July 30, 1968 D. F. DREHER 3,394,640

SEALING INSERTS FOR JOINTS IN CONCRETE

Filed Aug. 16, 1966 2 Sheets-Sheet 1

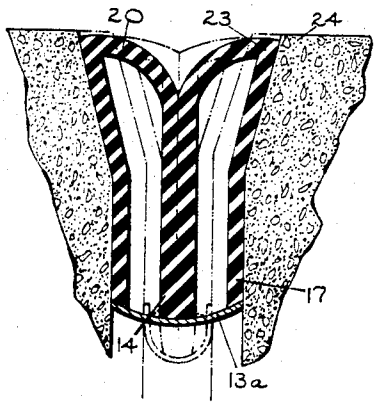


FIG. 2

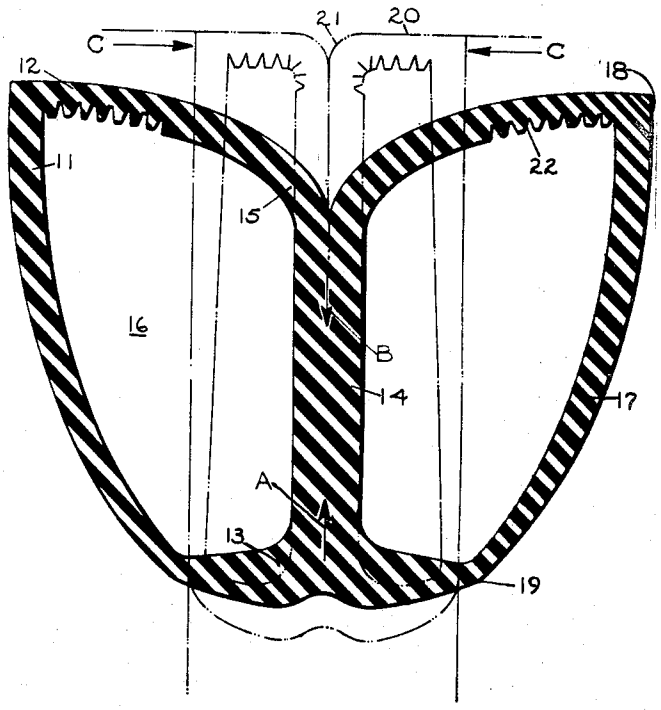


FIG. 1

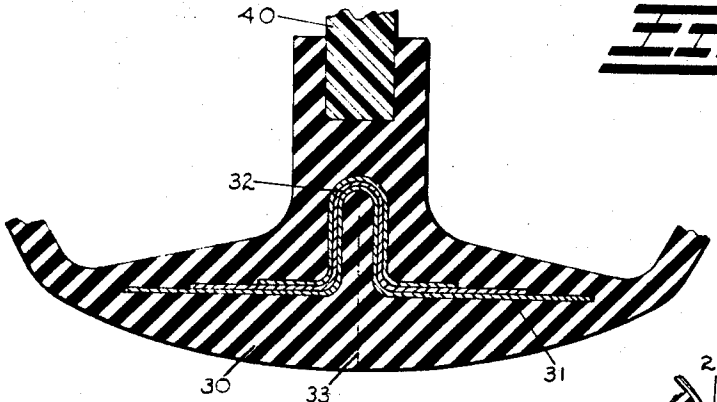


FIG. 4

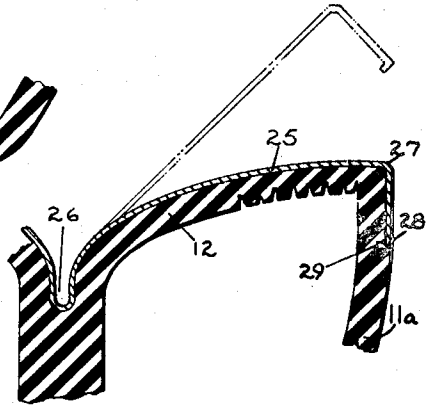


FIG. 3

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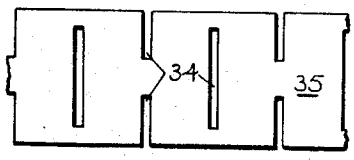


FIG. 5

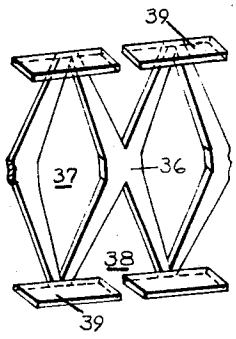


FIG. 6

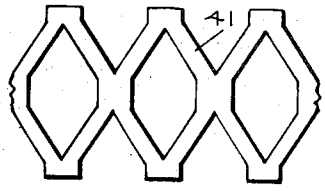


FIG. 7

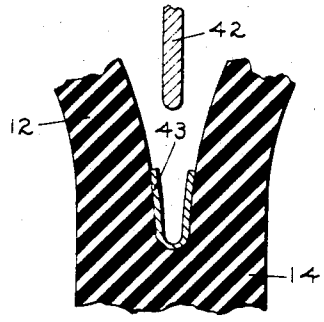


FIG. 8

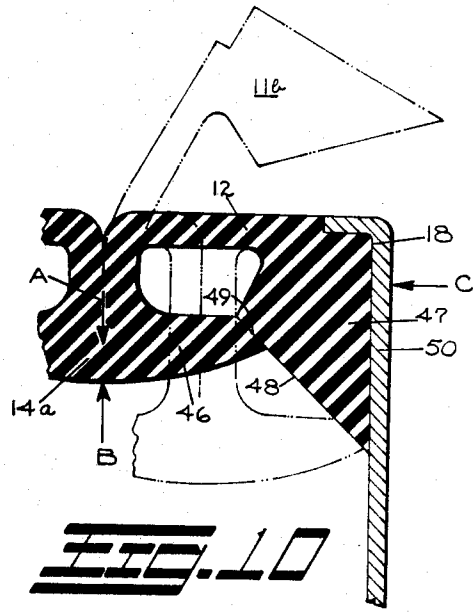


FIG. 10

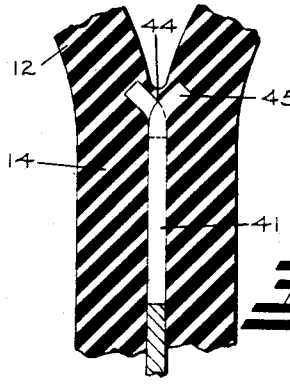


FIG. 9

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3,394,640

SEALING INSERTS FOR JOINTS IN CONCRETE

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Filed Aug. 16, 1966, Ser. No. 572,716
11 Claims. (Cl. 94—18)

This application discloses improvements on and includes features and concepts disclosed in my copending application Ser. No. 319,875, filed Oct. 29, 1963, now Patent No. 3,308,726. It relates further to the sealing of motionable joints between sections of concrete paving, and more particularly to improvements in the functional design of sealing inserts utilizing certain of the principles disclosed in the prior application.

In brief, the parent application teaches the construction of an elastomeric insert extruded with the operative ordinates upset in such manner as to cause it to be deflected when installed in a maximally-gapped joint, in which condition a top-centered V notch is closed, the top surfaces aligned and the substructure stressed load-supportably. As the joint narrows, the inboard portions of the top surfaces roll together and downward adjacent the vertical plane of symmetry, thereby maintaining full occupancy of the upper portion of the joint and levering the excess bulk into a lower position.

The present application outlines continuing development of compressionable sealing inserts obedient to the primary principles originally disclosed in the prior application, but including modifications in construction and design. Certain of these derive from critical appraisal by which it became apparent that operative behavior is subject to functional division and that these definitive functions could be executed individually and thereby more effectively.

In addition to furtherance of the objectives of the original invention as previously outlined, the objects of the present invention therefore include the perfecting of functionally divisive elements in sealing inserts of the general class described, more favorable depthing of such inserts, the use of multi-compositional treatments and combinations, and techniques by which increased reliability may be achieved, further exposition of which will be aided by reference to the accompanying drawings.

FIGURE 1, in enlarged cross section, shows a deep dual-chambered elastomeric insert which has been extruded in butterfly contour, the ghosted figure illustrating the same insert installed in an operative joint.

FIGURE 2, in schematic cross section, shows a similar insert installed in a joint with beveled corners.

FIGURE 3 is a part section of a similar insert with a disparately compositioned sheath overlaying the upper surface.

FIGURE 4 is a part section showing a constant rate base modified by envelopment of a multi-leaved spring element within the elastomeric extrusion.

FIGURE 5 illustrates a cross slotting treatment applicable to certain elements such as spring steel whereby differential coefficients of expansion may be tolerated in combinations for the purposes herein described.

FIGURE 6 suggests a modification of the shelf-X technique executed in spring metal prior to hardening, by which means a spring section may be made gradingly flexurable and thus similar in taper effect to the stepped leaves of the element shown in FIGURE 4.

FIGURE 7 shows an expanded metal strip usable as a stiffening element which is controllably amenable in distention and flexure.

FIGURE 8 is a greatly enlarged part section showing a stabilizing strip positioned at the base of the medial notch, which is designed to facilitate compressive installation and to prevent damage to the insert in such process.

FIGURE 9 is a similar part section wherein such stabilization is accomplished by splitting the top edge segments of a medial reinforcing element such as that illustrated in FIGURE 7.

FIGURE 10 is a part section illustrating a positive means for motioning the central stem downward in relation to joint width.

Referring now to the drawings and to FIGURE 1 in particular, there is shown in cross section an elastomeric extrusion **11** whose contours are deemed somewhat to resemble a butterfly, which term has been used descriptively throughout its development and should be interpreted as inclusive of this general species of sealing inserts. This group is characterized as having two upper members **12** opposed and merging at the plane of symmetry, a lower section **13** in spaced relation thereto, a central stem **14** capable of transmitting thrust A, B between the inboard portions **15** of the upper members **12** and the base section **13**, and having dual chambers **16** formed by the described elements. Although the outboard wall sections **17** as illustrated are not essential to the presently described species, both installation convenience and practicality suggest either their inclusion or that a functional equivalent thereof be provided, since thereby the outboard extremities **18** of the upper sections **12** may be held reliably in vertical spaced relation to those **19** of the section **13** and prevented from being dislodged in service.

When installed as shown schematically in the phantomed illustration the insert **11** is compressed horizontally C which causes the upper sections **12** to abut in the surface area of the joint and thereby to thrust downward as indicated at B in consequence of resistance to such flexure. The function of the section **13** is to accept a controlled amount of downward motion but to provide an upward thrust B opposedly thereto in order that the surface portions **20** of the upper sections **12** be maintained in alignment with the merging arcs **21** thereof made relatively sharp so that maximal surface occupancy of the joint space may be achieved. As the joint opens and closes ambiently the entire medial section of the insert rises and falls, with portions of the upper sections being transposed recyclingly between vertical and horizontal planes through the abutted arcuate segments **21** therebetween.

The butterfly design permits elliptical or arcuate treatment of the upper sections **12** and of the outer wall sections **17** as well, such treatment being both convenient and preferred when such connecting sections **17** are incorporated in the extrusion. Each of these sections may be either parallel or tapered and stress relief may be provided in those portions which are subjected to abrupt flexure, as indicated by the grooves **22** formed in the upper sections **12**. If desired, the chambers **16** may be filled either wholly or partially with a composition having a low bulk modulus of elasticity, e.g., a closed cell sponge latex, or such a material may be inserted at spaced intervals or at the ends of cut lengths. The primary purpose of such a fillant is to prevent the accumulation of water or foreign matter within the insert, the presence of which could prevent the required deformation under compression or proper recovery when relieved.

It will be apparent that the described surface sections **12** may be shorter or longer proportionately than illustrated and the height of the central stem **14** adjusted accordingly, and also that the depthing of the base section **13** is subject to considerable variation by appropriate dimensioning of the vertical sections.

It is of particular interest that this type of insert is capable of performing effectively when installed in poorly prepared slots in the paving, e.g., those in which corners have been chipped or those which flare outward as illustrated in FIGURE 2, wherein the phantomed illustration shows the joint in closed position with the vertical sec-

tions **14**, **17** abutting. It also will be apparent that the insert may be designed specifically for installation in joints having the exposed corners of the concrete beveled, which involves adjusting the relative length of the surface portions **20** or other dimensions equivalent thereto and forming the upper outboard corners **23** acute so as to conform to the angle of the bevel, this latter modification being somewhat significant with enlargement of the supplementary corner angle **24** of the concrete and increasingly with the use of higher-modulused compositions. Although current practice tends to avoid such beveling, the technique is urged by some authorities and strongly supported by logic since thereby the corner **24** is greatly strengthened and less subject to fracture. The negative consequences of beveling include widening of the exposed gap and the tendency of some compressible inserts to migrate upward and out of the joint. With respect to such consequences it is significant to note that both problems may be solved by use of the butterfly insert, the first in consequence of its capacity to maintain full occupancy of the bridged surface and the second by reason of the anchoring capacity of the motor section **13** which is under considerable horizontal compression and lever-wedged in such position as to render upward migration a virtual impossibility.

FIGURE 3 shows a portion of a similar insert **11***a* prepared for attachment of a sheath **25** overlaying its surface sections **12**. In this instance the sheath has been separately fabricated from flat stock, formed with a medial lengthwise notch **26**, a square upper outboard corner **27** and anchoring edges **28** which fit into recesses **29** formed in the extrusion **11***a*. It will be apparent that by such means, which may even include metal, the surface exposed to wear and abuse may be made exceedingly durable and thereby adapted to highly specialized and demanding applications. It also will be apparent that similar sheathing means may be utilized with other forms of sealing inserts including those described in the prior application previously identified, in which disparately compositioned surfacing layers were disclosed but wherein adhesional attachment to the supporting structure was suggested. By allowing slippage at the interface especially in and adjacent the area of sharp flexure, each of the arcuate segments may be stress equilibrated independently, thereby avoiding the compounding of stresses incident to bonded laminar flexure.

Directing attention now to the resilient member or element **13** normally positioned at the base of the insert, the contour shown in FIGURE 1 is illustrative of an all-elastomeric constant rate element capable of fulfilling the functional requirement previously described herein. In order to acquaint others in greater detail I refer to my technical paper (Dreher, D. F., A Structural Approach to Sealing Joints in Concrete, in Highway Research Record No. 80–Joints and Sealants. Highway Research Board Publication 1265, pp. 57–73) wherein the behavior of such elements is described together with certain principles applicable to their design. Both the range and the interpendence of the variants will be recognized by those who are skilled in the art, to whom it will be apparent that the work to be performed is determined in large measure by the flexural resistance characteristics of the upper sections **12** and that the amount of vertical motion required of the resilient base member **13** per se will be affected by the linear compressibility of the central stem **14** and by that of the upper sections **12**. Thus it is conceivable that means to provide this *function* could be incorporated in the central stem **14** supported upon a rigid base or contained within the upper sections **12**, or additively in combinations thereof, in which event the constructions would be modified considerably from those shown herein. Therefore the drawings should be considered illustrative of principles which are executable in a variety of physical forms, and related structural combinations obedient to the stated principles of this invention should be considered a part thereof.

A simple spring **13***a* to provide a force is shown in FIGURE 2, such an element having been utilized as a base for inserts described in the prior application. It will be understood that such a spring element may be modified in a number of respects affecting its rate of vertical motion, including the application thereto of the design techniques described in the descriptions which follow.

FIGURE 4 is illustrative of further development of constant rate elements designed for increased power potential and reliability with lessened dependence upon elastic recovery of rubber and rubberlike polymers. Herein the resilient member comprises an elastomeric body **30** enveloping a multiple step-leaved spring section **31**. In this instance the medial portion **32** of the spring section is arched reinforcedly and the elastomeric tie thereunder is designed to be made discontinuous to an appropriate height as suggested variantly by the dotted line **33**. By such means the mean circumferential arc of the composite element may be permitted to lengthen controllably as a geometric function of arcuate deflection. This type of modification is designed to compensate for the vertical deficiency in the sine curve above 45°, at which point vertical and horizontal motions are equal. It will be noted that the medial contour of the all-elastomeric section **13** shown in FIGURE 1 reflects a similarity in this aspect of design and that in consequence its motion behavior will lean in this described direction. It should be understood that the arched spring section **31**, **32** as shown is illustrative of an extreme application of the described principle, and that its normal application is moderated considerably therefrom. It also will be apparent that in certain cases such treatment should be avoided as exemplified by the prior suggestion concerning transference of portions of the *function* of the resilient member to other elements of the combination.

The second significant modification of a simple deflective spring member is the graded flexurability developed by the tapered contours of the base is the graded flexurability developed by the tapered contours of the base section **13** in FIGURE 1 and the elastomeric body **30** shown in FIGURE 4, together with the stepped leaves of the spring section **31** enveloped therein. By such means, increments of the outward portions of these base elements may be caused to lay tangentially against the supporting sidewalls of the joint even as initial compression occurs. The effect of this modification is to lessen the degree of early deflection and thereby to offset the steepness of the sine curve in this range of operation, so that the resultant vertical motion may be made to approximate the horizontal more closely.

FIGURE 5 is illustrative of a cross slotting pattern **34** designedly applicable especially to metallic spring elements **35** such as those included in the fortifying spring section **31** described above. The purposes of such slotting are to facilitate the combinational use of materials having importantly different coefficients of expansion by encouraging linear deformation of the more willful composition and weakening its capacity for forceful distension, and to provide means for keying together such combinations.

FIGURE 6 suggests another construction technique by which such a spring section **36** may be rendered less willful in linearity and rigidity, and in addition made gradingly flexural so as to resemble the spring effect developed by the stepped-leaf combination **31** shown in FIGURE 4. Such an element may be made by alternately cross cleaving **37** and punching arrowhead-shaped sections **38** of a strip of spring metal, stretching the strip and bending the peripheral rectangular sections **39** alignedly at an angle thereto, followed by hardening and tempering. This type of construction is ideal for protective envelopment in an elastomer since thereby the problem of interfacial surface anchorage is minimized. It will be noted that inclusion of the peripheral rectangular sections **39** as described is particularly beneficial since it provides enlarged anchorage

and operative bases for the narrow spring tips without loss of peripheral flexibility, whereas the fineness of unfortified tips could be injurious to the supporting elastomer.

In view of the wide divergence in basic requirements of force-exerting elements applicable to the present invention as suggested earlier in this description wherein it was shown that much of the vertical motion required could indeed be absorbed by other elements, the base motor could be stable or may comprise a simple block of elastomer designed to complement the required vertical deformation. Conversely, other forms of fully motionable base may be utilized including those which are lever-based, resembling the construction illustrated in the prior application and which have constant rate capabilities. Since technical developments are presently directed toward the use of higher modulated polymers, the suggested simplified solutions of the motor problem tend to be of less significance—except that the use of overlaying sheaths **25** again could alter this direction of development to more supple forms of underlying support.

Attention now is directed to the central stem **14** and more particularly to FIGURE 4 wherein the stem is shown as a disparately compositioned member **40** which in this instance comprises a rigid plastic. Such a construction may be coextruded when suitable materials are combined, or such a rigid element may be prefabricated and introduced through the extrusion die in any manner appropriate to such processing. It also will be apparent that the extruded elastomer may envelop completely a central stiffening member **40** such as that just described or one **41** such as that illustrated in FIGURE 7 which may be composed of metal prepared by patterned cross cleavage and linear extension in the traditional manner of fabricating shelf-X. This latter combination also is suggested by FIGURE 9, including a further modification later described herein. The stiffening of the central stem may be occasioned by a variety of purposes including positive transmission of vertical motion to and from the resilient base element, symmetrical stabilization of the insert concomitant with prevention of bowing or buckling under advehse or imbalanced conditions including those which obtain during installation, permissive use of a lesser cross section in order to provide occupancy space for a fillant and/or to permit an increase in the operative design range of the insert, increase in the height of the central stem occasioned by greater depthing of the resilient base member or section or by proportional reduction in the length of the upper sections, and linear stabilization of the insert in order to prevent distention during installation. Additionally it will be recognized that such stiffening elements may be so compositioned, dimensioned or structured as to modify controllably the degree of stem compressibility under varying loads, and that such elements may be used plurally, e.g., positioned in spaced relationship so as to contribute favorably to stability with minimal expenditure in space and materials. For similar stabilization purposes either the upper or lower edges may be extended into or adjacent the connecting sections of the insert.

The co-introduction of fortifying elements in extrusions of the character described is a useful tool in the hands of the designer, especially in developing larger units wherein savings in the cost of materials become increasingly significant and performance requirements tend to be more exacting. The use of expanded metal strip is of particular interest in this type of application since it adapts itself readily to such combination and permits substitution of a low cost raw material whose strength-to-weight factor makes it the more impressive. Although extrusional envelopment of such elements is preferred when using materials which are subject to deterioration under exposure, the extension technique may permit economic use of more costly materials such as stainless steel and in some cases the use of aluminum alloys. It will be further apparent that expanded metal elements may be used effectively in the levered inserts described in the prior application and suggested herein as a constant rate base for butterfly inserts.

FIGURES 8 and 9 are addressed to the problem of installation, which will be understood in this class of inserts to involve considerable compression since insertion must be made when the joint is not more than medianly spread. It will be recalled that one of the objects of the invention as originally disclosed refers to installation facility and that certain of the constructions described therein permit application of downward force against the medial section whereby the base of the insert is deflected and the outboard portions *drawn* rather than *pushed* into the desired sidewall placement. The same technique is patent in butterfly inserts having outer connecting sections **17** as shown in FIGURE 1, wherein the central stem **14** transmits the applied downward force directly to the medial portion of the base section **13** and draws the outer sections **17** into place. Since access to the head of the central stem is restricted by the merging upper sections **12** it is preferable that the forcing tool **42** be quite narrow in thickness, in consequence of which the unit pressure at its base could easily be capable of damaging the insert. Means for alleviating this difficulty is illustrated in FIGURE 8 wherein a V-formed steel strip **43** is positioned at the base of the merging upper sections **12** against which the tool **42** may be applied forcibly with lessened likelihood of causing damage. Such an accoutrement **43** may be incorporated in the extrusion or it may be inserted during installation. It will be noted that the overlaying sheath **25** shown in FIGURE 3 is similarly formed **26** and usable for the purpose just described.

For similar purpose FIGURE 9 suggests the forming of supporting crotches **44** at intervals along the upper edge of a central stiffening member **41** such as that illustrated in FIGURE 7, which has been modified by cleaving each of the upper segments shallowly and bending mated portions **45** thereof oppositely so as to form the described crotches.

FIGURE 10 is illustrative of a sub-species of sealing inserts which by definition are includable in the butterfly class even though in appearance there may seem little resemblance since the outer wall sections **17** of the typical butterfly are eliminated. That which causes this group to be sub-classified separately, however, relates not to such elimination but rather to the inclusion of means by which the rate of vertical motion may be made positive without reliance upon precise balancing of thrust between the upper sections **12** and the element **13**. In the drawing are shown in half-section a typical upper section **12**, a medial T-section **46** connected thereto which structurally may be deemed an accoutrement added to the central stem **14***a* and a guiding section **47** abuttable against each sidewall support, providing a diagonally inclined undersurface **48** against an opposing pair of which the contacting faces **49** of the T-section **46** are induced by upward thrust B. When subjected C to a narrowing joint, the medial section **14***a*, **46** is forced downward A by the inwardly motioned guiding sections **47** to a lowered position as suggested by the phantoming in the main section of the illustration. The portion phantomed above completes the extruded form **11***b* prior to stressed assembly with retainer sections **50**, each of which secures the upper extremity **18** of the insert relative to a base element capable of delivering upward thrust B to the medial sections by suitable means such as hereinbefore have been described. It should be understood that the guiding facility **46**, **47** may be positioned vertically wherever convenient including a location beneath the upward thrusting mechanism and that such mechanism need not necessarily comprise the form of force-providing elements specifically described herein. For example, the upward thrust required may be provided by tensionable ties chevroned from the sidewalls to the central stem or by undersupporting spring-like accoutrement having sidewall anchorages.

The need for lubrication of the sliding surfaces **48**, **49** will depend largely upon the frictional characteristics of the subject materials and upon the degree of net upward thrust [B—A] they must bear. It will be apparent that either or both surfaces may be faced differently from the remainder of the extrusion, e.g., with an interposed layer of metal or a disparate polymer, or by means of slip finish or specialized surface treatment. Effective lubricants when required may include graphite, molybdenum or silicone compounds, waxes or, conceivably, simple grease. A degree of porosity in the subject surfaces quite obviously would aid the retention of such lubricants.

To those who are skilled in the art it will be apparent that this type of construction is directed to the use of higher polymers which may be categorized as being more spring-like than elastomeric, which characteristics similarly are applicable broadly to the entire species herein described. It is significant to note in appraisal thereof that severe compressive deformation occurs only in the base section and that ambient flexure otherwise is limited to short rolling segments of the upper sections. Thus the insert could be said to have only three moving (flexing) parts. In addition it will be noted that the indicated improvements in resilient base design may contribute measurably to reduction in the severity of deformation within this element, and that further relief may be achieved by transference of portions of its motion-absorbence function to other sections.

Due to the existence of so many variants it is difficult indeed to define a specific embodiment of the invention which is clearly to be preferred, since this species of sealing inserts is applicable broadly to a great range of specification requirements. For general highway installations in sealing contraction joints which customarily are slotted from ¼ to ½ inch in width, and wherein cost considerations are inescapable, the preferred form would be essentially that as shown in FIGURE 1 and comprised of Neoprene. For aircraft ramp applications especially in engine start-up areas where flame, fuel and heat problems are encountered, a silicone rubber extrusion could be utilized if adequately protected from the fuel, e.g., with an overlaying sheath sealed effectively against the abutting concrete sections. In such an application the use of a metal sheath is intriguing especially if its conductive capacity could be utilized effectively for the transmission of heat into a sink and away from the body of the insert. Otherwise a Teflon sheath could be preferred. For heavy duty applications such as in bridge construction wherein the seals often are generously dimensioned (on the order of three to six inches or larger) Neoprene extrusions of relatively high durometer may be used effectively. Due to their size it is preferred that the central stem be fortified, e.g., with strips of expanded metal enveloped in the elastomer in spaced relation and that the motor element be made strongly reliant upon similarly enveloped spring steel, the construction of which would be dictated by the work to be performed.

In applications wherein medial supports are feasible it will be noted that inserts of the type described may be used plurally, whereby increased spans may be achieved at lessened material cost. Additionally it will be understood that fortifying elements may be incorporated advantageously in portions of the insert other than those hereinbefore expressly described, among which could be included the outer wall sections **17**, the inboard portions **15** of the upper members which in essence serve as extensions of the central stem **14** and therefore are subject to similar requirements, and as reinforcement in the upper corners of the extrusion.

The positive rate concept illustrated in FIGURE 10 is relatively new, and therefore difficult to appraise adequately at this writing. When more completely developed it could well constitute the preferred form of the invention, since its design potential seems quite expansive and subject both to simple treatment and to sophisticate execution.

Having thus described my invention, what I claim and desire to secure by Letters Patent of the United States is:

1. A compressible insert for sealing a variant joint space having contraposed faces, said insert comprising two flexural upper sections opposed in symmetry and joined centrally to form a central junction, said sections having a central junction and extensions upward and outward to define corner extremities to respectively engage said faces, a resilient base member, a central stem extending downward from said central junction and joining the resilient base member, said base member having extensions outward respectively to engage said faces and thereby, when the insert is compressed within the joint space, to exert an upward force counteracting the downward force exerted by said upper sections, the extensions of said upper sections being longer than those of said base member and adapted thereby to converge with the outward portions thereof adjacent said extremities essentially aligned when compressed between said faces.

2. The sealing insert as claimed in claim **1**, including means for holding each said corner extremity in spaced relation to the resilient base member.

3. The sealing insert as claimed in claim **2**, wherein the insert is an integral extrusion and the holding means for each corner extremity comprises an outer wall section which has a curvilinear and convex outer surface.

4. The sealing insert as claimed in claim **1**, wherein said resilient base member comprises a spring metal element.

5. The sealing insert as claimed in claim **4**, wherein the resilience of the resilient base member is supplied by a spring embedded in said base.

6. The sealing insert as claimed in claim **4**, wherein the spring metal element is enveloped in a protective composition and is gradingly flexural across its width, with its medial portion the more rigid and its peripheral portions the more flexible.

7. The sealing insert as claimed in claim **6**, wherein the metal element comprises a plurality of laminae, the outer extremities of each lamina extending progressively outward from the central stem.

8. The sealing insert as claimed in claim **1**, wherein the central stem comprises a stiffening element having a composition disparate from that of the upper sections.

9. The sealing insert as claimed in claim **4**, wherein the said spring metal element comprising said resilient base member is enveloped in a protective material.

10. The sealing insert as claimed in claim **1**, wherein the central stem comprises a stiffening element having the character of being less flexural than said upper sections of the insert.

11. The compressible insert as claimed in claim **1**, wherein each of the extensions of said upper sections includes a surface-exposable portion adjacent said extremity and a flexural portion next adjacent thereto, wherein the central stem is adapted to be motioned vertically in a plane parallel to said faces, the vertical motion thereof being semi-complementary to variations in width of the joint space, and wherein said flexural portions are adapted to roll inward and outward correspondingly with said vertical motion.

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JACOB L. NACKENOFF, *Primary Examiner.*