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(54) AN INSULATION-PIERCING ELECTRICAL CONTACT ELEMENT AND AN ELECTRICAL CONNECTOR UNIT EMBODYING THE SAME

(71) We, BUNKER RAMO CORPORATION, a Corporation organised and existing under the laws of the State of Delaware, United States of America, of 900 Commerce Drive, Oak Brook, Illinois, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to an insulation-piercing electrical contact element and an electrical connector embodying the same.

Electrical connectors having insulation-piercing contacts are well known in the art. An example of such an electrical connector is described in United States Patent Specification No. 3,867,005 and United States Patent Specification No. 3,002,176 also discloses this general type of electrical connector.

Soldering is a very time-consuming operation and requires considerable skill, particularly where miniaturized connectors are concerned. There is also the possibility of undesirable bridging connections occurring between adjacent contacts.

An alternative technique, which has gained increasing acceptance in the art and is also disclosed in the abovementioned U.S. patent specifications, is the utilization of insulation-piercing terminal elements as a portion of the contacts. Such terminal elements sever or cut through the insulation and establish an electrical connection to the conductor without stripping and without soldering. Insulation-piercing terminal elements usually involve the utilization of a forked structure having cutting edges that sever and penetrate the insulation, and serve as wiping surfaces in some configurations, to make the necessary electrical, and for that matter mechanical, connection with the conductor. The insulating-piercing terminal therefore serves to sever the insulation of the conductor and to act both as a mechanical and electrical connection for the contact and the conductor.

These known techniques are fully acceptable and completely satisfactory for electrically contacting solid insulated conductors. When dealing with stranded conductors, however, particularly stranded conductors in the range of 24—28 gauge, the strands are liable to snag upon, and even become severed by, the edges which are provided for piercing the insulation of an insulated conductor. When using standed conductors, undesirable problems can therefore arise due to snagging and/or severing of the individual strands, including incomplete and sometimes noisy connections which are intolerable.

It is accordingly an object of the present invention to provide an insulating-piercing contact element whereby the abovementioned problems concerning snagging and/or swerving of the individual strands of an insulated stranded conductor are solved.

According to this invention there is provided an insulation-piercing electrical contact element comprising a substantially parallel-sided notch for receiving an insulated conductor, and a mouth tapering into the notch for guiding the insulated conductor into the notch, each side of the notch being formed from sheet metal shaped to provide a wiping surface which, in use with a suitably sized insulated conducter forced into the notch, pierces the insulation of the conductor and makes electrical contact with the conductor, the sheet metal being additionally shaped to provide the corresponding side of the mouth in the form of a smooth surface flaring out from the notch and constituted by part of one of the major surfaces of the sheet.

The invention will now be described by way of example with reference to the accompanying drawings, in which:—

Figure 1 is a fragmentary perspective view of an electrical connector having insulation-piercing contact elements according to the present invention, only one such contact element being shown in this Figure,

Figure 2 is a fragmentary perspective view on an enlarged scale of a portion of the connector shown in Figure 1;

Figures 3, 4 and 5 are sectional views taken substantially along the line II—II in Figure 1, illustrating an insulated stranded conductor at different positions during the insertion process;

Figure 6 is a fragmentary partly sectioned isometric view of another embodiment of a termination contact element according to the present invention;

Figure 7 is a fragmentary perspective view of another embodiment of a termination contact element according to the invention;

Figure 8 is a fragmentary partly sectioned perspective view of still another embodiment of a termination contact element according to the invention;

Figure 9 is a fragmentary partly sectioned perspective view of still another embodiment of a termination contact element according to the invention;

Figure 10 is a fragmentary partly sectioned perspective view of yet another embodiment of a termination contact element according to the invention;

Figure 11 is a sectional view taken substantially along the line XI—XI in Figure 10;

Figure 12 is a fragmentary partly sectioned perspective view of another embodiment of a termination contact element according to the invention;

Figure 13 is a fragmentary sectional view on an enlarged scale of a termination contact element supported between barrier walls of a connector, shown before conductor insertion;

Figure 14 is a fragmentary sectional view on an enlarged scale, similar to Figure 13, illustrating the termination contact element and the conductor after insertion;

Figure 15 is a fragmentary partly sectioned perspective view of the intermediate and active elements of a contact and part of a contact mount;

Figure 16 is a fragmentary perspective view illustrating a folded end of the intermediate element as viewed in the direction XVI—XVI in Figure 15; and

Figure 17 is a sectional view taken along the line XVII—XVII in Figure 16.

The electrical connector illustrated in Figure 1, with the exception of the inventive features disclosed herein, is of substantially the same configuration as the apparatus shown in Figure 3 of the above-mentioned U.S. Patent Specification No. 3,867,005. It is readily apparent from Figure 3 of that patent specification, and from the present Figure 1, that the general construction of the present electrical connector is generally the same as that disclosed in Figures 1, 2 and 3 of U.S. Patent Specification No. 3,867,005. It is therefore readily apparent that the plurality of conductors and contacts of an electrical connector according to the said U.S. patent is also envisaged for an electrical connector which includes the features of the present invention.

Figures 1 and 2 illustrate the basic construction of an electrical connector 10 which is provided with a dielectric contact mount 12 in the form of a plug unit adapted for connection to a mating complementary receptacle unit (not shown). The contact mount 12, which is constructed of moulded dielectric material, such as "DAF" nylon, or polyester, has a plurality of spaced barriers 14 which define a pdurality of contact mounting passages 16. Each of the barriers 14 includes an extended portion 18 which defines strain relief passages 20 and each of the strain relief passages 20 has an entrance defined by a pair of oblique surfaces 22 and 24.

Each of the contact mounting passages 16 has a contact 26 mounted therein. Each of the contacts 26 includes an active contact element 28, here illustrated as having a hook-shaped reentrant portion 29 as in the abovementioned U.S. Patent Specification No. 3,867,005. The active portion could, however, have any desirable shape. The contact 26 also includes a termination contact element 30 and an intermediate contact element or portion connecting the active and termination elements, the intermediate portion to be described in detail below.

Each termination contact element comprises a pair of substantially parallel sidewalls 32 and 34 which extend substantially perpendicular to a bottom wall 36 to form an open U-shaped configuration.

In the termination contact element 30 illustrated in Figures 1 and 2, the sidewalls 32 and 34 have been dimpled to provide inwardly directed detents 38 which define a channel constriction or notch and which are designed to be in an interference relationship with at least the insulation of an insulated conductor inserted in the channel. Although the constriction or notch is illustrated as comprising a pair of opposed inwardly directed detents facing each other, it may alternatively comprise a pair of inwardly directed detents which are offset longitudinally with respect to each other along the termination contact element.

Each of the detents 38 includes a pair of inwardly directed portions 40 which join the respective sidewalls and which join each other along an edge surface 42 which constitutes a wiping surface for an exposed conductor, whether the conductor is solid or stranded. Each detent 38 also comprises a surface 44 which is continuous with the portions 40 and 42 back to the outer edge of the respective sidewall. The surface 44 is particularly characterized as a smooth surface, at least in the area immediately adjacent the wiping surface 42 and is further characterized as developing into the wiping surface 42 with a gradual change of direction.

In the construction illustrated in Figure 2, at least one of the channel walls 32, 34 and 36 affords support to the detents 38 against the forces exerted thereon during insertion of a conductor into the termination contact element. The surface 44 of each detent is supported against such insertion forces in the direction of insertion by the bottom wall 36 which is integrally connected to the inwardly directed portion 40 of the detent. The sidewall 32 integrally connected to the inwardly directed portion 40 of the detent provides support for the wiping surface 42 against insertion forces in a direction transverse to the direction of insertion.

As illustrated in Figures 3 to 5, as an insulated conductor C is forced into the channel of the termination contact element and thus into at least one notch defined by a pair of detents 38, the insulation I is opened to expose the conductor SC so that the same is subjected to wiping contact with the surfaces 42. Since the insulation is forced open as it passes over smooth surfaces having a gradual change of direction, as opposed to being severed by a cutting operation, the individual strands, if a stranded conductor is employed, are exposed to the change of direction defined by the surfaces, but the strands are not subjected to snagging and/or severing as would be the case with contact elements heretofore employed.

Referring again to Figure 2, as the conductor SC is forced downwardly into the termination contact element 30 to a desired position, it passes another detent element 50 which is embossed and lanced to include an underlying edge 54 which engages the inclulation I to retain the conductor within the channel of the termination contact element.

An insertion tool which is suitable for terminating electrical conductors in the termination contact element 30 is illustrated, in part, in Figure 1 as comprising an insertion blade 58 having a plurality of insertion portions 60, 62 and 64 which are to be positioned against a conductor at respective locations between the notches formed between successive pairs of detents 38. The blade 58 includes narrow portions 66 and 68 which are formed between opposed grooves on the sides of the insertion tool and are aligned with the notches formed by the detents 38. In addition, the blade 58 may comprise a further portion (not shown) for pressing the conductor into the respective strain relief passageway 20.

Because of the desirability of using high tensile strength materials, and inasmuch as such materials involve difficulties in forming reverse bends, and as it is highly desirable to use such materials for extended contact life, the termination contact element 30 is constructed in such a manner as to be adaptable for high tensile strength materials and mounting of the contacts within a contact mount. For this purpose, the sidewall 34 is provided with a flap 57 which is bent at 90° with respect thereto towards the sidewall 32 and the sidewall 32 is provided with a tab 56 which is bent in the opposite direction to overlie and retain the flap 57. This forms a stable box-shaped structure at the end of the termination contact element 30 which box-like structure is received in a complementary box-shaped portion of the passage 16 in the contact mount 12. The flap 57 integrally adjoins and supports the active contact element 28.

In some manufacturing processes, and in the case of different applications, it may be more advisable and advantageous to form the notch-defining structures by processes other than the above-described detenting process, for example by press-forming the sidewalls of the termination contact element or by press-forming the detents in a different configuration. Inasmuch as each of the detents is, in effect, an internal wall within the channel, the detents are also hereinafter referred to as inner walls which may have individual wall portions or wall sections.

Referring to Figure 6, for example, the same general shape for a detent is illustrated as is shown in Figures 1 and 2. In Figure 6, however, each of the detents 78 comprises a pair of inwardly directed walls 80 and 82 which converge in a rounded surface 84 and which are joined by an oblique surface 86 having a smooth portion adjacent the surface 84. The walls and surfaces 80 to 86 are formed in a separate process as a cup-shaped structure which is welded around the periphery, as at 88, to the respective sidewall 72 which extends from a bottom wall 76 parallel to a complementary sidewall 74 of a termination contact element 70.

Referring to Figure 7, a termination contact element 110 is illustrated as comprising a sidewall 112 (the other sidewall not being shown) which extends substantially normal to a bottom wall 114. An inner wall 116 as illustrated as comprising a pair of inwardly directed walls 118 and 120 having a bottom edge 122 above the bottom wall 114 and which are connected by a wide wiping surface wall 124. An additional wall 126, characterized by a smooth portion adjacent the surface 124, joins the walls 118, 120 and 124 with the free edge of the sidewall 112.

Referring to Figure 8, a termination contact element 90 is illustrated as having an inner wall 96, formed as a detent, including a pair of inwardly directed walls 98 and 100 extending from a sidewall 92 and converging in a rounded wiping edge surface 104. The sidewall 92 projects upwardly from a bottom wall 94. The contact element 90 also includes another sidewall as in Figures 1 to 6.

A smooth slanted surface 106 adjacent the surface 104 is provided on a member 108 of thin conductive sheet metal which is connected to and bent at an angle with respect to the surface 104 with its smooth major surface extending as a cover and guide over the walls 98 and 100. An aperture 102 is provided at the junction of the sidewall 92 and the bottom wall 94 to facilitate forming of the detent by a pressing process so that lancing or an abrupt swaging is not necessary at that point.

Figure 9 illustrates another termination contact element 130 which has a sidewall 132 projecting upwardly from a bottom wall 136. A similar sidewall projects upwardly from the opposite edge of the bottom wall 136. The channel of the termination contact element 130 includes an inner wall 138 which is formed out of and bent at substantially 90° with respect to the sidewall 132, the bending being facilitated by an aperture 134 at the junction of the sidewall 132 and the bottom wall 136. The inner wall 138 comprises a sidewall portion 140 having an edge 142, substantially the thickness of the sidewall 132 which forms the wiping surface for the conductor. The sidewall portion 140 has an extended portion 146 which is folded over in a smooth inwardly and downwardly directed fold 144 to define a smooth entrance to the notch, the junction of the edge surface 142 and the rounded surface 144 defining the change of direction mentioned in connection with the previously described embodiments.

Figures 10 and 11 illustrate a termination contact element 150 having a sidewall 152 which extends from a bottom wall 154. The sidewall 152 have been relieved by an aperture at 164 to facilitate the forming of a dimple in the production of an inner wall 156 which includes a pair of convergently inwardly directed surfaces 158 and 160 which are joined at a rounded surface 162 constituting the conductor wiping surface. In this embodiment of the invention the press forming of the inner wall occurs more closely adjacent the free edge of the sidewall 152 than in the case of the inner wall 78 formed in the sidewall 72 in Figure 6 so that the upper edge 166 of the sidewall 152 is turned outwardly and form a V-shaped notch. The space between the V-shaped notch 166 and the junction of the surfaces 158, 160 and 162 therewith constitutes a smooth surface 168 for guiding the conductor into the notch and preventing snagging of the individual strands of a stranded conductor as the notch effects opening of the insulation. The edges of the V may be coined if necessary, to prevent snagging.

A termination contact element 170 without side walls is illustrated in Figure 12, although it is readily apparent that side walls could be provided. This termination contact element 170 is produced by folding a flat strip of sheet metal which is formed at intervals along its length with longitudinally extending slots which are located midway between the edges of the strip. The strip is folded three times to produce each notch and two adjoining bottom wall portions, each notch being defined by a pair of notch-defining projections formed from a respective slotted part of the strip, while the bottom wall portions are formed from portions of the strip between successive slots therein. Each of the notch-defining projections comprises a pair of coextensive wall sections 174 and 176 which are joined by a rounded, smooth and inwardly obliquely directed surface 178. The surfaces of each pair of notch-defining projections lead down to respective parallel spaced apart side walls 180 formed from the corresponding edges of the respective slot in the strip, which side walls 180 form the wiping surfaces for the exposed conductor.

Figures 13 and 14 illustrate in more detail the relationships between the terminal element of Figures 1 to 5 and the conductor insulation I and core SC. As an example, parts of the conductor C and the connector 10 may have the following dimensions:

Diameter I	0.038 to 0.045
Diameter SC	0.015 to 0.020
Notch Width a	0.005 to 0.009
Channel Inside Width *b* ...	0.038
Channel Outside Width *c*	0.049 to 0.051
Barrier-Barrier Distance *d*	0.052 to 0.054

From the dimensions given above in inches, it is apparent that although the diameter of the insulation I is approximately the same diameter as the inside of the channel, the conductor diameter SC is much larger than the width of the notch. Therefore, as the insulated conductor C is pressed into the channel, even assuming that the conductor is centred, a stranded core undergoes a cross-sectional distortion due to displacement of the individual strands during insertion. This is illustrated in Figure 14. Also, as pressure is applied to the insulation I by an insertion tool, the insulation undergoes distortion and is moved axially of the core and outwardly of the channel. It is difficult to tell exactly where any individual strand may initially contact the surface 44 which leads into the notch. Therefore, a smooth surface 44 with a gradual change of direction to the wiping surface is utilized to prevent snagging of the individual strands. With larger strands and solid conductors, the change of direction can be more abrupt in that the possibility of snagging decreases with increasing conductor diameter.

Referring again to the dimensions given above, it is readily apparent that any transverse deflection of the sidewalls 32 and 34 is at a minimum because of the difference between the outside channel dimension and the distance between the barriers, for example 0.003 inches. The terminal element is therefore well supported and does not open up to any extent to receive the conductor, thus ensuring good mechanical connection and good wiping electrical connection.

Additional details of the box-shaped structure of the intermediate element are illustrated in Figures 15 to 17. It should be noted that the member 57 includes an embossed detent 184 for receiving the tab 56 so that the outer surfaces of the members 57 and the tab 56 are coplanar, which facilitates insertion of the terminal ends of the contacts into the dielectric support 12.

One of the side walls, the wall 34 in Figure 16, also carries a member 182 which is folded at 90° towards the opposite side wall as another feature of the box-like structure.

It is sometimes necessary to provide supporting feet for the intermediate element of a contact. Referring to Figure 17, the bottom wall 36 of the channel may be cut as at 186 and 188 to provide a pair of bottom wall sections 190 and 192 which may be folded downwardly to provide supporting feet.

WHAT WE CLAIM IS:—

1. An insulation-piercing electrical contact element comprising a substantially parallel-sided notch for receiving an insulated conductor, and a mouth tapering into the notch for guiding the insulated conductor into the notch, each side of the notch being formed from sheet metal shaped to provide a wiping surface which, in use with a suitably sized insulated conductor forced into the notch, pierces the insulation of the conductor and makes electrical contact with the conductor, the sheet metal being additionally shaped to provide the corresponding side of the mouth in the form of a smooth surface flaring out from the notch and constituted by part of one of the major surfaces of the sheet.

2. An insulation-piercing electrical contact element according to claim 1, wherein the wiping surface is also part of the major surface of the sheet.

3. An insulation-piercing electrical contact element according to claim 2, wherein the smooth surface merges gradually into the wiping surface through a convexly curved surface.

4. An insulating-piercing electrical contact element according to claim 2 or 3, wherein the wiping surface is formed by a bend line whereat two lateral wall portions of the sheet metal meet.

5. An insulation-piercing electrical contact element according to claim 4, wherein the smooth surface is formed by an oblique wall portion of the sheet metal extending between the lateral wall.

6. An insulation-piercing electrical contact element according to claim 4, wherein the smooth surface is formed by rolled-over margins of the lateral wall portions.

7. An insulation-piercing electrical contact element according to claim 2 or 3, wherein the wiping surface is formed by a connecting wall portion of the sheet metal joining two lateral wall portions and the smooth surface is formed by an oblique wall portion of the sheet metal extending between the lateral wall portions and joined thereto and to the connecting wall portion.

8. An insulation-piercing electrical contact element according to claims 4 to 7, wherein the said wall portions are formed by inward deformation of a side wall of a sheet metal channel member.

9. An insulation-piercing electrical contact element according to any of claims 4 to 7, wherein the said wall portions are a separately formed sheet metal structure welded on to the inside of a side wall of a sheet metal channel member.

10. An insulation-piercing electrical contact element according to claim 8, 9 or 10, wherein a projection extending from one of the side walls into the interior of the channel has an underlying edge for engagement with the insulation of an insulated conductor so as to retain the conductor in the channel after it has been inserted into the same past the ledge.

11. An insulation-piercing electrical contact element according to claim 8, 9 or 10, wherein the side walls are connected by a sheet metal part forming a box structure spaced along the channel from the notch.

12. An insulation-piercing electrical contact element according to claim 11, wherein the sheet metal part is integral with the edge of one side wall and is overlain by a tab bent over from the edge of the other side wall.

13. An insulation-piercing electrical contact element according to claim 11 or 12, wherein the end of the channel remote from the notch is closed by an end wall.

14. An insulation-piercing electrical contact element according to claim 1, wherein the wiping surface is an edge of the sheet metal and the smooth surface is the convex surface of a fold in the sheet metal.

15. An insulation-piercing electrical contact element substantially as hereinbefore described with reference to and as illustrated in Figs. 1 to 5 or any of Figs. 6, 7, 8, 9, 10 and 12 of the accompanying drawings.

16. An electrical connector including an insulation-piercing electrical contact element according to any preceding claim.

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Sheet 1

Fig-1

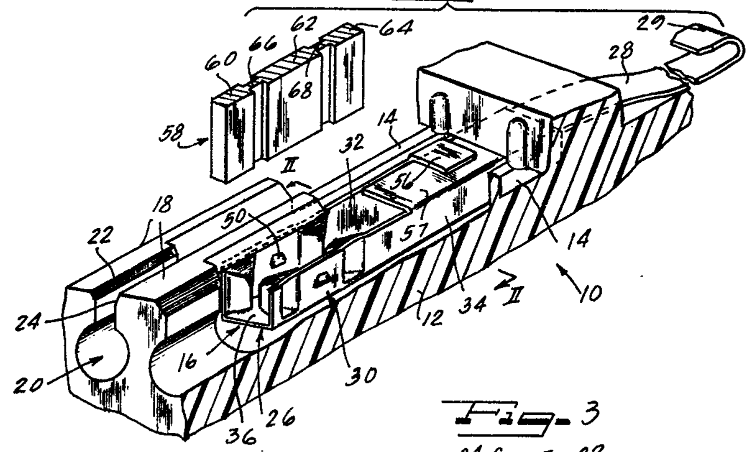


Fig-3

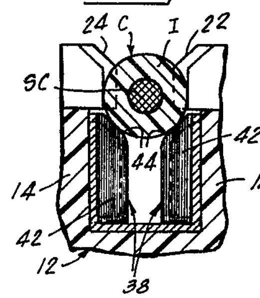


Fig-4

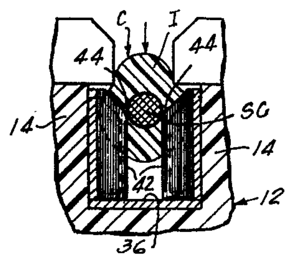


Fig-2

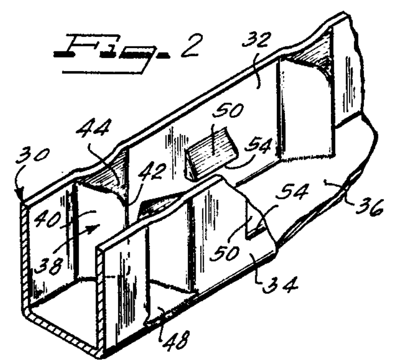
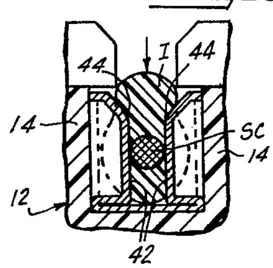


Fig-5



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Sheet 2

Fig. 6

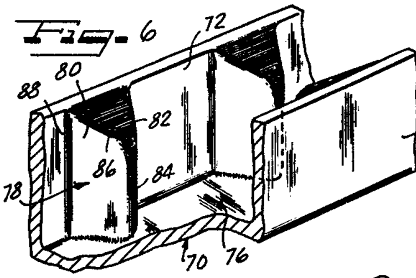


Fig. 7

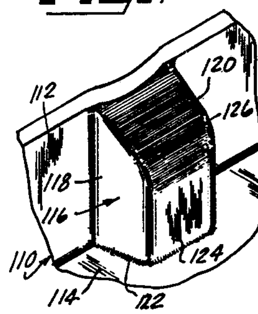


Fig. 8

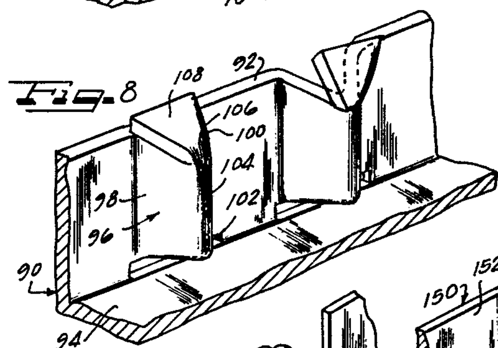


Fig. 10

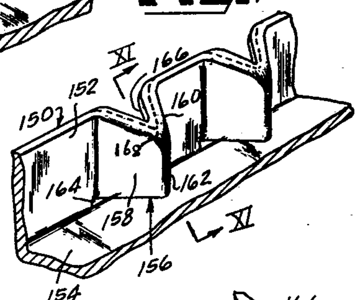
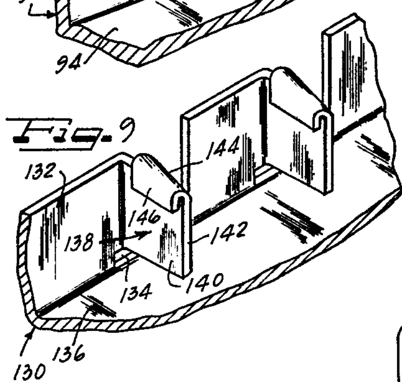


Fig. 9



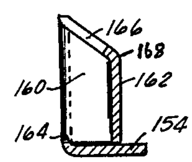


Fig. 11

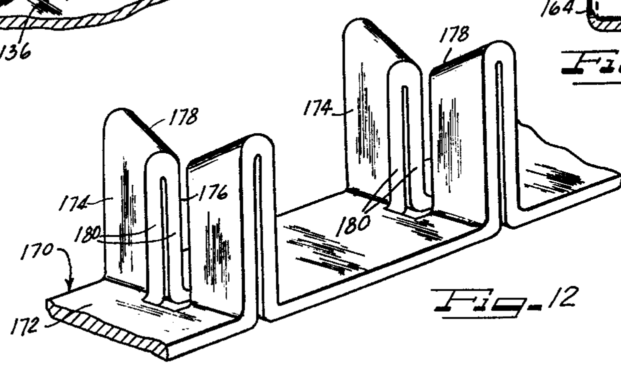


Fig. 12

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Sheet 3

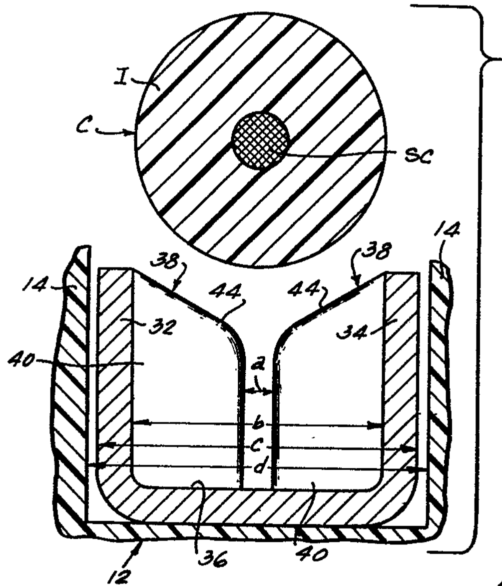
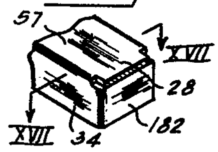


Fig. 13

Fig. 16



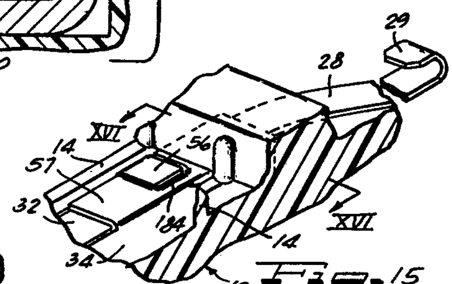


Fig. 15

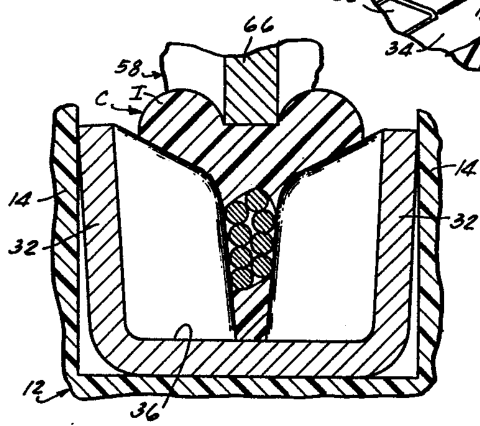


Fig. 14

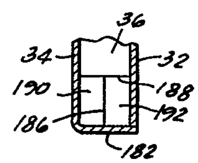


Fig. 17