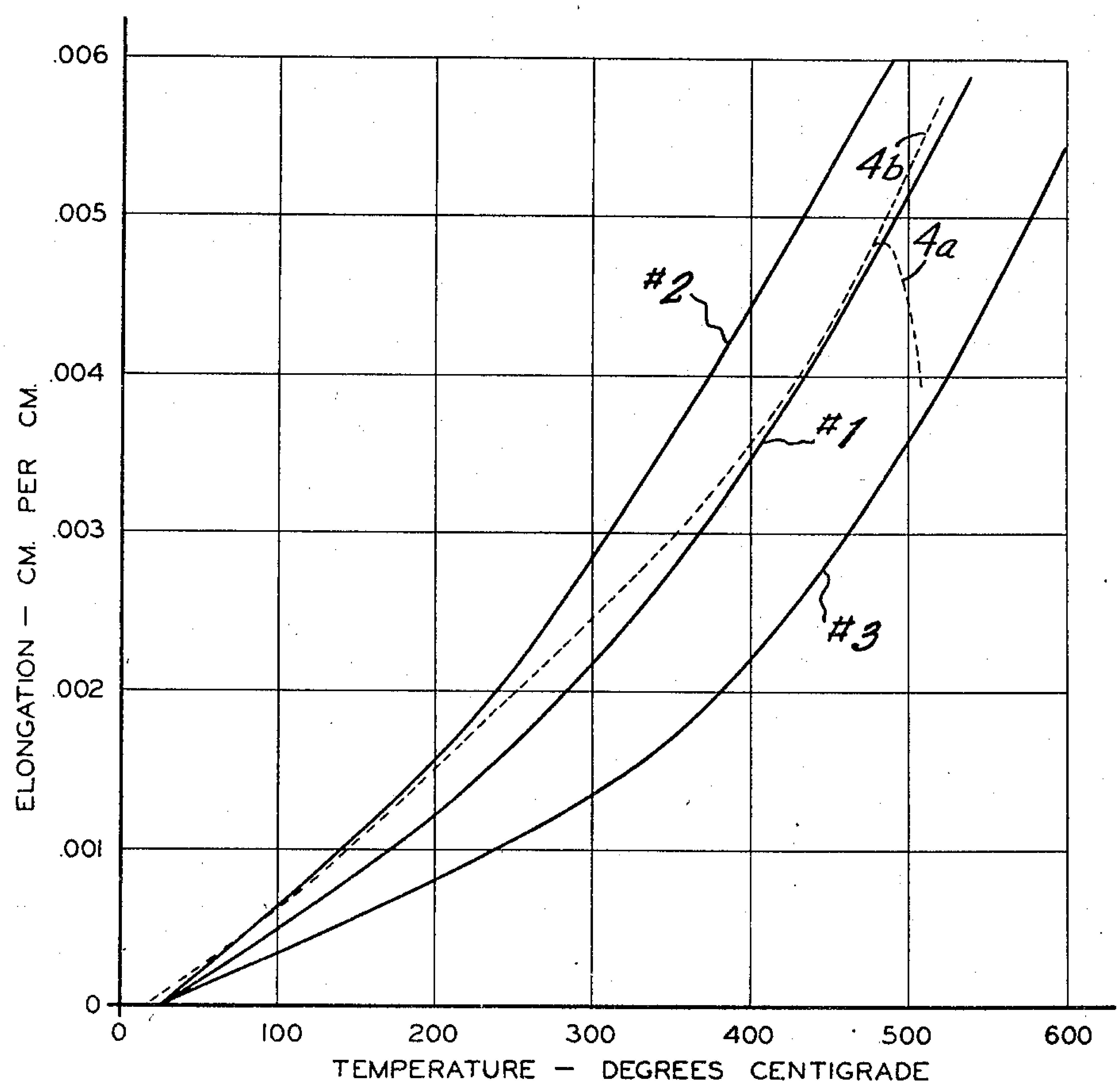

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METAL INSERT FOR VACUUM-TIGHT SEALING

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1 Claim. (Cl. 148—31)

This invention relates to special alloy metals and more particularly to metal inserts for providing a vacuum-tight seal to glass.

A principal object of the invention is to provide a special alloy which is capable of forming a satisfactory vacuum-tight seal with soft glass.

Another object is to provide a metal insert for vacuum-tight sealing to soft grades of glass, and the metal is of a special alloy which is relatively cheap to manufacture and is capable of easy working such as rolling, swaging, bending and the like, the metal being directly sealed to the glass so as to form therewith a unitary rigid body.

Other objects and advantages not specifically enumerated will be apparent after a consideration of the following detailed descriptions and the appended claim.

In the drawing which shows by way of example one typical embodiment of the invention, the single figure thereof shows the temperature-elongation characteristics of the metal insert according to the invention.

In certain devices, for example electron discharge tubes, it is necessary to provide a glass-to-metal seal which will remain vacuum-tight over long periods and over relatively wide temperature ranges. While this is true in the case of ordinary flexible lead-in wires, it is especially true where the metal part to be sealed into the glass is of rigid construction. Thus there is disclosed in application Serial No. 145,198, filed May 28, 1937 (issued Patent No. 2,238,025), a radio tube header consisting of a glass button-like member into which are sealed the various contact prongs in the form of rigid metal rods. While devices of this category have been successfully manufactured in large quantities, the cost of manufacture has been increased over the ordinary radio tube because of the cost of the usual metal alloys that have been deemed necessary to effectuate the vacuum-tight seal. On the other hand, it is possible to seal a slightly harder glass together with a chromium-iron alloy, e. g., Allegheny 55. One type of alloy that has been used in this kind of radio tube header consists of iron, nickel, cobalt and chromium and is quite costly to manufacture and work.

I have found that it is possible to make devices such as disclosed in said U. S. Patent No. 2,238,025, with soft glass headers and by using for the prongs an alloy which is relatively cheap to manufacture and work. While the invention is not limited to any particular kind of soft glass, it is particularly useful where the glass-to-metal seal employs a glass having the following composition:

SiO_2	PbO	Al_2O_3	CaO	Na_2O	K_2O	Mn_2O_3
63.1%	20.2%	0.28%	0.94%	7.6%	5.5%	0.88%

After extended investigation, I have also found that in order to provide an alloy which is satisfactory for use in such devices as radio tubes wherein the vacuum is of the order of 10^{-6} mm. of mercury or less, the following conditions must be fulfilled.

1. The thermal expansion curves of the alloy and glass should match over the temperature range of the glass up to softening point thereof; and the metal is wetted by the glass, that is, the metal oxide dissolves partly in the glass.

2. The oxide layer on the metal must adhere tenaciously to the metal core.

3. A protective oxide layer must be formed on the metal core by pre-oxidation, so as to prevent the formation of a flaky oxide during subsequent heating of the alloy, for example the heat encountered in sealing the alloy into glass.

While the first of the above conditions has long been recognized in the vacuum-tube art, the importance of the second and third conditions have been ignored with the result that it has not been found possible to use ordinary ternary alloys of iron, nickel and chromium to form a vacuum-tight seal to soft glasses.

The tenacious adherence of the oxide to the metal as set forth in the second of the above conditions and which can be obtained by the methods disclosed hereinbelow, makes it possible to eliminate all the special precautions of annealing the glass to metal seal which are necessary in known seals of hard glass and known alloys. In these prior seals elaborate annealing procedure must be resorted to in order to avoid a separation between the metal and the oxide after the seal has been made. Otherwise practically speaking it is impossible to cool the metal and glass in a seal at the same rate, unless very elaborate annealing processes are used, due to the greater conduction of heat away from the metal part. This differential in the cooling temperatures, and the associated differences in expansivity put a great strain on the oxide to metal bond. Unless this bond is extremely tenacious there will be a tendency to break away at this part. With the great strength and adherence of the oxide, formed according to this invention, to the metal, seals can be cooled in production equipment without annealing if necessary and still obtain vacuum-tight conditions.

In accordance with the invention, the alloy consists of approximately 42 percent nickel; 4 to 8 percent chromium, 0.1 to 2 percent of aluminum, and the balance substantially entirely of iron and a small percentage of manganese of the order of 0.25 percent to 0.4 percent. I have found that such an alloy in addition to having desirable expansion coefficients over a wide range of temperatures rendering it suitable to form a vacuum-tight weld with glass of the type described above, also has a relatively high tensile strength of from 125,000 to 150,000 pounds per square inch. This is particularly desirable where the alloy forms the rigid contact prongs of a radio tube. I have found that when the metal parts which are to be sealed in a vacuum-tight manner to corresponding matched glasses are of known alloys, e. g., those sold respectively under the trade names "Fernico," "Fernichrome," "Kovar" and "Allegheny 55," the addition of a small percentage of aluminum will also produce the required strong bond between these known alloys and their overlying metal oxide layers. The addition of a small percentage of the said metal to said known alloys also enables the seal with their corresponding matching glasses to be made with considerably better results, and without requiring special annealing precautions which are usually required between said known alloys and their matching glasses. For a detailed description of said known alloys reference may be had to U. S. Patents 1,942,260 and 2,071,196. The composition of the alloys "Fernico" and "Kovar" is the same and consists of approximately 54% iron; 28% nickel; and 18% cobalt. "Fernichrome" consists of approximately 37% iron; 30% nickel; 25% cobalt and 8% chromium. Allegheny #55 consists of approximately 0.35 carbon; 1.0% manganese; 0.6% silicon (maximum); 23–30% chromium; 0.6% nickel and the balance iron.

If desired, the alloy can be annealed at a temperature of 1000° C. so as to render it ductile. Furthermore, by pre-oxidizing the alloy at a temperature of about 1300° C. in a suitable atmosphere, for example an atmosphere of moist H_2, a tightly adherent chromium oxide layer is formed on the exterior surface, which oxide facilitates wetting by the molten glass and the formation of a vacuum-tight bond or weld upon subsequent cooling. I have found that by using the range of proportions of alloy constituents as mentioned above, it is possible to vary them to provide a corresponding series of alloys whose mean linear expansion between zero and 300° centigrade can be given any desired value between 60×10^{-7} centimeters per degree centigrade, and 150×10^{-7} centimeters per degree centigrade.

Thus there is shown in Fig. 1, a family of curves illustrating the characteristics of three separate alloys having compositions within the range of constituents above mentioned. The dotted curve of Fig. 1 represents the expansion characteristic of a soft glass, such for example as that described hereinabove, which has a "softening" point at approximately 475° C. Beyond this "softening" point the glass begins to sag as indicated by the section 4a of the curve. However, by extrapolation, the equivalent elongation can be calculated and is represented by the section 4b of the curve.

Curve No. 1 represents the expansion characteristics upon heating and cooling of an alloy of the above mentioned composition containing approximately 42 percent nickel; 4 to 8 percent chromium, the balance being iron with a small percentage of manganese. It will be seen that this alloy matches quite closely the characteristics of the glass. I have found that the match is sufficiently close to enable the manufacture of satisfactory radio tube headers of the type disclosed in said U. S. Patent No. 2,238,025, which are free from undesirable strain around the prongs, up to the softening point of the glass, with the result that the vacuum-tight character of the seal remains permanent.

Curve No. 2 shows the expansion characteristic of an alloy consisting of 42 percent nickel; 8 to 12 percent chromium, and the balance iron.

Likewise curve No. 3 illustrates the expansion characteristics of an alloy consisting of 42 percent nickel and the balance iron.

The total impurities including the manganese should not appreciably exceed 0.885 percent with the carbon impurities not appreciably greater than 0.15 percent. Thus in one alloy that was found to have the desired properties for vacuum-tight sealing, the alloy in addition to containing the iron, chromium, nickel, aluminum, manganese constituents as described above, contained the following impurities having negligible effect on the desirable properties of the alloy.

	Percent
Carbon	0.15
Silicon	0.30
Sulphur	0.020
Phosphorus	0.015

An increase of the carbon contents will increase the hardness of the alloy, and it is thus possible to control the hardness of the material by addition of carbon up to 0.55% to any desired degree within limits.

This application is a continuation-in-part of application Serial No. 336,515, filed April 25, 1939.

What I claim is:

A metal insert for use in sealed highly evacuated devices such as electron tubes and the like having a soft glass portion to which the insert is to be sealed, said insert consisting of a core of an alloy of approximately 42% nickel, not less than 50% iron, from 4 to 8% chromium, the alloy being free from cobalt and having a tightly adherent sheath in the form of an oxide of at least one of the core metals, the alloy core also having included therein from 0.1 to 2% of aluminum to facilitate formation and bonding of said sheath to the core, the percent of said aluminum being insufficient to affect materially the temperature-expansion characteristics of said core.

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