

Dec. 4, 1934.

N. L. DERBY
THERMOSTATIC ELEMENT
Filed Aug. 25, 1931

1,983,269

2 Sheets-Sheet 1

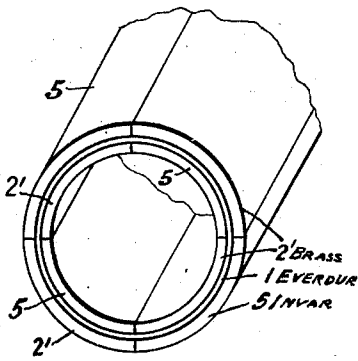


FIG. 4.

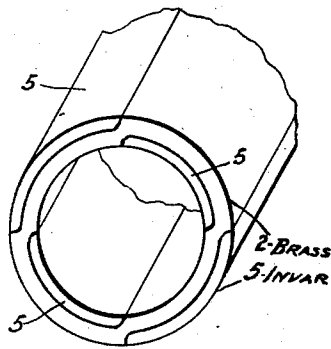


FIG. 3.

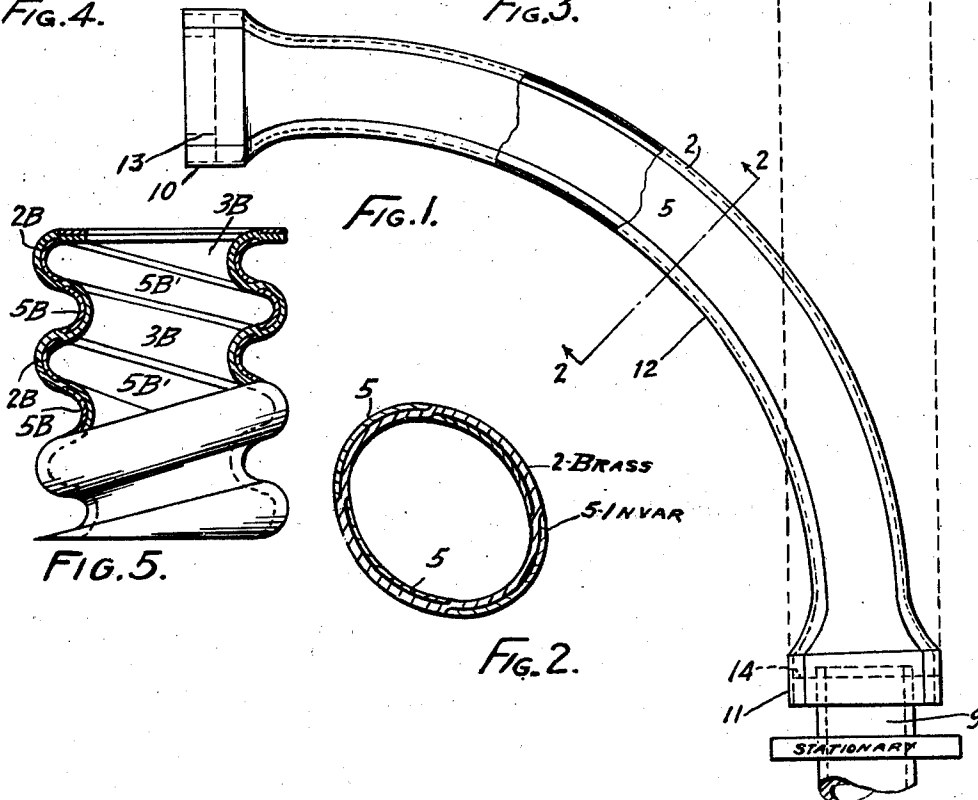


FIG. 1.

FIG. 5.

FIG. 2.

Norman L. Derby
INVENTOR

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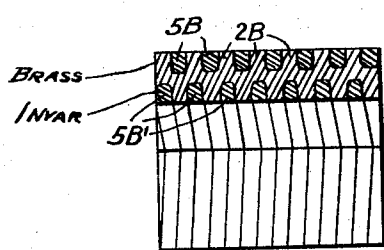


FIG. 6.

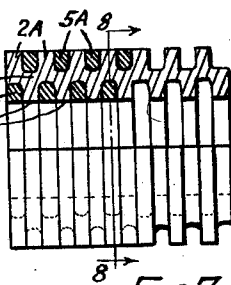


FIG. 7.

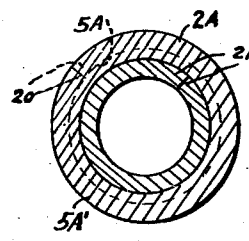


FIG. 8.

FIG. 15.

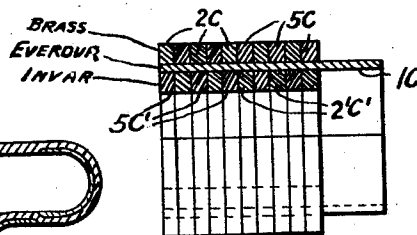
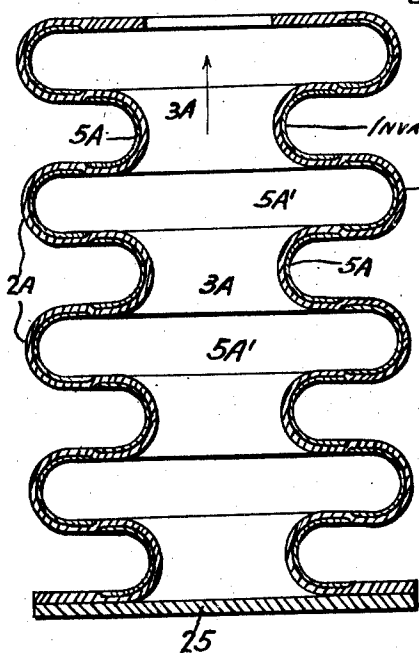


FIG. 9.

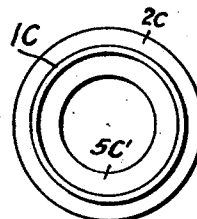


FIG. 10.

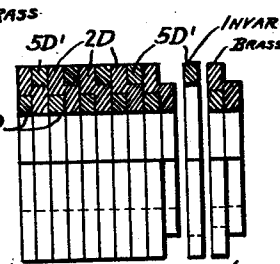


FIG. 11.

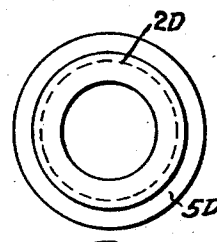


FIG. 12.

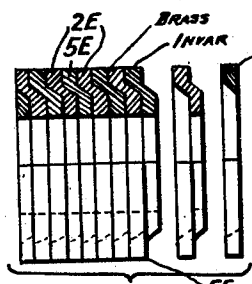


FIG. 13.

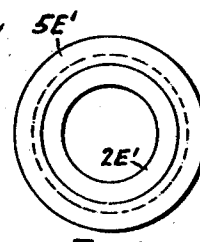
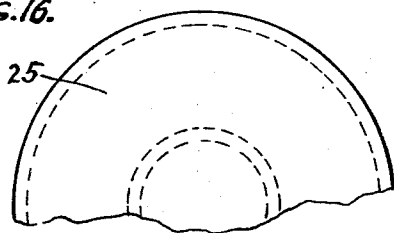


FIG. 14.

FIG. 16.



Norman L. Derby
INVENTOR

UNITED STATES PATENT OFFICE

1,983,269

THERMOSTATIC ELEMENT

Norman L. Derby, Jackson Heights, N. Y.

Application August 25, 1931, Serial No. 559,186

16 Claims. (Cl. 297—11)

This invention relates to thermostatic elements composed of metallic members joined together and makes use of principles of, and comprises improvements on the invention of my copending application Serial No. 492,707, filed November 1, 1930.

The general object of the present invention is to provide a hollow thermostatic element which may take various forms, but each of which comprises curved portions formed of layers of metals having different coefficients of expansion and so arranged as to cause the elements to deflect or change in form and dimensions in a novel and effective manner, in response to changes in the temperatures to which the element is subjected.

In the accompanying drawings:

Fig. 1 is a side elevation of a thermostatic element in the form of a curved tube which straightens or increases its curvature as its temperature is increased or diminished;

Fig. 2 is a transverse section on the line 2—2 of Fig. 1;

Fig. 3 is a perspective view of a portion of a compound tubular ingot composed of two metals from which the thermostatic element shown in Figs. 1 and 2 may be made;

Fig. 4 is a perspective view of a portion of a compound tubular ingot, composed of three different metals, suitable for making tubular thermostatic elements generally similar to that shown in Figs. 1 and 2;

Fig. 5 is an elevation partly in section of a thermostatic element in the form of a helically corrugated tube;

Fig. 6 is a longitudinal elevation, partly in section, of a tubular ingot having helically wound external and internal inserts;

Fig. 7 is a longitudinal elevation partly in section of a tubular ingot similar to that shown in Fig. 6 except that the inserts are parallel to a plane at right angles to the longitudinal axis of the tubular ingot;

Fig. 8 is a section on the line 8—8 of Fig. 7;

Fig. 9 is a longitudinal elevation partly in section of a compound tubular ingot containing three different metals;

Fig. 10 is an end elevation of the compound ingot shown in Fig. 9;

Fig. 11 is a longitudinal elevation of a compound ingot suitable for making a bellows, built up of recessed washers of one metal and rings of another metal;

Fig. 12 is an end elevation of the ingot shown in Fig. 11;

Fig. 13 is a longitudinal elevation of a com-

pound ingot built up from a series of cupped washers;

Fig. 14 is an end view of the ingot shown in Fig. 13;

Fig. 15 is a vertical sectional elevation of a thermostatic bellows element made from the ingot shown in Fig. 7; and

Fig. 16 is an inverted plan view of part of the bellows shown in Fig. 15.

The thermostatic element shown in Figs. 1 and 2 is in the form of a bent tube 12 having one end 11 fixed, and its opposite end 10 free to move. As shown, the longitudinal axis of the free end 10 is at right angles to the longitudinal axis of the stationary end 11. The tube end portions 10 and 11 are circular in shape and are fitted with reinforcing washers 13 and 14, respectively. However, the free end 10 may be completely closed by a circular disc. As shown, the washer 14 surrounds a stationary nipple 9 by which the thermostatic element is supported. In its cold condition, the body portion of the tube 12 is of the elliptical cross section shown in Fig. 2.

The element shown in Figs. 1 and 2 may be formed from the compound tubular ingot shown in Fig. 3 by suitably reducing the thickness of the ingot to form a tube of circular cross section and then flattening and bending the body portion of the tube, so that in its cold condition, the body portion will have the cross section shown in Fig. 2, and the tubular element will have the longitudinal curvature shown in Fig. 1, the long diameter of the elliptical section being parallel to the axis of longitudinal curvature of the element. The ingot shown in Fig. 3 comprises a tubular body portion 2 of a metal as brass having a relatively high coefficient of thermal expansion and formed with diametrically opposed longitudinal extending recesses in its periphery in which are secured longitudinal inserts 5 of a metal as invar having a relatively low co-efficient of thermal expansion, and formed with diametrically opposed longitudinal extending recesses in its inner wall, alternating about the axis of the ingot with the recesses first referred to and in which are similarly secured longitudinal extending inserts 5 of invar, or the like metal having a low coefficient of thermal expansion. The periphery of the ingot is thus divided circumferentially into four equal segments of which two of brass or the like alternate with two of invar or the like, the outer surface of the segments being flush. The inner curved surface of the ingot is similarly formed of four segments, two of brass or the like and two of invar. In

effect each outer segment of one metal is lined by an inner segment of the other metal.

As shown in Figs. 1 and 2, the outer segments at the ends of the long axis of the elliptical section are formed of invar. When the tubular element shown in Figs. 1 and 2 is heated, the relative expansion of the brass segments relative to the invar segments tends to change the elliptical cross section of the body portion shown in Fig. 2 to one more nearly circular, with the result that the longitudinal curvature of the element will diminish and the element will deflect from its full line position toward the dotted line position shown in Fig. 1. The greater the temperature change the more nearly circular the cross section of the portion of the tube becomes, and therefore, the greater the deflection. The action of the element is thus similar to that of a Bourdon tube, but is due to temperature changes and not to fluid pressure variations. If the temperature increase is sufficient to make the cross section of the body portion of the element circular, or approximately so, the element will assume a position intermediate its full and dotted line positions shown in Fig. 1 which is determined by the relative lengths of the concave and convex sides of the element. On cooling, the element will regain its original bent shape and elliptical cross section.

It is also possible to reverse the action of such an element as is shown in Figs. 1 and 2, so that the longitudinal curvature of the element will be increased by heating the element above its cold temperature. Thus, if the element shown in Figs. 1 and 2, while heated to a relatively high temperature and without altering the position of its stationary end 11, as shown in Fig. 1, is permanently bent parallel to a plane at right angles to the plane of Fig. 1, and at the same time the body portion 2 of the element be given a permanently elliptical cross section with the long diameter of the ellipse at right angles to the long diameter of the element as shown in Figs. 1 and 2, the body portion of the element thus formed will tend to reduce its longitudinal curvature and to approach the circular cross section when the element cools down.

A tubular element as shown in Figs. 1 and 2 may be used as a power unit or as a temperature indicator. It may also be arranged to indicate the temperature differential between a fluid inside the tube and another fluid exposed to the outside of the tube, as for instance, in devices for measuring or controlling the humidity in a chamber.

Fig. 4 shows a trimetallic tubing or ingot which may be used instead of that shown in Fig. 3, in the formation of a thermostatic tubing or element generally like that shown in Figs. 1 and 2. The ingot shown in Fig. 4 comprises a tubular central shell 1 of relatively tough metal, as everdur, with two longitudinal strips 5 of invar secured to the outer surface, and two longitudinal strips 5 of invar secured to the inner surface of the shell 1, the outer and inner invar strips 5 being relatively disposed about the axis of the ingot as are the invar strips 5 of Fig. 3. Between the outer invar strips 5, two longitudinal strips of brass 2' are secured to the outer side of the shell 1 between the outer invar strips 5, and two longitudinal strips of brass 2' are secured to the inner side of the shell 1 between the inner invar strips 5. As everdur, like brass and unlike invar, has a substantial thermal coefficient of expansion, a thermostatic element of the form shown in Figs.

1 and 2, with the outer invar strips intersected by the long axis of the elliptical section of the body portion of the element will change in respect to its longitudinal curvature and the cross sectional shape of its body portion in response to changes in temperature as does the element shown in Figs. 1 and 2.

In Figs. 7 and 8 is represented a compound tubular ingot which when die drawn longitudinally will be suitable for making corrugated thermostatic tubing as shown in Figs. 15 and 16. The ingot shown in Figs. 7 and 8 comprises a tubular center member 1A of high expansion metal like brass, having a series of outside and inside longitudinal ribs or projections 2A and 3A, respectively. The said projections form rings extending circularly about the longitudinal axis of the ingot, the sides of said rings being generally parallel to planes transverse to the longitudinal axis of the tube. The space between each adjacent pair of projections 2 is filled by a curved strip 5A of invar with its two ends 20 abutting as shown in Fig. 8, and the space between each pair of projections 3A is similarly filled by a curved strip 5A' of invar having abutting ends 21. After the invar strips 5A and 5A' have been inserted in the corresponding spaces, they are permanently joined to the walls of the projections, and to the body center member 1A. After the compound tubular ingot thus formed is drawn through a series of dies until it has acquired the desired reduction of wall thickness, the ingot may be given the corrugated form shown in Figs. 15 and 16 by any means now in general use for making deeply corrugated thin walled tubing. With the invar at the concave sides of the corrugation curves and brass at their convex sides as shown in Figs. 15 and 16, the element will shorten when heated and elongate when cooled. As shown, one end of the corrugated element is secured to an end disc 25.

Fig. 6 shows a compound tubular ingot similar to that shown in Figs. 7 and 8, excepting that in Fig. 6 the internal and external ribs or projections 2B and 3B, and the spaces between them, are helical instead of circular, and the invar in said spaces consists of a continuous outer helical coil 5B like a coil spring, and another similar but smaller coil 5B'. The compound ingot of Fig. 6 is die drawn and corrugated as in the case of the ingot shown in Figs. 7 and 8, but the corrugated thermostatic tube thus formed, which is shown in Fig. 5, will have helical corrugations instead of the straight corrugations shown in Fig. 15.

Figs. 9 and 10 are longitudinal and side elevations, respectively, of a trimetallic tube suitable when drawn down, to make corrugated tubing generally similar to that shown in Figs. 15 and 16. The ingot shown in Figs. 9 and 10, consists of a center tubular shell of everdur, and alternating rings 2C and 5C of brass and invar, respectively, joined to the outer wall surface of the everdur shell, and alternating rings 2C' and 5C' of brass and invar, respectively, joined to the inner wall surface of the everdur shell. The inner and outer rings are staggered so that any portion of the ingot showing brass at its outer surface will show invar at the inside surface.

Figs. 11 and 12 show a compound tubular ingot composed of circular sections 2D of high expansion metal like brass, each of which has a recess in one face and a hub extending from the opposite face, with a ring or washer 5D of invar fitting in the recess, and with another and larger ring 5D' of invar fitting on said hub section.

The brass and invar members after being assembled and joined into a unitary structure may be drawn down and corrugated to form an element of the general character shown in Figs. 15 and 16.

5 Figs. 13 and 14 show a compound tubular ingot composed of cupped annular laminations 2E of brass, alternating with similar laminations 5E of invar, the projecting hub of one lamination fitting in the recess in an adjacent lamination. The
10 laminations when joined together with a binder into a unitary structure may be die drawn longitudinally and corrugated to form a thermostatic element like that shown in Figs. 15 and 16. At the ends of the ingot are invar ring laminations
15 5E' and 5E'' specially formed to give the ingot flat end surfaces.

In the construction of the compound tubular ingots suitable for making thermostatic elements as herein described, it is to be understood that
20 wherever surfaces of two members come together, they are to be permanently joined along their contacting surfaces.

In one method of securing inserts of invar between rigidly connected projection or ribs of
25 brass, the parts are thoroughly pickled and cleaned to remove all foreign matter. Next, the parts to be joined together are moistened and then covered with a thin layer of flux such as powdered borax. The strips of invar are then placed in the spaces between adjacent brass ribs or projections with a thin sheet of silver solder, having a
30 melting temperature of about 1600° F., interposed between the contacting surfaces. When the sides of the projecting legs and invar strips are slightly tapered it is preferable to tack the sheets of silver solder onto the invar strips by spot welding and then force the strips into the spaces in the brass while the brass is at a temperature of approximately 500° F. Then after the compound ingot is allowed to cool down to room temperature,
40 it is clamped in a heat resisting vise which exerts considerable pressure to prevent lateral expansion of the spaces holding the invar, when the ingot is again heated. Next the compound ingot clamped in the vise is placed in the furnace and heated slightly above the melting temperature of the solder. The ingot is then allowed to cool down slowly while still in the furnace, to prevent undue oxidation of the members. After cooling the
50 ingot is rolled down to the thermostatic element thickness desired, which may be two or three hundredths of an inch in some cases.

In my said prior application, Ser. No. 492,707, filed November 1, 1930, I have described other
55 methods of manufacturing ingots and the production of bimetallic thermostatic metal therefrom of a suitable thickness, for example, of a thickness of two or three hundredths of an inch, which may be followed in the manufacture of any
60 of the ingots and elements described herein.

Any of several other metals may be used in place of brass as the high expansion metal in the ingots and elements previously described herein as including brass portions with invar used in
65 each case as the low expansion metal. For instance, I may use nichrome steel as the high expansion metal in making bimetallic elements for use at high temperature, and may join it to the invar steel with copper in an atmosphere of hydrogen in accordance with the process for making gear blanks as outlined in Steenstrup Patent No. 1,659,550 issued February 14, 1928, to the General Electric Co. Likewise I may make use of everdur
70 as the high expansion metal in lieu of brass in the arrangement heretofore described, and may

join it to the invar with silver solder, using as a flux 90% fused borax and 10% sodium fluoride. Furthermore, everdur may be fused into grooves in an invar slab to make bimetallic elements by automatic carbon arc welding of the type known as the "Electronic Tornado" system, produced by the Lincoln Electric Company.

In making a trimetallic ingot such as that shown in Figs. 4 or 9, various other metals besides
85 everdur may be used for the center member, however it is preferable to use a metal having a coefficient of heat expansion approximately the same as the high expansion strips joined. The thermostatic elements are more sensitive when the high expansion metal thickness is slightly
90 thicker than the low expansion metal thickness, and in the drawings an effort has been made in every case to show a brass thickness greater than the invar thickness.

What I claim and desire to secure by Letters
95 Patent is:—

1. A hollow thermostatic element the wall of which comprises a center member having spaced projecting members extending therefrom, and members having a different coefficient of heat
100 expansion than said projecting members filling spaces between said projecting members.

2. A hollow thermostatic element the wall of which comprises a center member having projecting members extending from opposite faces
105 thereof, and members having a different coefficient of heat expansion than said projecting members permanently positioned between adjacent projecting members.

3. A hollow thermostatic element the wall of which is composed of a series of portions each including inner and outer layers of different materials, the outer layer material in each of
110 some of said portions having a greater coefficient of expansion than the corresponding inner layer material, and respectively adjacent portions of said wall having outer layer material with a smaller coefficient of expansion than that of the inner layer material.

4. A hollow thermostatic element, the wall of which comprises some portions more externally
120 convex than adjacent portions, some of said portions comprising an outer layer of material having one coefficient of expansion and an inner layer of material having a different coefficient of thermal expansion.

5. A hollow thermostatic element, the wall of which comprises a set of portions more externally
130 convex than the portions of another set adjacent thereto, each of said portions comprising an outer layer of material having one coefficient of expansion and an inner layer of material having a different coefficient of expansion, the layer having the higher coefficient being at the inner side of the element in the said portions of one set
135 and at the outer side of the element in the said portions of the other set.

6. A thermostatic element in the form of a circumferentially complete section of a tube and comprising a curved wall portion extending part
140 way about the tube axis and including an inner layer of material having one coefficient of expansion and an outer layer of material having a different coefficient of expansion.

7. A thermostatic element in the form of a section of a tube the wall of which comprises a circumferentially extending series of portions each including an inner layer of material having one coefficient of expansion and an outer layer
150 of material having a different coefficient of ex-

pansion, the inner layer coefficient being greater in one or more portions and less in one or more other portions than the corresponding outer layer coefficient.

5 8. A thermostatic element in the form of a section of a tube with opposite sides flattened and each including an inner layer of material having one coefficient of expansion and an outer layer of material having a higher coefficient of expansion.

10 9. A thermostatic element in the form of a section of a tube with an opposing pair of sides more sharply curved than the intervening sides and each of said opposite pair of sides including an inner layer of material having one coefficient of expansion and an outer layer of material having a smaller coefficient of expansion.

15 10. A thermostatic element in the form of a section of a tube the wall of which comprises inner and outer layers each of which includes a circumferential series of curved portions with adjacent portions of each series formed of materials having different coefficients of expansion and with the juxtaposed inner and outer layer portions formed of materials having different coefficients of expansion.

20 11. A thermostatic element in the form of a tube bent into an arc and having the portions of its wall at the inner and outer sides of the arc and the remaining wall portions each formed with inner and outer layers of materials having different coefficients of expansion, the coefficient of expansion of the outer layer material being greater in the first mentioned portions, and less in said intervening portions than the coefficient of expansion of the corresponding inner layer material.

25 12. A thermostatic element in the form of a tube bent into an arc and having portions of its wall at the inner and outer sides of said arc connected by intervening wall portions, each of the latter of which comprises inner and outer layers of materials having respectively larger and smaller coefficients of expansion.

13. A thermostatic element consisting of a curved tube having its convex and concave sides flattened and each formed with inner and outer layers of materials having different coefficients of expansion, the two inner layers forming portions of the inner surface of the tube and the two outer layers forming portions of the outer surface of the tube and the two layers forming portions of one of said surfaces having coefficients of expansion greater than those of the respectively adjacent layers forming portions of the other of said surfaces.

14. A thermostatic element in the form of a tube bent into an arc and having its sides at the inner and outer sides of the arc each formed with an outer layer of material having one coefficient of expansion and with an inner layer of material having a smaller coefficient of expansion, and having the more rounded portions of its wall formed with outer and inner layers of material respectively having smaller and larger coefficients of expansion.

15. A thermostatic element in the form of a curved tube of elliptical cross section and having more sharply curved portions of its wall formed with inner and outer layers of materials having respectively larger and smaller coefficients of expansion, and having less sharply curved portions of its wall formed with inner and outer layers of materials having respectively smaller and larger coefficients of expansion.

16. A thermostatic element in the form of a section of a tube of elliptical cross section having the more sharply curved portions of its wall each formed with an inner layer of material having one coefficient of expansion and an outer layer of material having a smaller coefficient of expansion and having its less sharply curved wall portions each formed with an inner layer of material having one coefficient of expansion and an outer layer of material having a greater coefficient of expansion.

NORMAN L. DERBY.

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