May 26, 1942. W. E. KINGSTON 2,284,151

UNITARY STEM AND CONTACT BASE FOR ELECTRON TUBES AND THE LIKE

Original Filed April 25, 1939

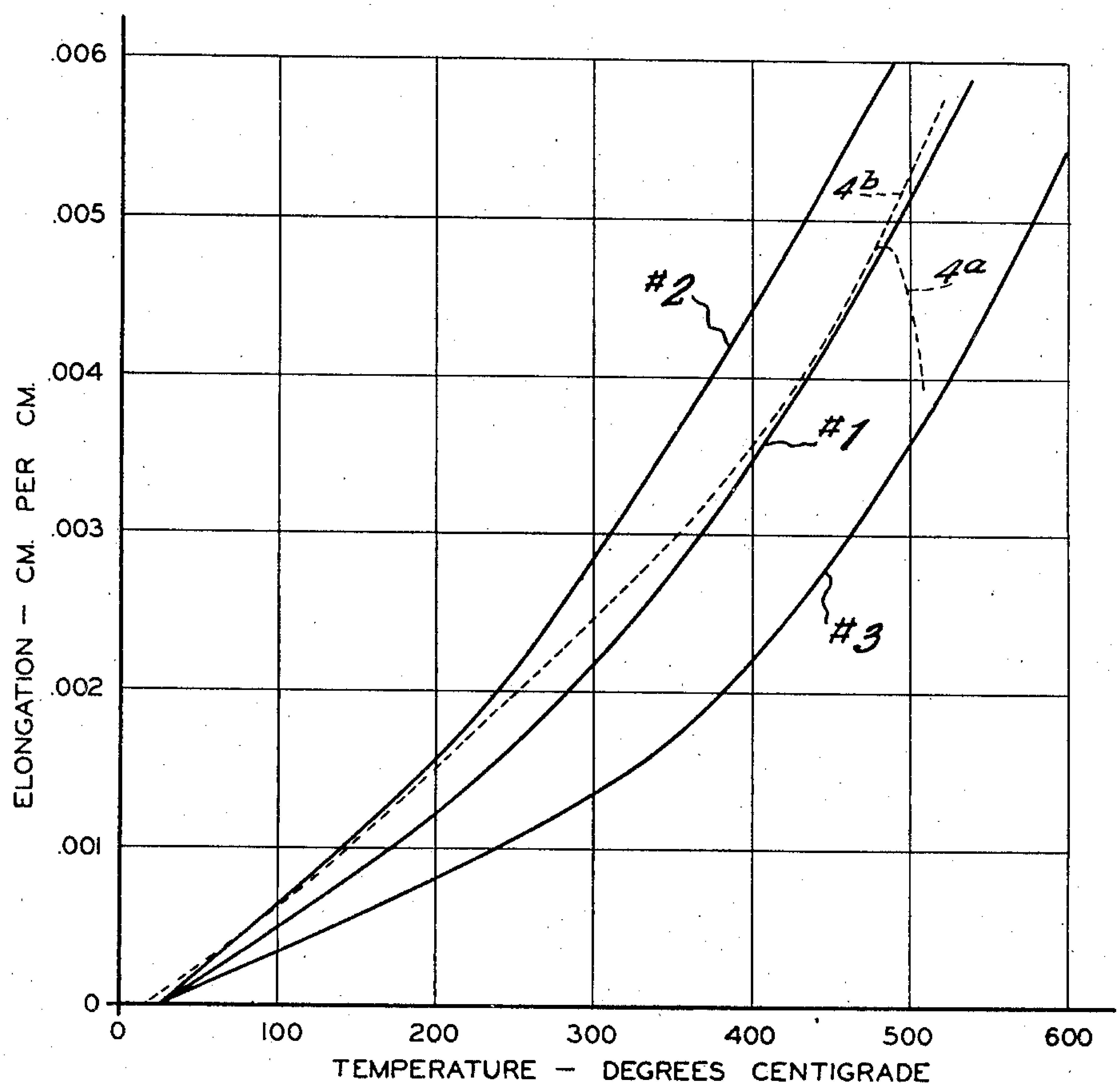

Fig. 1.

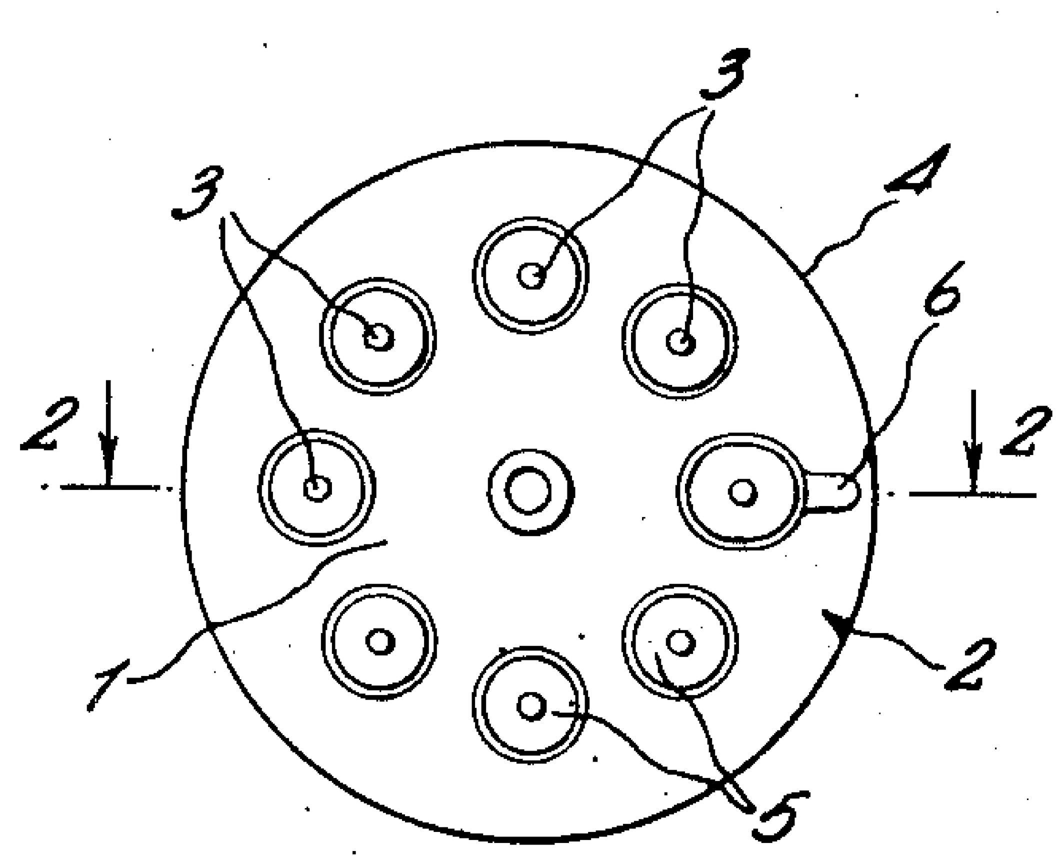

Fig. 3.

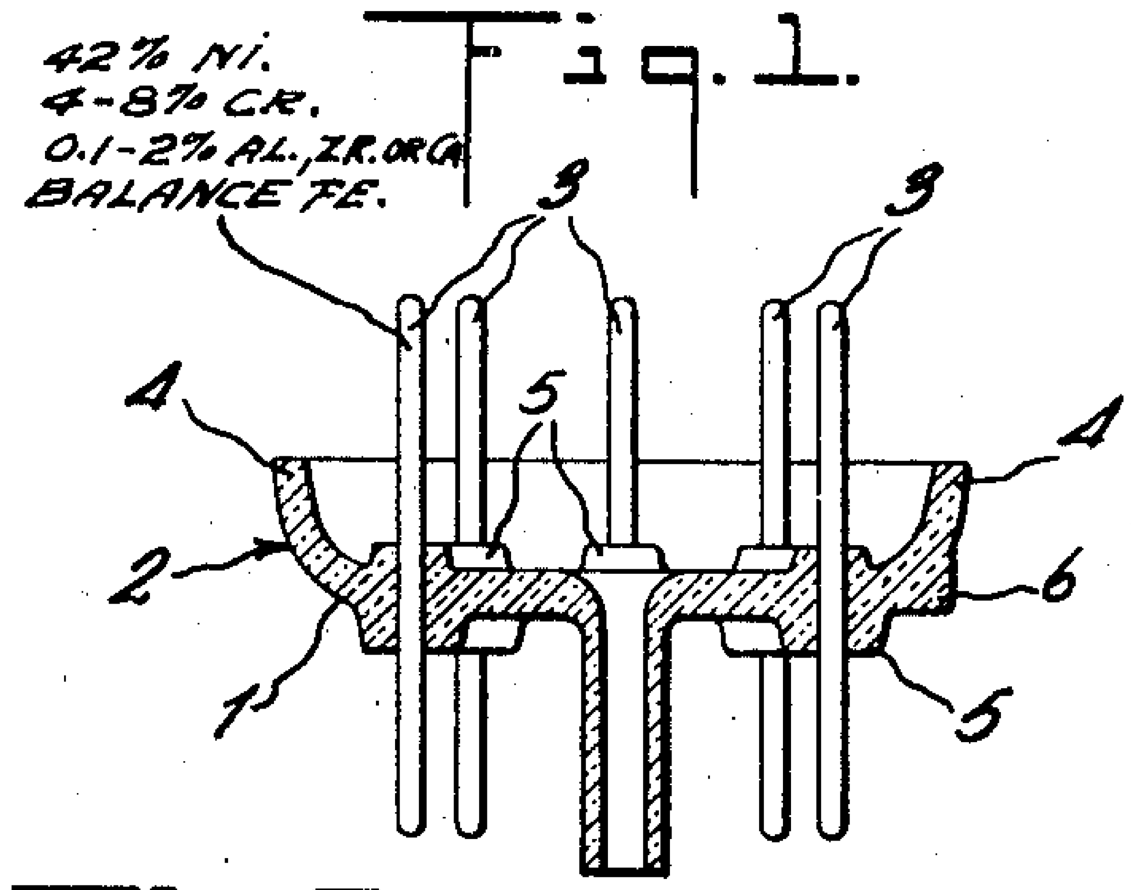

Fig. 2.

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Patented May 26, 1942 **2,284,151**

UNITED STATES PATENT OFFICE

2,284,151

UNITARY STEM AND CONTACT BASE FOR ELECTRON TUBES AND THE LIKE

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Original application April 25, 1939, Serial No. 336,515. Divided and this application September 26, 1940, Serial No. 358,477

6 Claims. (Cl. 250—27.5)

This invention relates to electron tubes and more especially to composite stem-bases for such tubes.

A principal object of the invention is to provide an improved unitary stem-base which has the contact prongs sealed directly therein the prongs being of a specially chosen alloy which has the necessary mechanical and tensile strength and hardness while at the same time allowing a vacuum-tight seal to be made with a glass stem of the soft glass type.

Another object is to provide a novel form of alloy contact prong for electron tubes.

Another object is to provide an improved alloy lead-in conductor for electron tubes, lamps and similar highly evacuated devices.

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

In the drawing which shows by way of example one typical embodiment of the invention,

Fig. 1 shows the temperature-elongation characteristics of the alloy prongs and glass stem according to the invention.

Fig. 2 is a cross-sectional view of an electron tube header embodying features of the invention.

Fig. 3 is a bottom view of Fig. 2.

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 Patent No. 2,238,025, a radio tube header consisting of a glass button-like member through 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, for example "Corning 125 AJ" glass together with a chromium-iron alloy, e. g. Alleghany 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 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 of the "Corning G-12" type. An example of a soft glass that may be used may have the following composition.

	Percent
SiO_2	63.1
PbO	20.2
Al_2O_3	0.28
CaO	0.94
Na_2O	7.6
K_2O	5.5
Mn_2O_3	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; such as a glass sold commercially under the designation "Corning 705 AJ" by the Corning Glass Works of Corning, New York, and an alloy sold under the trade name "Fernico." 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 from 38 to 45 percent nickel; 3 to 15 percent chromium; 0.1 to 2 percent of a metal of the group consisting of aluminum, zirconium or calcium; and the balance substantially entirely of iron. If desired, a small percentage of manganese of from 0.25 to 0.4 percent may be added to facilitate melting and casting. When the alloy is to be sealed to a glass such as "Corning G-12" glass, the preferred proportions are 42 percent nickel; 4 to 8 percent chromium, a small percent of aluminum, zirconium or calcium, 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 "Corning G-12" glass, 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, zirconium, calcium, boron, beryllium, carbon, strontium, or thorium, 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 metals 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" consist 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 150×100^{-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 "Corning G-12" glass, 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 "Corning G-12" 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 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.

Referring to Fig. 2, there is shown in cross section, a typical radio tube header embodying the invention. The header consists of a glass cup-shaped member having a circular button-shaped bottom **1** and a smoothly curved rim **2**, and which terminates in a substantially cylindrical lip **4**, the bottom portion at least of the cup-shaped member being preferably formed of a soft grade of glass such as "Corning G-12." Sealed through the member **1** are a plurality of rigid metal rods **3** which extend outwardly to form rigid contact prongs for the radio tube to which the header is sealed in any well-known manner. The prongs are preferably formed of the alloy above mentioned consisting of approximately 42 percent nickel; 4 to 8 percent chromium, and the balance substantially of iron with a small percent of aluminum, zirconium or calcium.

Fig. 3 is a bottom view of Fig. 2, from which it will be seen that the portions of the header through which the prongs are sealed, are provided on both sides with integral beads **5**. Preferably, one of the heads is oval-shaped and provided with a rib **6** which cooperates with a correspondingly shaped perforation in a metal cup base such as disclosed in Patent No. 2,250,184, so as to properly locate the prongs with respect to the base. While particular materials and parts have been described however, it will be understood that various changes and modifications may be made without departing from the spirit and scope of the invention. Furthermore, while the alloy according to the invention has been described as applied to a radio tube header, it is capable of other uses where a stainless and easily workable alloy is required. Furthermore, because of its widely adjustable expansion coefficient, it is capable of use as a thermostat element such as in a bi-metallic thermostat, and also as one element of a thermocouple the other of which may be iron or other base metal. In the foregoing description the percentages of the various constituents are in terms of weights. In the subjoined claims, the expression "balance substantially iron" is meant that the balance of the alloy is composed largely of iron but may contain a small percent of impurities which are not purposely introduced and which have no appreciable effect on the desired properties of the alloy. Thus the balance may include from 0.25 percent to 0.4 percent manganese as above pointed out and 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 division of application Serial No. 336,515, filed April 25, 1939.

What I claim is:

1. A unitary stem base for closing off a radio tube bulb or the like comprising a button-shaped member of soft glass, and a plurality of rigid metal rods sealed through the glass, said rods being of an alloy composed of 38 to not more than 45% nickel; 3 to 15% chromium; 0.1 to 2% metal of the group consisting of aluminum, zirconium and calcium; and the balance substantially of iron, the alloy having sufficient hardness and tensile strength to permit said rods to be used directly as external plug-in prongs without danger of weakening the seal.

2. A unitary stem base for closing off a radio tube bulb or the like comprising a button-shaped member of soft glass and a plurality of rigid metal rods sealed through the glass, said rods being of an alloy containing approximately 42% nickel; 4 to 8% chromium; up to 2% metal of the group consisting of aluminum, zirconium and calcium; and the balance substantially iron, whereby the alloy has sufficient hardness and tensile strength to permit said rods to be used directly as plug-in prongs without danger of weakening said seal.

3. A unitary stem base according to claim 2 in which the glass has a non-linear temperature-elongation characteristic and the said rods have substantially the same non-linear characteristic and are directly sealed through the glass in a vacuum-tight manner, the alloy of the rods being free from inflexion points from approximately 20° C. to 600° C.

4. A unitary stem base according to claim 2 in which the glass has an expansion of from 0.005 cm./cm. over a temperature range of from zero to approximately 500° C., and the metal has substantially the same expansion characteristic as the glass over said range, each of said rods having a tensile strength of over 100,000 pounds per square inch.

5. A rigid contact prong for highly evacuated devices such as radio tubes comprising a rod of an alloy of from 38 to not more than 45% nickel; 3 to 15% chromium; 0.1 to 2% metal of the group consisting of aluminum, zirconium and calcium, the balance substantially iron, whereby the alloy has sufficient hardness and tensile strength so that said rods can be used directly as plug-in prongs.

6. A rigid contact prong for highly evacuated devices such as radio tubes comprising a rod of an alloy of approximately 42% nickel; 4 to 8% chromium, up to 2% metal of the group consisting of aluminum, zirconium and calcium, the balance substantially iron whereby the alloy has sufficient hardness and tensile strength so that the said rod can be used directly as a plug-in prong.

WALTER E. KINGSTON.

Certificate of Correction

Patent No. 2,284,151. May 26, 1942.

WALTER E. KINGSTON

It is hereby certified that errors appear in the above numbered patent requiring correction as follows: In the heading to the printed specification, line 7, in the heading to the drawing, line 3, and on page 3, first column, line 43, for "April 25, 1939" read *May 22, 1940*; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 13th day of April, A. D. 1948.

[SEAL]