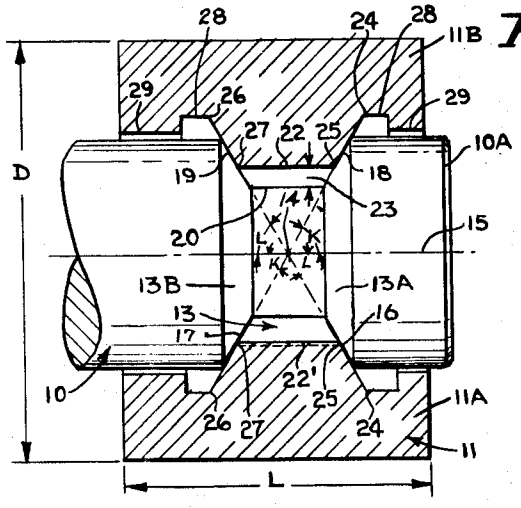
Aug. 18, 1964 L. A. KLEVEN 3,145,362

ELECTRICAL RESISTANCE DEVICE

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FIG. 1



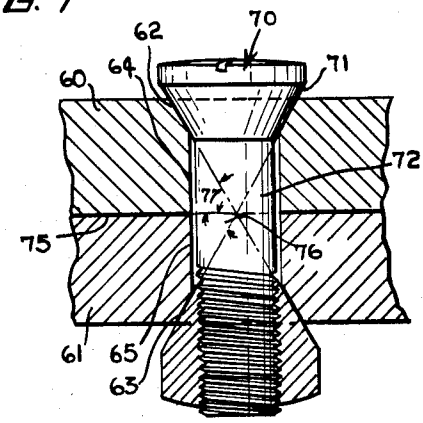


FIG. 3

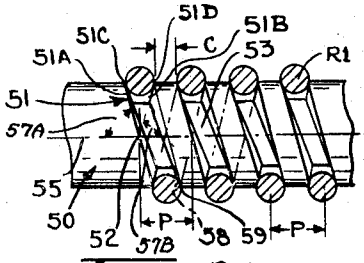


FIG. 2A

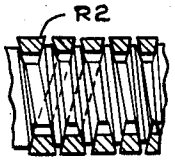


FIG. 2B

FIG. 4

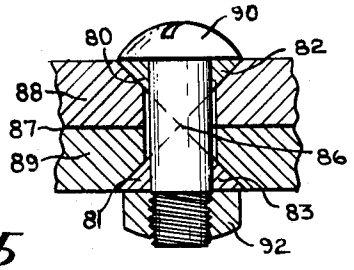
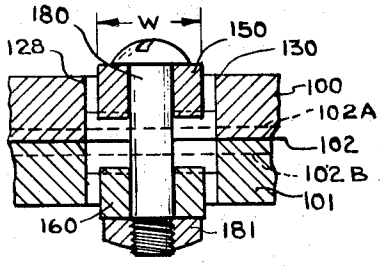
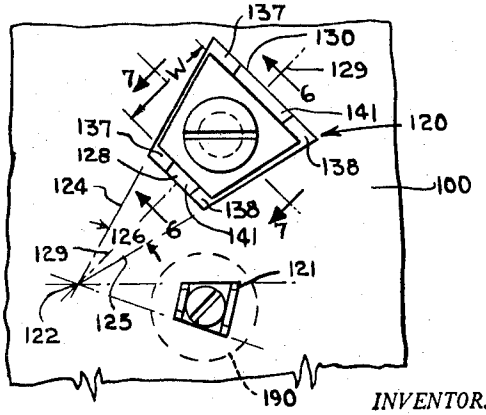


FIG. 5

FIG. 6





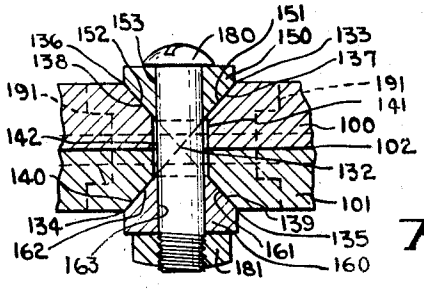


FIG. 7

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FIG. 8

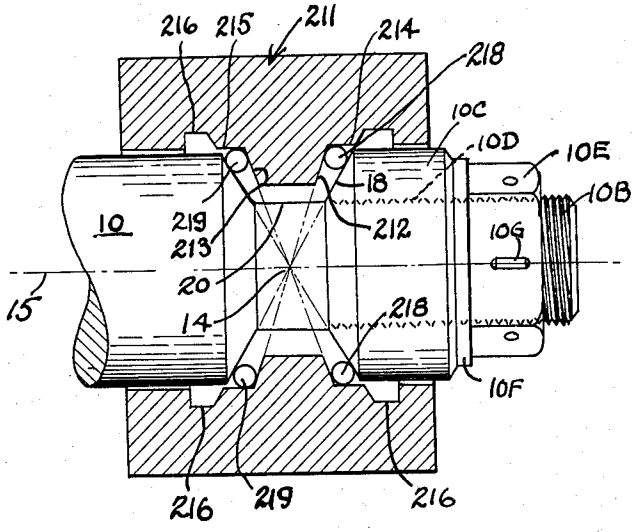
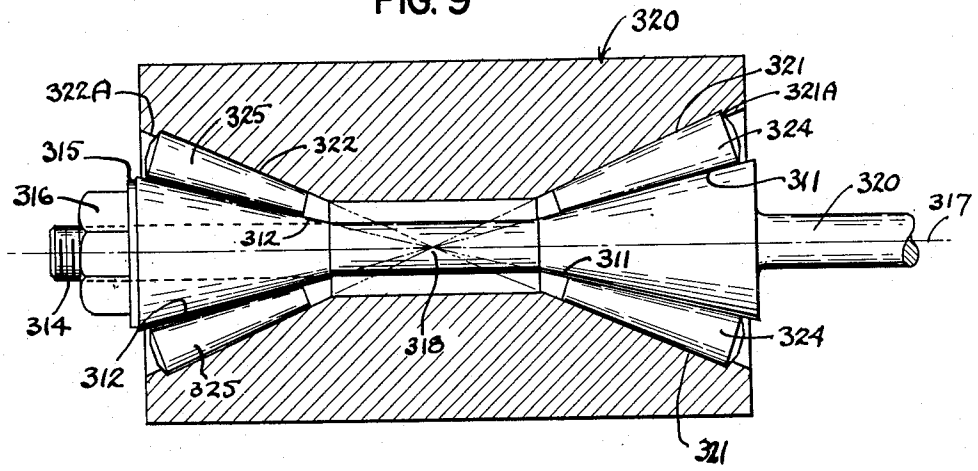


FIG. 9



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3,145,362

ELECTRICAL RESISTANCE DEVICE

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Original application Jan. 4, 1961, Ser. No. 80,657, now Patent No. 3,107,950, dated Oct. 22, 1963. Divided and this application Jan. 21, 1963, Ser. No. 252,917
4 Claims. (Cl. 338—303)

This application is a divisional application of the application Serial No. 80,657, filed January 4, 1961, and now Patent No. 3,107,950, issued October 22, 1963.

This invention relates to mechanical structures and particularly to mechanical joints wherein the supporting and supported elements are of materials which have different coefficients of expansion. There are many situations in which the aforesaid characteristics prevail. Thus, in bearings, the shaft, which is the supported structure, might be steel, whereas the bearing which is the supporting structure must be material suitable for bearings, such as babbitt, bronze or some of the rare metals such as silver. Another situation is in connection with electrical resistance elements that are used for heat or as resistance elements in electrical circuits. In this situation the supporting component is usually an insulator such as a ceramic material and the supported structure is an electrical resistance wire such as Nichrome, platinum or other electrical resistance materials, the type of element depending upon the use. Likewise in constructions utilizing plastics or wood in association with other materials, expansions and contractions occur due to humidity changes, more especially than due to temperature changes. Again in other situations it is desirable to provide fastenings between structures, where the fastening element is of one material and the fastened element is of another material. In this situation the supporting structure is either the "fastened" or the "fastening" element and the other component is the other one. Sometimes structural components of varying materials are bolted together.

In all of these situations the effect of variation in conditions such as temperature or humidity is to produce a slight but positive working or movement at the area of contact of the supporting and supported components. This is true of the shaft and bearing, the electric resistance element and its support and the fastening and fastened components of varying metals, or plastics and metal or wood and metal, and in any other situations wherein diverse materials are brought into facing or bearing contact with each other and load is transferred. When changes in environmental conditions occur, such as temperature or humidity changes, or both, there is a working or movement of the several components relative to each other which produces stress or looseness and this is undesirable. In respect to bearings, where the shaft passes through a bearing of diverse material, the effect of heating is normally to increase the clearance of the bearing, which is undesirable. It is desirable in many instances to maintain a precise clearance at a bearing so as to provide for precision operation, regardless of the temperature to which the machine is subjected.

Throughout this specification and claims the terminology "mechanical joint" is therefore intended to mean any of the inter-related machine elements of the most diverse kind, whether they be a static support, as for example an electrical resistance support with resistance elements mounted thereon or whether it be a machine element such as a bolt or rivet passing through plates of diverse materials, or a bearing shaft in a bearing or connections between diverse materials.

It is an object of this invention to provide mechanical supports which maintain constant clearance regardless of

the changes in environment to which the materials of the structure are subjected. It is another object of the invention to provide an improved mechanical structure wherein a constant holding pressure between the parts is maintained regardless of changes in environmental conditions to which the entire structure is subjected and regardless of diversity of materials as between the supported and supporting element of the structure. It is another object of the invention to provide improved machine bearings. It is another object of the invention to provide an improved electrical resistance and support therefor. It is another object of the invention to provide an improved fastening element. It is a further object of the invention to provide fastening elements which may be used for attaching together machine elements having coefficients of expansion which differ under the environmental conditions of temperature, humidity, etc., to which they are exposed.

Other and further objects are those inherent in the invention herein illustrated, described and claimed and will be apparent as the description proceeds.

To the accomplishment of the foregoing and related ends this invention then comprises the features hereinafter fully described and particularly pointed out in the claims, the following description setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but a few of the various ways in which the principles of the invention may be employed.

The invention is illustrated with reference to the drawings wherein corresponding numerals refer to the same elements and in which

FIGURE 1 is a vertical sectional view through a machine shaft and bearing therefor.

FIGURES 2A and 2B are vertical sectional views showing two exemplary forms of resistance elements and supports therefor embodying the present invention.

FIGURES 3 and 4 are respectively vertical sectional views through two exemplary forms of bolt fastening devices embodying the invention.

FIGURE 5 is a plan view of a modified form of the invention wherein two plates of diverse material are bolted together.

FIGURE 6 is a vertical sectional view taken along the line and in the direction of arrows **6—6** of FIGURE 5.

FIGURE 7 is a vertical sectional view taken along the line and in the direction of arrows **7—7** of FIGURE 5.

FIGURES 8 and 9 are vertical sectional views of other forms of bearings utilizing the principles of the invention.

In the explanation of the invention in the specification which follows, variations in expansion are frequently exemplified as being due to variations in the thermal coefficients of the diverse materials used, since this is a frequent reason such variations in mechanisms and static devices occur. However, variations in expansion are many times also due to other causes such as humidity, and it is therefore to be understood that this invention is therefore applicable to all situations wherein diverse materials in the same device expand or contract at different rates when subjected to changes in the environment to which they are subjected, and that the term environment where used herein is intended to be inclusive of all conditions such as temperature, humidity, etc., which, in respect to the materials in the device, will cause them to expand and contract at different rates.

Referring to the drawings, FIGURE 1 exemplifies a form of pillow-block bearing embodying the invention, and in which shaft **10** is rotatably in the journal bearing **11**. The bearing **11** is a unitary structure having portions **11A** and **11B**, which are parts of a split "block" fastened together by bolts or other fastenings not shown. The bearing **11** is composed of a material which is different than the material used in the shaft **10**, and it has a thermal

coefficient of expansion which is slightly different than the thermal coefficient expansion of the material of the shaft, otherwise binding would occur.

The shaft **10** is provided with a bearing groove generally designated **13** which has the sidewalls **13A** and **13B** and bottom **20**. These sidewalls are generated as frustroconical surfaces (as viewed in section), the apex of the frustroconical surfaces being the point **14**, which is on the centerline **15** of the shaft **10**. The frustroconical surfaces have imaginary apexes at **14**, and the frustroconical surfaces are "opposed," that is to say they face in opposite directions (and have a common apex point). It will be appreciated from FIGURE 1 that if a vertical plane were passed through the shaft **10** it would intersect the frustroconical surfaces on the lines **16–17** and on the lines **18–19**. These two lines **16–17** and **18–19** cross at the "apex" point **14** which is on the center line of the shaft **10**. From another viewpoint one might consider the shaft bearing surfaces as being formed as a surface of revolution of the lines **16, 17** and **18, 19** around the axis **15** of the shaft, holding point **14** constant as an intersection between these lines and with the surface terminated at base line **20**, which forms the bottom of the shaft groove **13**. Also that the line **16–19** should be at a constant angle L with reference to the centerline **15** throughout the surface of revolution and the line **17–19** should be at a constant angle K with reference to centerline **15** throughout the surface of revolution. The lines **16–19** and **17–18** should have a common meeting point at the point **14**, but angles K and L need not be the same size angles, but can be and commonly are, for convenience, made the same size.

The groove **13** is formed with a bottom surface **20** and enough material is left in the shaft so that it is strong enough for the purpose intended. The shaft may continue on in both directions from the bearing **11** or it can be a cut-off as at **10A**, or it may be extended for purposes of taking a coupling, etc.

The bearing **11** has a minimum diameter bore at **22**, and it is provided with frustroconical surfaces (or surfaces of revolution, however, designated) which exactly match in size and dimension the corresponding surfaces of the groove **13** in shaft **10** except for bearing clearance and except that the line **22** (which is the minimum diameter of the bearing) always provides a clearance **23** to the line **20** of the shaft. These surfaces need not be planar but may be any shape, such as ball bearing surfaces. The bearing **11** is, of course, split into two or more pieces axially so as to allow it to be put on the shaft. Assembly bolts not shown hold all bearing segments together. Bearing **11** is provided with lubrication means, as required. Unlike an ordinary sleeve bearing, the bearing of this invention will take axial loads.

The thus formed surfaces of bearing **11** extend (in the sectional view) from **25** to **24** and from **27** to **26**. At the diameter of **24** and **26** the bore, if desired, may be continued right out to the ends of the bearing with clearance around the shaft at the diameter of surfaces **28—28** or again reduced to diameter **29** at each end which allows clearance so as not to touch the shaft but affords some protection from dust and dirt. The design of the bearing beyond the frustroconical surfaces **24–25** and **26–27** can be as desired and may include grease seals, slinger rings, etc. as desired. Any suitable support for the bearing is made in the machine in which it is used and, as previously stated, the bearing can be split into two or more segments by a plane or planes passing through centerline **15**. The bearing support holds the bearing segments together into one whole. The surfaces of revolution **24–25** and **26–27** of the bearing (which are also frustroconical about axis **15** with common apexes at **14**) thus provide a land which has a minimum width at **22** between reference locations **25** and **27** and a maximum width between reference locations **24** and **26**, measured in an axial direction. The frustroconical surfaces of the

bearing **11** are, of course, made so as to provide just a little clearance where these surfaces contact the corresponding surfaces of the shaft **10**.

The attributes of this arrangement provide the unexpected result that if the dimensions of the shaft and the dimensions of the bearing increase or decrease unequal amounts, as may occur when the bearing and shaft (having differing thermal coefficients of expansion) are subjected to a change in environment (i.e. commonly, a change in temperature) the clearance between the surfaces of the shaft and the cooperating mating surfaces of the bearing will not change. Thus, if one assumes that the temperature increases, and assumes further that the bearing material expands faster than the shaft material, (for a given amount of temperature change), there would in effect be an increase of dimension of the bearing in the direction of its length axially and a corresponding increase in dimension in diameter. Furthermore, all portions of the bearing would increase proportionately but at a different rate than the shaft, and consequently the line **22** which forms the minimum diameter of the bearing would in effect be increased as shown at the dotted line **22'**. The increased axial dimension of the bearing at **22'** will be more than the corresponding increase in axial dimension of the shaft (which has an assumed, lower thermal coefficient of expansion than that of the shaft). Hence the increase in dimension at **22'** must be accommodated without decrease in bearing clearance. Fortunately, according to this invention, and because of the shaping of the bearing surfaces as described, this will occur because of the corresponding increase in diameter of the bearing at the line **25–27**. The bearing surfaces simply ride out a little further radially in the shaft groove. Consequently the bearing will maintain a precise clearance relative to the shaft regardless of the change of temperature. This is true because the surfaces of the bearing and of the shaft are generated as shown in FIGURE 1 with the apexes of the frustrocones at a common point **14** on the axis of the shaft.

FIGURE 1 exemplifies a form of pillow-block bearing, that is to say, one in which the shaft surface slides with reference to the bearing surface, being separated only by the lubricating film. The invention is also applicable to other bearing forms using ball or tapered roller bearings. FIGURE 8 shows the invention using ball bearings and FIGURE 9 shows the invention using tapered roller bearings.

In FIGURE 8 the shaft **10** is constructed as described except that the conical surface **18** is made removable, as a collar **10C**. The shaft at diameter **20** is continued to the right end as at **10B** (as shown in FIGURE 8) and is threaded at **10D**. The cone **10C** is also threaded so that during assembly it can be turned down until the bearing is adjusted after which the washer **10E** and lock nut **10F** are placed and tightened and locked by split-key **10G**. The bearing **211** is similar to bearing **11** of FIGURE 1 but the frustroconical surfaces **212** and **213** are generated about lines which intersect a point **14** and each has a constant angle relative centerline **15** as in FIGURE 1. These frustroconical surfaces each include a step **214** (for surface **212**) and **215** for **213**, and these surfaces then continue as shown, similar to FIGURE 1, for finishing the bearing. Cone **10C** is adjusted so that the apex of surface **18** is at point **14**, and coincides with the apex of cone **19** at this same point. Grease seals, etc. may be provided as desired. The surfaces **212–214** and **213–215**, form races to receive sets **218** and **219** of ball bearings which roll on the frustroconical surfaces **18** and **19** respectively. This bearing can be designed for zero clearance and preloaded, if desired. Assuming a different coefficient of expansion for the material in the bearing **211** and balls **218** and **219** as compared to the expansion for the material of the shaft **10**, if then a temperature change should occur, the ball bearings will simply track at a different place on the conical surfaces **18** and **19**.

In FIGURE 9 there is illustrated a form of bearing of the tapered roller type constructed in accordance with the principles of this invention. Here the shaft **310** has two conical elements **311** and **312** thereon. Surface **312** is made separate and can be threaded onto the threaded end **314** and held in place by lock washer **315** and nut **316**, similar to FIGURE 8. Each of the conical surfaces are generated and located so as to be frustroconical surfaces of revolution about axis **317** of shaft **310**, having a common apex at **318**. The bearing **320** likewise has frustroconical bearing surfaces of a slightly greater included angle than the cones **311** and **314**, these being the frustroconical bearing races **321** and **322**, which likewise have a common apex at **318** on the shaft axis **317**. These surfaces have steps **321A** and **322A** to hold the conical rollers from endwise movement. The conical rollers in sets **324** and **325** seat on surfaces **321–321A** and **322–322A** and respectively fill the spaces between conical surfaces **311** and **321** and between **314** and **322**. The rollers may be distributed by races, not shown. The conical surface **312** is adjusted to bring its apex to **318** and thus coincide with the apex of cone **311**. This bearing can be designed for zero clearance and preloaded, if desired.

The bearing structure operates similar to that shown in FIGURE 8.

Referring to FIGURES 2A and 2B there are illustrated two exemplary forms of electrical resistance supports and the resistances thereon. In FIGURE 2 there is a support **50** which may, for example, be of insulating material such as ceramic material. The support **50** has a spiral groove formed therein at **51**, this groove being such that a full turn produces the pitch P between the points **52** and **53**. These points may be brought closer together, until the clearance at dimension C is reduced to a minimum permissible amount. In this drawing the same clearance C is provided as one-half of the pitch P but one must regard the amount of clearance C, as being an amount that can be adjusted as desired. The sidewalls **51A** and **51B** of the groove are each generated by revolving a line around the centerline **55** of the cylindrical support **50**. The extension of the lines denoting the surfaces **51A** and **51B** meet at the point **52** on the centerline **55**. Furthermore, the angle **57A** between the line **51A** and the centerline **55** is constant and the angle **57B** between line **51B** and centerline **55** is constant. These angles **57A** and **57B** have apexes on centerline **55**. Angles **57A** and **57B** need not be equal, but for manufacturing convenience are preferably equal. The intersection of the lines **51A** and **51B** at the surface of the cylindrical support **50** is at the points **51C** and **51D**, and these points are points on parallel spiral lines. These spiral lines defined as the loci of all points **51C** and **51D** are parallel and define the width of the groove at the surface of the cylindrical support. It is as though a pair of parallel spiral lines were drawn on the insulator and the turns spaced so that one turn does not overlap another turn. The pitch P need not be constant but for convenience in manufacturing, it is preferably constant. With these parallel lines, the surfaces **51A** and **51B** are then generated by revolving around the axis of the cylinder a pair of lines which intersect at the axis **55** and each line always has a certain angle with reference to the axis. The groove **51** so formed is quite similar to the "Acme" form of thread, used on machinery with this difference, that the groove sidewalls, if extended in depth, would intersect at the axis of the support.

The electrical resistance which is used in the groove is a wire of uniform, preferably circular cross section throughout the length of the resistor, the resistor being wound on a spiral so that the spiral nests in the groove formed in the insulator. A wire of frustroconical cross-section such as a shape as defined by corners **24–25–27–26** of FIGURE 1, could be used, but for manufacturing convenience and least cost, a wire of circular cross-section

is normally preferred. In FIGURE 2A the cross-section of the resistance element is circular whereas in FIGURE 2B it is polygonal. In FIGURE 2A the diameter of the resistor R1 is such that it will seat within the groove or "thread" formed in the insulator but without resting on the bottom of the groove. In FIGURE 2B the cross-section is made something like that of a V-belt so that the sides of the resistor element have the same angularity as the groove and will rest in the groove without touching the bottom.

The effect of this arrangement is as follows: If the insulator and resistor are subjected to a change of temperature and assuming that they have different coefficients of expansion and the temperature increases, these elements, namely the support **50** and the resistor R1 or R2, will "grow" at different rates. However, the growth is proportional in all directions and the result is that the point (or line) of contact of, for example, the resistor R1 which in one condition might have been at the level **58**, in another higher temperature condition would seat at a level farther up in the groove at **59**. Thus for temperature changes the contact between the resistor elements R1 or R2 and the insulating support always remains but the two elements will seat lower or higher in the groove **51**, depending upon the particular temperatures involved. It will be noted that in this design, as in FIGURE 1, the lines which generate the sides of the groove always intersect at the center line of the object, which is to say, the center line **55** of the insulator in FIGURES 2A and 2B. In FIGURE 1 the lines intersected at a common point **14** of the centerline **15**, whereas in FIGURE 2A and 2B the point of intersection shifts along the centerline because of the spiral configuration of the groove, but the intersection is always on the centerline. The action is the same as in FIGURE 1, so long as the pitch of the spiral remains relatively small, as shown.

In FIGURE 3 there is illustrated a bolt fastening for several members **60** and **61**, which can be of the same or diverse materials. The fastening **70** is illustrated as a bolt but it will be understood that it can be a fastening of any kind which has two heads, one on each end, for holding two objects together. Thus it may be a rivet or the like. The characteristic of the fastening is that the underside of the head is provided with a frustroconical surface **71** whereas the underside of the nut is provided with a similar frustroconical surface **72**. Two corresponding cooperating frustroconical surfaces are also formed at **62** for the plate **60** and at **63** for the plate **61**. It is noted that the shank **72** of the bolt is somewhat smaller than the holes **64** and **65** in the plate **60** and **61** respectively.

The bolt **70** is put in place and the nut **72** is screwed down (or if it is a rivet the head is set). This brings the frustroconical underside portion **71** against the frustroconical portion **62** of the plate **60** and the frustroconical underside portion **72** of the nut against the surface **63** of the plate **61**. Notice that all frustroconical surfaces of the bolt (head and nut) and also of the plates **60** and **61** have a common apex at **76**, which is a point in the plane **75**, forming the contacting surfaces between the elements **60** and **61** which are fastened together. These angles **76** and **77** between the plane **75** (of contact elements **60** and **61**) and the frustroconical surfaces **62** and **63** can be any size desired so long as they are equal and opposite and so long as the apexes of the frustroconical surfaces are one point **76** in the plane **75**. The hole **64–65** to the two plates is always made large enough so as to provide a little clearance for the shank of the bolt **72**.

The net effect of this construction is that regardless of changes of temperature of the plates **60–61** and the bolt **70–72**, uniform pressure will be generated between the frustro-conical surfaces of the bolt and the adjacent similarly formed surfaces of the plate, even though the elements expand or contract different amounts. In this ar-

rangement the bolt-nut **70–72** need not be the same as the same materials of the plates **60–61** and also the plate **60** and **61** can be different materials, provided only one such bolt-nut **70–72** is used for holding them together.

In FIGURE 4 the arrangement is the same as in FIGURE 3 except that the frustroconical portion of the bolt-nut arrangement is made as separate collars **80** and **81**, these collars having frustroconical surfaces **82** for the collar **80** and **83** for the collar **81**, the apexes of which are at the point **86** on the plane **87** which forms the boundary between the two elements **88** and **89** being held together. The form of the bolt-nut **90–92** can be any ordinary nut as shown, or any other formation which is suitable for the purposes, and the bolt-nut **90–92** is made of the same material as that of which the frustroconical elements **80** and **81** are made.

The result of this arrangement is exactly the same as in FIGURE 3, already described.

In FIGURES 5, 6 and 7 there is shown a fastening involving several plates elements **100** and **101** which are of different materials, that are bolted together by a plurality of bolts. It will be appreciated that if two plates of diverse materials having different coefficients of expansion are fastened together, so as to be immovable with reference to each other, that any temperature change imposed on the composite will cause the two plates to expand at differing rates, and will cause warpage to dish the element. A familiar form of bi-metal component operates in this manner. In order to prevent such warping of the materials due to temperature changes it is essential that the two plates of different coefficients of expansion be permitted to "work" relative to each other. In other words, one plate must slide freely on the other as the temperature changes, otherwise a rotational moment will be imposed upon material and will cause it to warp and dish. The bolting together of several plates of diverse material is therefore fraught with difficulty, because the fastenings must permit the aforesaid "working" which occurs due to changes in temperature.

According to the present invention this difficulty is overcome by providing a plurality of fastenings as shown in FIGURES 5, 6, and 7, all located as illustrated at **120** and **121** in FIGURES 5, 6 and 7. All fastenings, of which two (i.e. **120** and **121** are shown) are located around an imaginary center **122** which can be on or off of the area of the plates **100–101** being fastened together. Giving attention to FIGURE 5, each of the locations of fastenings **120** and **121** and regardless of its size, is generated as an opening between a pair of radial lines **124** and **125** which intersect at the center **122**. These radial lines diverge outwardly at a constant angle **126**, and at a certain place they are intersected by a cross-line **128**, which is at right angles to the center line **129**, which is a bi-sector of the angle **126**. Farther out again the aperture, through which the fastening passes, is bounded by the line **130**. The lines **124**, **128**, **125** and **130** therefore define a fastening location or area and an aperture is provided through each plate **100** and **101** within the confines of such area.

Referring to FIGURES 6 and 7, the boundary line **102** between the two plates **100** and **101** may just as well be any line as at **102A** or **102B**, but wherever it is, it establishes the plane through which pass planes defining the aperture surfaces of the fastening location. Thus viewed as at in FIGURE 7, which is a section along lines **7—7** of FIGURE 5, the plane **102** has in it a point **132** through which will pass the plane and line **133–134**. Similarly the plane and line **135—136** passes through the point **132**. These two lines **133–134** and **135–136** (as shown in FIGURE 7) illustrate the angularly disposed planar surfaces at **137** and **138** of plate **100** and the similar angularly disposed surfaces **139** and **140** of plate **101**. These angularly disposed surfaces slant down into the plate **100** (similar for plate **101**) until intersecting slot at **141** for plate **100** (and matching slot at **142** for plate **101**). It will be appreciated that this slot **141-142** is wider adjacent the terminal boundary **130** (see Figure 5) than it is at boundary **128**, but the characteristics of the formation is the same. When viewed in the transverse section **6—6**, as in FIGURE 6 (and regardless of where along the slot the section is taken) the slant surfaces **137** and **138** (also **139** and **140**) would, if extended, intersect at the plane **102** as at **132**.

The fastener is composed of two bars **150** for plate **100** and **160** for plate **101**, each of which reaches across the slot, preferably but not necessarily normal to line **129**. Thus, bar **150** reaches across from surface **137** to surface **138** and the bar **150** has its under surfaces **151** and **152** shaped to match the slant of surfaces **137** and **138** respectively of the slot in plate **100**. Similarly there is another bar **160** on the opposite side, for plate **101**, and it has a slanting surface **161** which mates against the surface **139** of the plate **101** and a slanting surface **162** which mates against the slanting surface **140** of the plate **101**. These two bars **150** and **160** are similar and they have in them aligned apertures as at **153** and **163**, and through the apertures is passed a bolt **180**, which is provided with a nut **181**, and both nut and bolt are made of the same material as the bars **150** and **160**.

The bars are made of a width W as shown in FIGURE 5 and FIGURE 6 such that a little clearance is provided between the bars (**150** and **160**) and the boundaries **128** and **130** and hence there is clearance for the bars to slide a little along the slots in the direction of the dimension W.

All of the fastenings that are used between the plates **100** and **101** are made in this fashion. If desired the fastening locations in the plates composed of slanting surfaces and aperture can be made as factory-fabricated inserts as shown by the dotted line **190**, for the fastening **121** of FIGURE 5. Thus the inserts may be fashioned separately and simply pressed into a suitable shaped aperture in the plate **100** as shown at **190** in FIGURE 5 and in dotted lines **191** in FIGURE 7. This is a manufacturing convenience.

The result of this arrangement is that even though temperature changes are imposed upon the plates **100** and **101** and upon fastenings **120–121**, the fastenings will maintain a uniform holding pressure against the plates, and will not be loosened. The fastenings will slide a little in their respective apertures as previously explained so as to take up the change in dimension occasioned by the varying expansions of the materials.

As many apparently widely different embodiments of this invention may be made without departing from the spirit and scope thereof, it is to be understood that I do not limit myself to the specific embodiments herein.

What I claim is:

1. A device comprising a first body having opposed outer surface portions thereof, said body being of a material which expands and contracts under influence of certain changes of environments, said body having an outwardly facing intaglio support indentations in opposed outer surface portions, each of said indentations having opposed outwardly sloping sidewalls, said sidewalls being defined by lines passing through a point in the first body and intersecting periphery lines on the surface portions of the body defining the perphery of the indentations, and a second body composed of a different material which expands and contracts at a different rate under influence of the same changes of environment, said second body having integarl portions shaped so as simultaneously to engage in a constant relationship in respect to the opposed sidewalls of the indentations of the first body so as to be supported thereby, said second body being so shaped as to remain out of contact with the other portions of said first body which would obstruct movement of said opposed sloping sidewalls, said device being further characterized in that the first body is a cylinder and has a spiral groove therein, said groove

having outwardly sloping divergent opposed spiral sidewalls, said second body being of constant cross-sectional shape so as to rest in contact with the sidewalls of the groove, and bent spirally to conform to the spiral groove.

2. The device specified in claim 1 further characterized in that the second body is a rod of circular cross-sectional bent in a spiral so as to rest in contact with the opposed sidewalls of the groove.

3. The combination comprising a cylindrical support having a spiral groove in the outer cylindrical surface thereof, said groove having a bottom and being outwardly divergent and characterized in that the intersection of the walls of the groove and a plane through the axis of the cylindrical support define lines which intersect each other at said axis and form equal and opposite angles with reference to said axis, and a spiral element composed of a rod of material different from the material

composing the support, said rod having a cross-sectional shape and a size so as simultaneously to engage opposed sidewalls of the groove.

4. The device specified in claim 3 further characterized in that the support is an electrical insulator and said rod is an electrical conductor.

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