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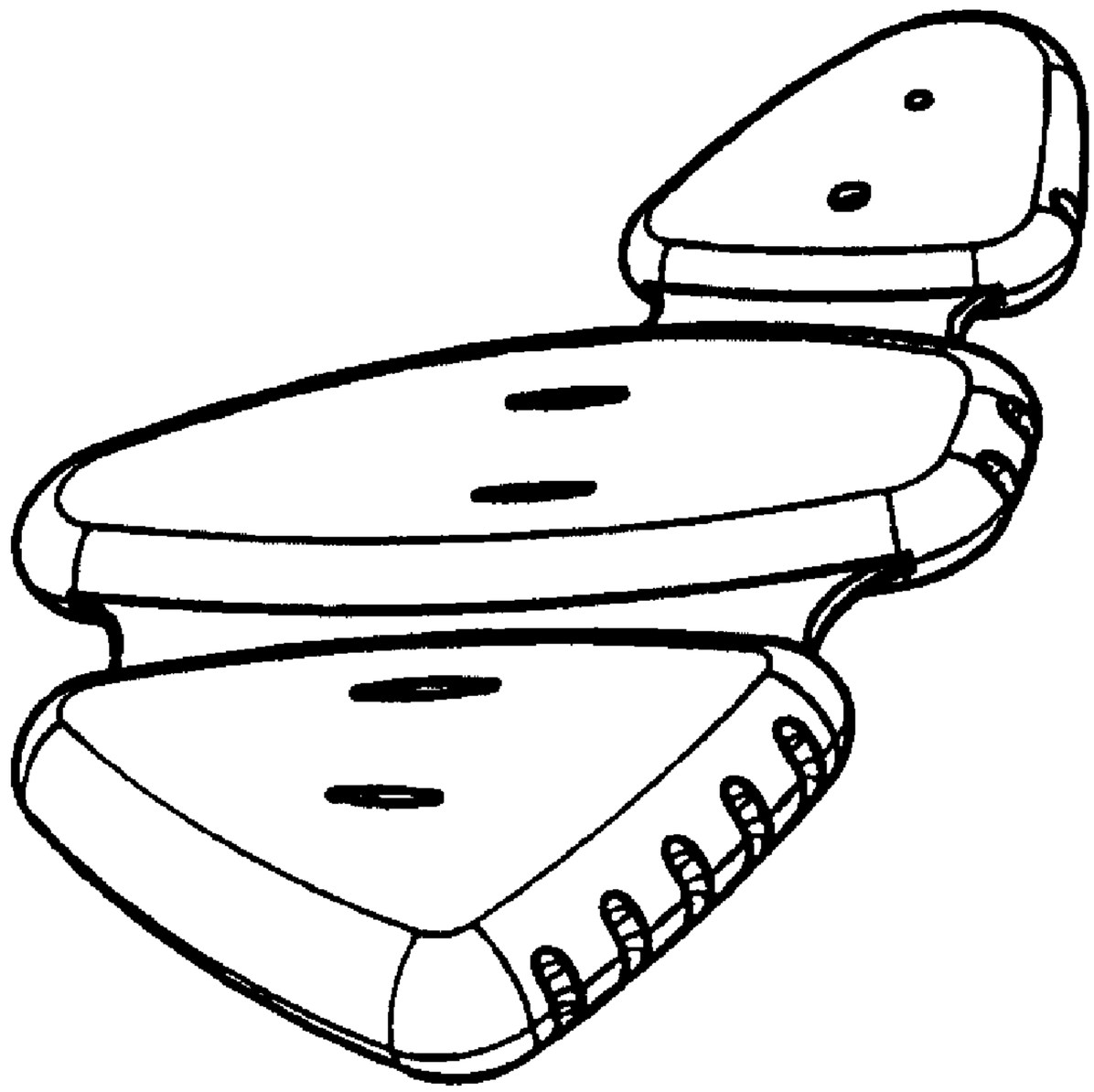
(54) Titre : INSERTION DE CHAUSSURE DES ELEMENTS ENTOURES DEFORMABLE
(54) Title: SHOE INSERT OF ENCASED DEFORMABLE ELEMENTS



(57) Abrégé/Abstract:
An insert for a shoe is disclosed which includes an airtight casing (114) having a plurality of elements (110) positioned therein which are elastically deformable such that the biomechanics of the foot of the user are optimized.

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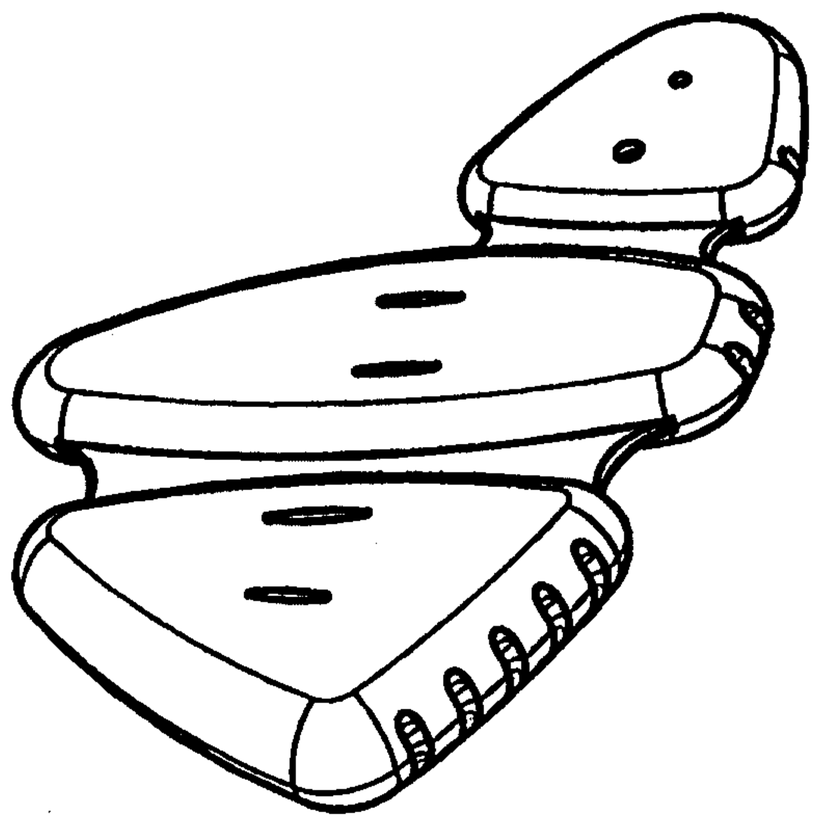
(54) Title: INSERT OF ENCASED DEFORMABLE ELEMENTS

(57) Abstract

An insert for a shoe is disclosed which includes an airtight casing (114) having a plurality of elements (110) positioned therein which are elastically deformable such that the biomechanics of the foot of the user are optimized.



SHOE INSERT OF ENCASED DEFORMABLE ELEMENTS

BACKGROUND OF THE INVENTION

Field of the Invention:

The present invention is directed to a method and apparatus corresponding to an insert for a shoe with improved elastically deformable elements and arrangements therefor which permit optimization of the biomechanics of a user's foot.

Discussion of the Background

Barrel shaped elastically deformable elements are taught in the U.S. Patent NO. 5,092,060 issued to Frachey et al and U.S. Patent No. 5,396,896 issued to Frachey et al, which is illustrated in Figures 179-182. Frachey et al '060 et '896 teach a sports shoe comprising a vamp A at a lower support part 1 which comprises a sole 2 a wedge 3, a mounting insole 5, and a further insole 6. Elastically deformable elements 14 of Frachey et al '060 contained inside an insert 13, are arranged in seat 16 formed in wedge 3. The deformable elements 14 are formed by molding a synthetic high elasticity material and are substantially barrel shaped, with their major cross-section being substantially in the central region 20 in which said elements are joined together by an integral bridging portion 28. Deformable elements 14 are arranged in an insert 13 made of thermoplastic material enclosed in an airtight casing 15 which is constructed of plastic material such as polyurethane or similar material. The air inside casing 15 has a pressure of less than or equal to atmospheric pressure.

With reference to Figures 179-182 of the present application, the sports shoe of Frachey et al '060 comprises a vamp A and a lower support part 1 comprising a sole 2, for example of synthetic rubber, to which a wedge 3, for example of thermoplastic polyurethane,

is fixed in a known manner. The wedge comprises a recess 4, bounded by a raised edge 10, carrying a mounting insole 5, for example a cork, on which there is positioned a further insole

6, for example of fabric (not shown in Fig. 181). The sole 2, constructed advantageously of rubber, comprises the usual notches 7 and incisions or recessed portions 8 in its lower surface. It also comprises a front raised edge 11, and a lateral edge 12 which extends along the entire remaining perimeter of the sole.

According to this conventional sports shoe, in the lower part of the shoe there is arranged an insert 13 comprising elastically deformable elements 14 made of thermoplastic material enclosed in an air-tight casing 15 constructed of plastic material such as polyurethane or a similar material. In casing 15 there is present air that has a pressure less than or equal to atmospheric pressure. In this example, the insert 13 is positioned in seats 16 and 17 provided in the wedge 3 and in the insole 5 respectively, said seats being superposed. Alternatively, seat 17 can be omitted with insert 13 located only in seat 16 of wedge 3, so that the insole 5 is superimposed and covers seat 16.

More specifically, the elements 14 of the insert 13 are formed by molding any synthetic high-elasticity material and are substantially barrel-shaped, i.e., they are tapered at their opposing free ends 18 and 19 and have their major cross-section substantially in the central region 20 in which said elements are joined together by an integral bridging portion 20A. The barrel shaped elements are barrel shaped in the sense that all vertical cross sections taken along the vertical axis thereof are barrel shaped. Due to manufacturing requirements of insert 13, free ends, 18, 19 of barrel-shaped elements 14 are fastened to casing 15. This is actually the preferred embodiment of insert 13, wherein in a first phase, elements 14 are obtained by means of molding; subsequently they are encased inside thermo-soldering plastic sheets which constitute casing 15; the elements 14 are encased by sheets when they are at a relatively high temperature so that a welding of free ends 18, 19 of elements 14 with the sheets occurs. The connection between casing 15 and the barrel-shaped elements has the advantage of anchoring said elements inside said casing, thereby preventing the casing and barrel-shaped elements from moving during use of the shoe according to the invention and so contributing together with the mutual connection of the barrel-shaped elements 14 to desirable multidirectional stability and flexibility of the resulting shoe. This affords greater stability for insert 13 within the shoe, and permits better performance of the function for which it is intended, which functions will be further defined below.

The shape of elements 14, as shown and described by way of example, allows considerable absorption of the stresses caused by the user's foot as he moves, and at the same time allows a large part of the absorbed energy to be retransmitted rapidly but gradually to the foot. In order to secure the insert 13 within the seats 16 and 17, the insole 6 comprises on that face 21, facing the insole 5, a projection 22 of a shape corresponding to said seats and arranged to cooperate with them and with the insert 13. In the alternative embodiment recited above, the projection 22 can be omitted. The casing 15 of insert 13 comprises a flange 23 which, when the insert 13 has been positioned in the lower part 1 of the shoe, rests on a step 24 provided between the insole 5 and an inner surface 25 of the wedge 3. In the alternative, where the hole or seat 17 is omitted, the flange 23 rests on the contour of the wedge seat 16.

Finally, the sole comprises a reinforcement element 28 positioned below the insert 13 or in other positions of the sole where other inserts may be located, said reinforcement element 28 being formed, for example, of plastic material e.g. of natural or synthetic rubber and being advantageously somewhat transparent. Element 28 may or may not be tinted. Reinforcing element 28 is of a wear and abrasion resistant material and is preferably located in the heel portion and in the metatarsal portion of the sole.

During the use of a shoe according to this conventional insert, each time the user presses the lower part 1 of the shoe with his foot, the insert 13 is pressed towards the sole 2. Specifically, the pressing action exerted by the foot depresses the elements 14 which deform and increases the pressure within the airtight casing 15 which is constricted by the surrounding wall portion of its seat. When the user's heel ceases its pressing action, the elements 14 return to their initial configuration, so as to transmit a large part of the energy acquired during the pressing action to the user's foot, which therefore receives a gradual thrust at his heel (or other part of the foot, e.g., the metatarsal one) separates from the ground. To said thrust, exerted on the user's foot by elements 14, there must be added the thrust exerted by the air which is present inside insert 13, thus air being under pressure due to the action by the user's foot. These combined thrusts help transfer to the user's foot part of the energy transmitted by the user to the ground during movement.

Elastic inserts like the one disclosed above can be located in the other regions of the support part 1, in particular in proximity to the frontal region of the sole 2 and the wedge 3

and more particularly in the metatarsal zone 3A as shown in dotted lines in Fig. 179, where the seat is references by 16A and the insert by 13A, thus allowing the user (particularly an athlete) to obtain increased pickup during acceleration or during changes in the rate of movement.

The insert 13 shown in Fig. 179 and 181 comprises only one layer of elements 14; however, there can be provided an insert 13 having two or more layers of elements 14 superimposed as shown in Fig. 182. In particular, if the above cited insert has two layers of elements 14, a first layer supports the second whose deformable elements rest on the elements positioned below.

This conventional insert permits an improvement in the return of par of the energy (passed on by the user to the ground) to the foot of the user. It must be noted that, in the same manner previously described, free ends 18, 19 of barrel-shaped element 14, are fastened to (or soldered on) casing 15, whereas the contact surfaces of the two layers of element 14, if used, would be fastened to (or soldered on) each other. This affords stability for insert 13, preventing one of the layers from sliding over the other one within casing 15. A shoe constructed in accordance with the invention satisfies the aforesaid requirements and in particular enables most of the energy expended during movement to be retransferred to the foot.

SUMMARY OF THE INVENTION

The present invention has as the object thereof the provision of a method and apparatus which permits a shoe to have improved elastically deformable elements and arrangements therefore. The elements serve to optimize the biomechanics of the user's foot when wearing the shoe wherein the use of deformable elements which make it possible to provide for a more continuous contact therewith by the user's foot and therefore more evenly distribute energy transferred between the user's foot and the elements while maintaining the flexibility necessary in the shoe sole.

A further object of the present invention is to utilize deformable elements connected by bridging portions such that, when constructed as deformable batteries, for example, such can more easily bend along the bridging portion. Accordingly, one aspect of the present

invention is to align the deformable elements such that the bridging portions are aligned with flex lines of the foot so as to thereby better follow and maintain contact with the sole of a user's foot. A further advantage of the present invention is that the casing or encapsulating bag is formed by a vacuum forming or blow molding which thereby lowers the cost of manufacturing and makes the same easier to accomplish. A further object of the present invention is to provide an arrangement whereby the stiffness and viscoelastic properties of the deformable elements are varied throughout positions in the sole in order to match the biomechanics of the user's foot, and preferably, according to the particular athletic activity of the user.

According to the present invention, there is provided an article of footwear, which comprises:

a vamp;

a lower support connected to said vamp, said lower support including a midsole; and

at least one insert mounted in said midsole and which includes first and second airtight casings each having a plurality of elements positioned therein which elastically deformable such that the biomechanics of a foot of a user are optimized, said first and second casings being interconnected by a bridging portion for permitting flexibility between said first and second casings, said deformable elements being interconnected by integral bridging portions for permitting flexibility between the deformable elements, said deformable elements each having a substantially oval-shaped horizontal cross-section, and wherein said bridging portion of said first and second casings is aligned with a flex line of the foot of the user.

According to the present invention, there is also provided a method of forming an insert for an article of footwear, which comprises:

forming at least one insert from a plurality of interconnected elements;

inserting said elements into first and second casings so as to be positioned in a midsole portion of an article of footwear such that the biomechanics of a foot of a user wearing the article of footwear are optimized wherein the step of forming the interconnected element comprises forming at least two batteries of deformable elements so as to be respectively positioned in said first and second casings wherein said deformable elements are each substantially oval-shaped in horizontal cross-section, the step of forming the elements comprising forming at least two batteries of said deformable elements, and

interconnecting said first and second casings by a bridging portion wherein the step of forming the deformable elements comprises interconnecting said deformable elements by integral bridging portions.

According to the present invention, there is also provided an article of footwear, which comprises:

a vamp;

a lower support connected to said vamp, said lower support including a midsole; and

at least one insert mounted in said midsole and which includes firsts and second airtight casings each having a plurality of elements positioned therein which are elastically deformable such that the biomechanics of a foot of a user are optimized, said first and second casings being interconnected by a bridging portion aligned with a

flex line of the foot of a user, and said deformable elements being interconnected by integral bridging portions for permitting flexibility between the first and second castings.

According to the present invention, there is also provided a method of forming an insert for an article of footwear, which comprises:

forming at least one insert from a plurality of interconnected elements;

inserting said elements into first and second casings so as to be positioned in a midsole portion of an article of footwear such that the biomechanics of a foot of a user wearing the article of footwear are optimized wherein the step of forming the interconnected elements comprises forming deformable elements so as to be respectively positioned in said first and second casings, and

interconnecting said first and second casings by a bridging portion aligned with a flex line of the foot of a user.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

Figure 1 is a top, front and left side perspective view of a SOLE INSERT embodying a first embodiment of the present invention;

Figure 2 is a top plan view thereof, the bottom view being a mirror image of the top view shown:

Figure 3 is a front elevational view thereof;

Figure 4 is a right side elevational view thereof;

Figure 5 is a cross-sectional view thereof taken along line 5-5 of Figure 2;

Figure 6 is a top plan view thereof showing the pillars in phantom lines;

Figure 7 is a top, front and left side perspective view of a second embodiment thereof;

Figure 8 is a top plan view thereof, the bottom view being a mirror image of the top view shown;

Figure 9 is a front elevational view thereof;

Figure 10 is a left side elevational view thereof;

Figure 11 is a right side elevational view thereof;

Figure 12 is a cross-sectional view thereof taken along line 12-12 of Figure 8;

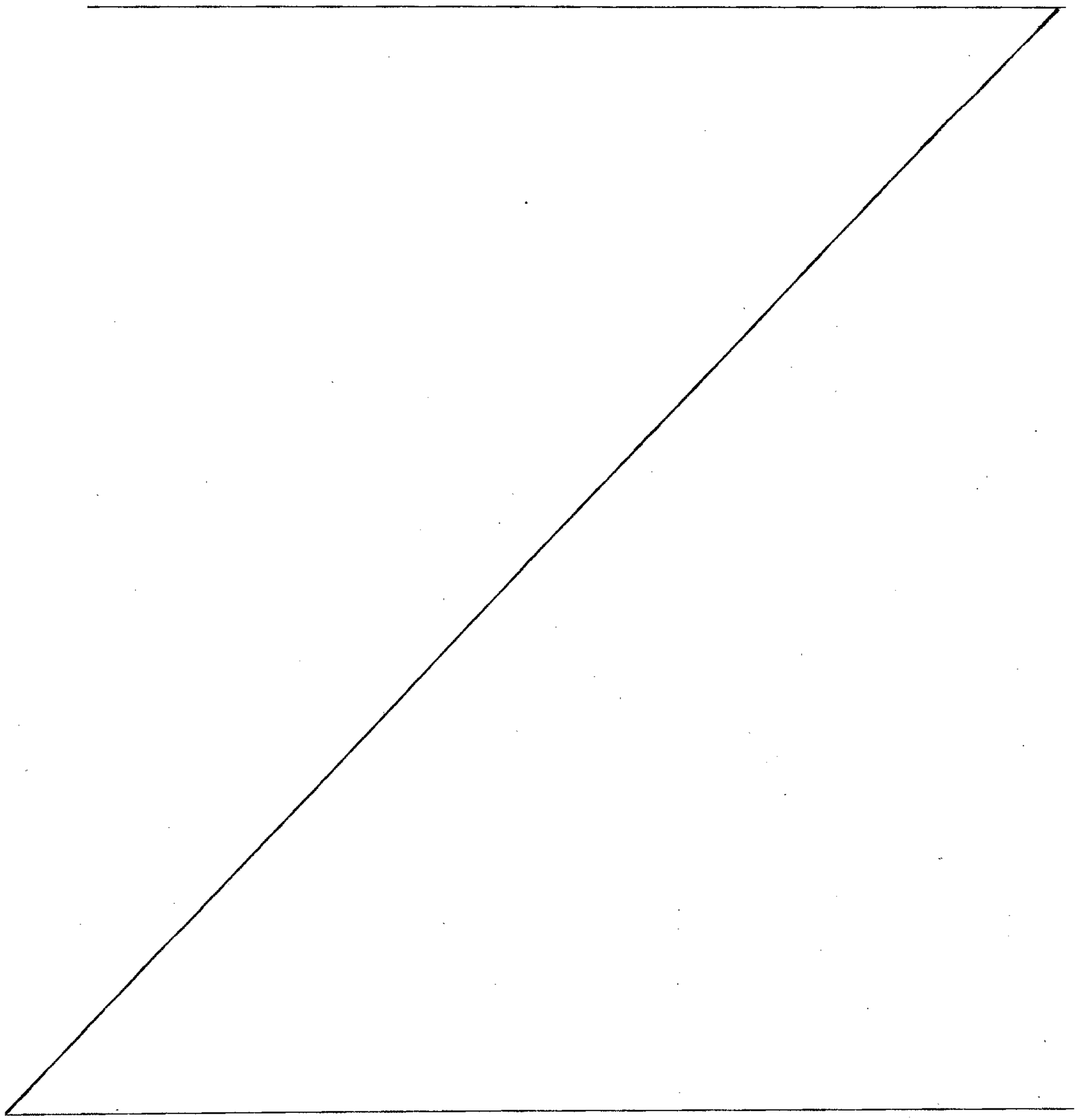


Figure 13 is a top plan view thereof showing the pillars of the insert in phantom lines;

Figure 14 is a top, front and left side perspective view of a third embodiment of the present invention;

Figure 15 is a top plan view thereof, the bottom view being a mirror image of the top view shown;

Figure 16 is a front elevational view thereof;

Figure 17 is a left side elevational view thereof;

Figure 18 is a right side elevational view thereof;

Figure 19 is a cross-sectional view thereof taken along line 19-19 of Figure 15;

Figure 20 is a top plan view thereof showing the pillars of the insert in phantom lines;

Figure 21 is a top, front and left side perspective view of a fourth embodiment of the present invention;

Figure 22 is a top plan view thereof, the bottom view being a mirror image of the top plan view shown;

Figure 23 is a front elevational view thereof;

Figure 24 is a right side elevational view thereof;

Figure 25 is a cross-sectional view thereof taken along line 25-25 of Figure 22;

Figure 26 is a top plan view thereof showing the pillars of the insert in phantom lines;

Figure 27 is a top, front and left side perspective view of a fifth embodiment thereof;

Figure 28 is a top plan view thereof, the bottom plan view being a mirror image of the top plan view shown;

Figure 29 is a front elevational view thereof;

Figure 30 is a left side elevational view thereof;

Figure 31 is a right side elevational view thereof;

Figure 32 is a cross-sectional view thereof taken along line 32-32 of Figure 28;

Figure 33 is a top plan view thereof showing the pillars of the insert in phantom lines;

Figure 34 is a top, front and left side perspective view of another embodiment of the present invention;

Figure 35 is a top plan view thereof, the bottom plan view being a mirror image of the top plan view shown;

Figure 36 is a front elevational view thereof;

Figure 37 is a left side elevational view thereof;

Figure 38 is a right side elevational view thereof;

Figure 39 is a cross-sectional view thereof taken along line 39-39 of Figure 35;

Figure 40 is a top plan view hereof showing the pillars of the insert in phantom lines;

Figure 41 is a top of a front and right side perspective view thereof;

Figure 42 is a top plan view thereof, the bottom plan view thereof being a mirror image of the top plan view shown;

Figure 43 is a front elevational view thereof;

Figure 44 is a left side elevational view thereof;

Figure 45 is a right side elevational view thereof;

Figure 46 is a cross-sectional view thereof taken along line 46-46 of Figure 42;

Figure 47 is a top plan view thereof showing the pillars of the insert in phantom lines;

Figure 48 is a bottom, rear and right side elevational view of another embodiment of the present invention;

Figure 49 is a top plan view thereof, the bottom plan view being a mirror image of the top plan view shown;

Figure 50 is a front elevational view thereof;

Figure 51 is a left side elevational view thereof;

Figure 52 is a right side elevational view thereof;

Figure 53 is a top, front and right side perspective view of another embodiment of the present invention;

Figure 54 is a rear, top and left side perspective view thereof;

Figure 55 is a top plan view thereof, the bottom view being a mirror image of the top plan view shown;

Figure 56 is a rear elevational view thereof;

Figure 57 is a right side elevational view thereof;

Figure 58 is a cross-sectional view thereof taken along line 58-58 of Figure 55;

Figure 59 is a top plan view thereof showing the pillars of the insert in phantom lines;

Figure 60 is a bottom, right side and rear perspective view of another embodiment of

the present invention;

Figure 61 is a top plan view thereof;

Figure 62 is a front elevational view thereof;

Figure 63 is a rear elevational view thereof;

Figure 64 is a right side elevational view thereof;

Figure 65 is a bottom plan view thereof;

Figure 66 is left side elevational view thereof;

Figure 67 is a cross-sectional view thereof taken along line 67-67 of Figure 61;

Figure 68 is a rear, bottom and left side perspective view thereof;

Figure 69 is a top, front and right side perspective view thereof;

Figure 70 is a top plan view thereof;

Figure 71 is a right side elevational view thereof;

Figure 72 is a left side elevational view thereof;

Figure 73 is a bottom plan view thereof;

Figure 74 is a front elevational view thereof;

Figure 75 is a rear elevational view thereof;

Figure 76 is a cross-sectional view taken along line 76-76 of Figure 73;

Figure 77 is a top, front and left side perspective view of another embodiment of the present invention;

Figure 78 is a top, rear and left side perspective thereof;

Figure 79 is a top plan view thereof, the bottom plan view being a mirror image of the top plan view shown;

Figure 80 is a front elevational view thereof;

Figure 81 is a rear elevational view thereof;

Figure 82 is a right side elevational view thereof;

Figure 83 is a cross-sectional view thereof taken along line 83-83 of Figure 79;

Figure 84 is a bottom plan view thereof showing the pillars of the insert in phantom lines;

Figure 85 is a bottom, front and left side perspective view of another embodiment of the present invention;

Figure 86 is a top, front and right side elevational view thereof;

Figure 87 is a top plan view thereof;

Figure 88 is a right side elevational view thereof;

Figure 89 is a left side elevational view thereof;

Figure 90 is a bottom plan view thereof;

Figure 91 is a front elevational view thereof;

Figure 92 is a rear elevational view thereof;

Figure 93 is a cross-sectional view thereof taken along line 93-93 of Figure 90;

Figure 94 is a top, front and right side elevational view of another embodiment of the present invention;

Figure 95 is a rear, bottom and left side perspective view thereof;

Figure 96 is a top plan view thereof; the bottom plan view being a mirror image of the top plan view shown;

Figure 97 is a right side elevational view thereof;

Figure 98 is a left side elevational view thereof;

Figure 99 is a bottom plan view thereof;

Figure 100 is a front elevational view thereof;

Figure 101 is a rear elevational view thereof;

Figure 102 is a rear, bottom and right side perspective view thereof;

Figure 103 is a rear, bottom and front side perspective thereof;

Figure 104 is a rear and bottom side perspective view thereof;

Figure 105 is a cross-sectional view thereof taken along line 105-105 of Figure 100;

Figure 106 is a top, front and left side view of another embodiment of the present invention;

Figure 107 is a top plan view thereof, the bottom plan view being a mirror image of the top plan view shown;

Figure 108 is a front elevational view thereof;

Figure 109 is a right side elevational view thereof;

Figure 110 is a left side elevational view thereof;

Figure 111 is a cross-sectional view taken along line 111-111 of Figure 107;

Figure 112 is a top plan view thereof showing the pillars of the insert in phantom lines;

Figure 113 is a top, front and right side perspective view of another embodiment of the present invention;

Figure 114 is a top plan view thereof, the bottom view being a mirror image of the top plan view shown;

Figure 115 is a front elevational view thereof;

Figure 116 is a right side elevational view thereof;

Figure 117 is a left side elevational view thereof;

Figure 118 is a cross-sectional view thereof taken along line 118-118 of Figure 114;

Figure 119 is a top plan view thereof showing the pillars of the insert in phantom lines;

Figure 120 is a top, front and right side perspective view of another embodiment of the present invention;

Figure 121 is a top plan view thereof, the bottom plan view being a mirror image of the top plan view shown;

Figure 122 is a front elevational view thereof;

Figure 123 is a right side elevational view thereof;

Figure 124 is a left side elevational view thereof;

Figure 125 is a cross-sectional view thereof taken along line 125-125 of Figure 121;

Figure 126 is a top plan view thereof showing the pillars of the insert in phantom lines;

Figure 127 is a top, front and right side perspective view of another embodiment of the present invention;

Figure 128 is a top plan view thereof, the bottom plan view being a mirror image of the top plan view as shown;

Figure 129 is a rear elevational view thereof;

Figure 130 is a right side elevational view thereof;

Figure 131 is a cross-sectional view thereof taken along line 130-130 of Figure 128;

Figure 132 is a top plan view thereof showing the pillars of the insert in phantom

lines;

Figure 133 is a top, front and right side perspective view of another embodiment of the present invention;

Figure 134 is a top plan view thereof, the bottom plan view being a mirror image of the top plan view shown;

Figure 135 is a right side elevational view thereof;

Figure 136 is a rear elevational view thereof;

Figure 137 is a top, front and left side perspective view of another embodiment of the present invention;

Figure 138 is a top plan view thereof, the bottom plan view being a mirror image of the top plan view shown;

Figure 139 is a right side elevational view thereof;

Figure 140 is a rear elevational view thereof;

Figure 141 is a top, rear and left side perspective view of another embodiment of the present invention;

Figure 142 is a top plan view thereof, the bottom plan view being a mirror image of the top plan view shown;

Figure 143 is a right side elevational view thereof;

Figure 144 is a rear elevational view thereof;

Figure 145 is a cross-sectional view thereof taken along line 145-145 of Figure 142;

Figure 146 is a top plan view thereof showing the pillars of the insert in phantom lines;

Figure 147 is a bottom, front and left side perspective view of another embodiment of the present invention;

Figure 148 is a top plan view thereof, the bottom plan view being a mirror image of the top plan view shown;

Figure 149 is a right side elevational view thereof;

Figure 150 is a rear elevational view thereof;

Figure 151 is a bottom, front and right side perspective view of another embodiment of the present invention;

Figure 152 is a top plan view thereof, the bottom view being a mirror image of the top plan view shown;

Figure 153 is a right side elevational view thereof;

Figure 154 is a rear elevational view thereof;

Figure 155 is a bottom, front and right side perspective view of another embodiment of the present invention;

Figure 156 is a top plan view thereof, the bottom view being a mirror image of the top plan view shown;

Figure 157 is a right side elevational view thereof;

Figure 158 is a rear elevational view thereof;

Figure 159 is a cross-sectional view thereof taken along line 159-159 of Figure 156;

Figure 160 is a top plan view thereof showing the pillars of the insert in phantom lines;

Figure 161 is a bottom, front and left side perspective view of another embodiment of the present invention;

Figure 162 is a top plan view thereof, the bottom plan view being a mirror image of the view shown;

Figure 163 is a right side elevational view thereof;

Figure 164 is a rear elevational view thereof;

Figure 165 is a bottom, front and left side perspective view of another embodiment of the present invention;

Figure 166 is a top plan view thereof, the bottom plan view being a mirror image of the view shown;

Figure 167 is a right side elevational view thereof;

Figure 168 is a rear elevational view thereof;

Figure 169 shows on a reduced scale an example of the orientation of the inserts in a shoe utilizing the embodiments of Figures 1-6, 7-13, 85-93 and 106-112;

Figure 170 shows on a reduced scale the inserts in a shoe which utilizes the embodiments of Figures 27-33, 34-40 and 41-47;

Figure 171 shows on a reduced scale a shoe which utilizes the inserts of Figures 27-33

and 125-130;

Figure 172 illustrates on a reduced scale a shoe utilizing the inserts of Figures 27-33;

Figure 173 shows on a reduced scale a shoe utilizing the embodiment illustrated in Figures 53-61;

Figure 174 shows on a reduced scale a shoe utilizing the embodiments of Figures 106-112, 73-119 and 120-126;

Figure 175 illustrates on a reduced scale a shoe utilizing the embodiments of Figures 77-83 and 106-112;

Figure 176 illustrates on a reduced scale a shoe utilizing the embodiments of Figures 77-84 and 127-132:

Figure 177 illustrates on a reduced scale a shoe utilizing the embodiments of Figures 53-59;

Figure 178 illustrates on a reduced scale a shoe utilizing the embodiments of Figures 77-84 and 127-132;

Figure 179 is an exploded view of the lower part of a sports shoe for a conventional shoe;

Figure 180 is a bottom view thereof;

Figure 181 is a section view taken along lines 181-181 of Figure 180;

Figure 182 is a section view of an alternate embodiment of the conventional shoe of Figure 179.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

With respect to the embodiments shown in Figures 1 through 178, these are directed to improved deformable elements and specific arrangements optimized for the biomechanics of a user's foot. In particular, Figures 1 through 168 disclose improved shapes of the elastically deformable elements, and arrangements therefore within airtight casings. For example, Figure 6 illustrates an arrangement of elastically deformable elements which are substantially oval shaped in cross-section. According to another aspect of the invention, the deformable elements have been cored, wherein a hole has been formed through the center of

the deformable element in order to reduce the weight of the element. For example, Figure 6 illustrates an arrangement of elastically deformable members 110 which are substantially oval in a cross-section. Deformable members 110 are provided with holes 112 which reduce their weight. It is also conceived that deformable elements 110 are dimpled or otherwise reduced in order to minimize the weight of elements 110. Preferably, elements 110 are vacuumed sealed in a casing 114. The edges of elements 110, are tapered as shown in dashed lines in Figure 6 and illustrated as recesses 118 in Figure 5. Figure 6 shows an arrangement of deformable elements 110 which are broken down into three deformable element batteries 116, wherein each battery includes at least two deformable elements 110 which are joined by integral bridging portions 120. Each of the deformable element batteries 116 are joined by battery bridging portion 122. Preferably, bridging portions 122 are integrally formed with casing 114 which is vacuum sealed around elements 110.

The advantage achieved by forming deformable elements 110 with an oval cross-section, is that it is possible to use larger elements which provide a more continuous contact and therefore more evenly distributed energy transfer between the user's foot and the element, while maintaining the flexibility necessary in a shoe sole. For example, it has been found that it is more costly to provide an array of elastic members including a large number of elements 110, and that the flexibility of the resulting sole is reduced if larger elements are used. It has also been found that deformable elements that are substantially round or barrel shaped do not flex with the sole of the shoe during use and therefore do not provide continuous support of the user's foot during use. In order to provide better support of the user's foot, the present invention employs the use of oval deformable elements 110 connected by bridging portion 120. Constructed as such, deformable battery 116, for example, can more easily bend along bridging portion 120. Therefore, an aspect of the invention is to align deformable elements 110 such that bridging portions 120 are aligned with flex lines of a foot. The flex lines referred to are generally known in that when a user is walking or running, the sole of the user's foot bends throughout each step. Therefore an aspect of the invention is to construct deformable elements 110 and batteries 116 such that deformable elements 110 can flex with the bend lines of a foot and thereby better follow and maintain contact with the sole of a user's foot.

Another advantage attained by the invention, is that casing or encapsulating bag 114 is formed by a vacuum forming or blow molding which thereby eases and lowers the cost of manufacturing.

Another aspect of the invention is that the arrangement, stiffness and viscoelastic properties of deformable elements are varied throughout positions in the sole in order to match the biomechanics of the user's foot, and preferably, according to the particular athletic activity.

Figures 160-167 show that a deformable element 110 may comprise a single unitary member having either a plurality of holes 124 or none at all to best suit the effect on the foot of the user and to minimize weight where necessary.

Figures 169-178 disclose a variety of arrangements of deformable elements 110 and deformable batteries 116 according to a particular athletic activity. As shown in Figure 169, deformable elements 110 are arranged inside deformable batteries 116 such that bridging portions 120 and 122 are aligned with flex lines of the foot. Therefore, bridging portions 120, 122 allow deformable elements 110 and batteries 116 to flex as the sole of the user's foot flexes during an athletic activity.

The arrangement shown in Figure 169, is optimized for running. A heel unit is aligned with the first contact area of the sole with the ground during the heel strike phase of running gait. The rearmost battery of the heel unit is hinged to the central battery of the heel unit to reduce the accelerating leverage that results from the heel striking a unitary cushioning element. A separate battery of the heel unit is placed toward the arch of a wearer's foot and is made more stiff than the other parts of the heel unit. This arrangement reduces the pronation rate of a wearer and thus reduces the risk of chronic stability related injuries.

A forefoot section of three parts is provided at least under the first and second metatarsal-phalangeal joints of a wearer. This is an area exposed to great stress during the push off phase of the running gait. A narrowed and hinged segmental arrangement is provided in the forefoot area unit and includes a hinge 122 leading to a battery under the wearer's great toe. A hinge 120 between the elements may be provided at any point in the structure such that the hinge is in general alignment with the joints of a wearer's foot or is oriented to match with the rotational distortion of the sole and midsole resulting from their

flexion and compression during foot contact with the ground common to running.

Figures 170 through 173 show alternative embodiments for arrangements optimized for running. Figure 170 includes a separate element placed on the medial border of the sole, generally under the wearer's arch. This has a greater stiffness then the other elements in the heel area of this arrangement to reduce the degree or rate of pronation of a wearer's foot during running. The forefoot has two separate elements with an area of separation corresponding generally to the metatarsal-phalangeal joints of a wearer. Figure 171 includes a forefoot pad under the first, second and third metatarsal-phalangeal joints of a wearer. The barrel elements shown therein are ovoid and their longitudinal axis is generally aligned with the flex lines of a wearer's foot to permit greater ease of flexion.

Figure 172 shows a heel element with a hinged portion between the central heel cushioning portion and a lateral cushioning portion positioned to absorb some impact energy upon the heel striking the same. The hinging reduces the tendency of a heel to act as a unitary plate of material and thus reduces the leveraged acceleration of the sole towards the ground. This in turn reduces the rate of pronation of a wearer.

Figure 173 shows a heel element with a hinged portion between the central heel cushioning portion and a lateral cushioning portion positioned to absorb some impact energy at heel strike. The rear lateral border of the pad is positioned away from the outside border of the sole and midsole to permit encapsulation of the parts with a foam such as PU or EVA.

Similarly, Figures 174 through 177 illustrate arrangements optimized for basketball. Figure 174 shows a sole including two heel and two forefoot elements divided about a generally longitudinal axis. This division reduces the tendency of the cushioning elements to act as a monolithic sheet and thus reduces the leveraged acceleration resulting from forceful ground impacts on the lateral or medial borders of the shoe. These impacts may occur during landing on a court surface after jumping in the air.

Figure 175 includes cushioning elements at the rear of the heel to protect the wearer from impact shock during running on a court surface. The forefoot includes a laterally placed element. This reduces the tendency of the sole to collapse under the forefoot lateral border during the motion known as cutting, or the application of other rapid lateral shearing forces to the shoe.

Figure 176 provides a heel cushion for court running actions and a forefoot pad positioned in from the borders of the sole. This permits full encapsulation of the element in foam to reduce manufacturing costs while still permitting a user the extraordinary benefits of the cushioning elements featured in this invention.

Figure 177 shows a shoe sole including a heel cushioning element provided for comfort during the running phase of basketball game. This is positioned inward from the border of the sole to permit full encapsulation of the part in foam.

Finally, Figure 178 illustrates an arrangement optimized for tennis. Figure 178 shows a sole featuring two aspects of the present invention. The heel provides cushioning under calcaneus of a wearer during the heel strike motions associated with lunging for a stroke or running on the heels. A separate forefoot section cushions the foot under the first four metatarsal-phalangeal joints of a wearer. This is an area exposed to stress by the motions of service and many movements needed to position a player for optimum return strokes.

Obviously, numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

WHAT IS CLAIMED IS:

1. An article of footwear, which comprises:

a vamp;

a lower support connected to said vamp, said lower support including a midsole; and

at least one insert mounted in said midsole and which includes first and second airtight casings each having a plurality of elements positioned therein which are elastically deformable such that the biomechanics of a foot of a user are optimized, said first and second casings being interconnected by a bridging portion for permitting flexibility between said first and second casings, said deformable elements being interconnected by integral bridging portions for permitting flexibility between the deformable elements, said deformable elements each having a substantially oval-shaped horizontal cross-section, and wherein said bridging portion of said first and second casings is aligned with a flex line of the foot of the user.

2. An article of footwear as claimed in claim 1, wherein the air pressure in said casing is less than atmospheric pressure.

3. An article of footwear as claimed in claim 1, wherein said deformable elements comprise cored elements for reducing the weight thereof.

4. An article of footwear as claimed in claim 2, wherein said deformable elements comprise dimpled elements for reducing the weight thereof.

5. An article of footwear as claimed in claim 1, wherein said bridging portions are integrally formed with said casing.

6. An article of footwear as claimed in claim 1, wherein said deformable elements are located in at least one of the heel portion, lateral portion, forefoot portion and metatarsal portion of the lower support.

7. An article of footwear as claimed in claim 1, wherein said elements comprise cored elements for reduction of weight of said elements.

8. An article of footwear as claimed in claim 1, wherein said bridging portions are connected to said airtight casing.

9. An article of footwear as claimed in claim 1, wherein said elements comprises batteries of a least three elements that are interconnected by bridging portions.

10. An article of footwear as claimed in claim 1, which comprises a hinge member which interconnects adjacent elements wherein said hinge member is one of a hinge in alignment with a least one joint of a wearer's foot and a hinge which is oriented to match a rotational distortion thereof.

11. An article of footwear as claimed in claim 1, wherein at least one of said elements is located on a medial border of a sole portion of the shoe so as to be

positioned substantially beneath an arch portion of the foot.

12. An article of footwear as claimed in claim 1, wherein said elements include an element located in a heel portion of the midsole and wherein said at least one element has a stiffness greater than said element located at the heel portion of the midsole so as to reduce the degree of pronation of the foot of the user during running.

13. An article of footwear as claimed in claim 11, wherein a forefoot portion of said at least one element comprises two adjacent separate elements with an area of separation therebetween corresponding generally to a metatarsal-phalangeal joint of the foot of the user.

14. An article of footwear as claimed in claim 11, wherein a portion of said at least one element includes a forefoot pad located under a first, second and third metatarsal-phalangeal joint of the foot.

15. An article of footwear as claimed in claim 11, wherein said at least one element includes a plurality of ovoid barred elements having a longitudinal axis aligned with flex lines of the user's foot to permit greater ease of flexion.

16. An article of footwear as claimed in claim 1, wherein said at least one insert comprises a heel insert having a central heel cushioning portion and a lateral cushioning portion with a hinged portion interconnecting said central heel cushioning portion and said lateral

cushioning portion for absorbing impact forces from the heel of the foot of the user and for reducing leveraged acceleration of the sole towards the ground as well as a rate of pronation of the user.

17. An article of footwear as claimed in claim 1, wherein said at least one insert comprises a heel insert having a central heel portion, a lateral cushioning portion and a hinged portion interconnecting said central heel portion and said lateral cushioning portion.

18. An article of footwear as claimed in claim 17, wherein a rear lateral border portion of said insert is distanced from an outside border of the sole and midsole to permit encapsulation of insert with a foam member.

19. An article of footwear as claimed in claim 1, wherein said insert comprises first and second heel elements and first and second forefoot elements divided about a substantially longitudinal axis so as to reduce leveraged acceleration of the foot of the user.

20. An article of footwear as claimed in claim 1, wherein said insert comprises a plurality of cushioning elements located at a rear portion of the heel and at least one laterally positioned forefoot element to reduce any tendency of the sole to collapse under a forefoot lateral border portion of the sole during a cutting motion of the user when running.

21. An article of footwear as claimed in claim 20, wherein said at least one laterally positioned forefoot element comprises a single element.

22. An article of footwear as claimed in claim 1, wherein said insert comprises at least one heel element and a forefoot pad positioned inwardly from adjacent borders of the sole to permit encapsulation thereof in the sole.

23. An article of footwear as claimed in claim 1, wherein said insert comprises a heel cushioning element positioned inwardly from an adjacent border of the sole to permit full encapsulation of said element in the midsole.

24. An article of footwear as claimed in claim 1, wherein said insert comprises a heel element for providing cushioning under the calcaneus portion of the foot and a separate forefoot element for cushioning the foot under the first four metatarsal-phalangeal joints of the foot.

25. A method of forming an insert for an article of footwear, which comprises:

forming at least one insert from a plurality of interconnected elements;

inserting said elements into first and second casings so as to be positioned in a midsole portion of an article of footwear such that the biomechanics of a foot of a user wearing the article of footwear are optimized wherein the step of forming the interconnected element comprises forming at least two batteries of deformable

elements so as to be respectively positioned in said first and second casings wherein said deformable elements are each substantially oval-shaped in horizontal cross-section, the step of forming the elements comprising forming at least two batteries of said deformable elements, and interconnecting said first and second casings by a bridging portion wherein the step of forming the deformable elements comprises interconnecting said deformable elements by integral bridging portions.

26. The method as claimed in claim 25, wherein the step of forming the interconnected element comprises forming elements which are substantially oval shaped in cross-section.

27. The method as claimed in claim 25, wherein the step of forming the elements comprises forming cored elements for reduction of weight of said elements.

28. The method as claimed in claim 25, wherein the step of forming the elements comprises forming elements which are interconnected by bridging portions.

29. The method as claimed in claim 28, which comprises interconnecting the bridging portions with an airtight casing.

30. The method as claimed in claim 25, wherein the step of forming of the elements comprises forming elements as batteries of at least three elements and interconnecting said batteries by bridging portions.

31. The method as claimed in claim 25, which comprises interconnecting adjacent elements of said plurality of elements with hinge members wherein said hinge members comprise one of hinge members in alignment with at least one joint of the user's foot and a hinge oriented so as to match a rotational distortion thereof.

32. A method as claimed in claim 25, which comprises the step of forming the elements such that at least one of the elements is located on a medial border of a sole portion of the shoe so as to be positioned substantially beneath an arch portion of the foot.

33. The method as claimed in claim 25, wherein the step for forming the elements so as to include an element located in a heel portion of the midsole and forming at least one of said elements so as to have a stiffness greater than the element located at the heel portion of the midsole so as to reduce a degree of pronation of the foot during running.

34. The method as claimed in claim 25, which comprises locating at least one of the elements in a forefoot portion of the shoe so as to have two adjacent separate elements with an area of separation therebetween corresponding generally to a metatarsal-phalangeal joint of the foot.

35. The method as claimed in claim 25, which comprises locating at least one of the elements in a forefoot portion of the sole so as to include a forefoot

pad located under a first, second and third metatarsal-phalangeal joint of the foot.

36. The method as claimed in claim 32, wherein the forming of the elements comprises forming at least one element so as to include a plurality of ovoid barrel elements having a longitudinal axis aligned with flex of the user's foot to permit greater ease of flexion.

37. The method as claimed in claim 25, wherein the step of inserting at least one insert comprises inserting at least one insert in a central heel cushioning portion of the midsole and locating a lateral cushioning portion interconnecting the central heel cushioning portion and the lateral cushioning portion so as to absorb impact forces from the heel portion of the foot and to reduce leveraged acceleration of the midsole towards the ground as well as a rate of pronation.

38. The method as claimed in claim 25, wherein inserting the insert comprises inserting a heel insert into the midsole having a central heel portion, a lateral cushioning portion and a hinge portion interconnecting the central heel portion and said lateral cushioning portion.

39. The method as claimed in claim 38, which comprises distancing a rear lateral border portion of said insert from an outside border of the shoe and the midsole to permit encapsulation of the insert with the foam member.

40. The method as claimed in claim 25, wherein the step of inserting the insert comprises inserting an

insert having at least first and second heel elements and first and second forefoot elements and divided about a substantially longitudinal axis so as to reduce leveraged acceleration on the foot.

41. The method as claimed in claim 25, wherein the step of inserting the insert comprises inserting an insert having a plurality of cushioning elements located at a rear portion of the heel and at least one laterally positioned forefoot element to reduce any tendency of the sole to collapse under a forefoot lateral border portion on the midsole during a cutting motion of the user when running.

42. The method as claimed in claim 41, wherein at least said laterally positioned forefoot element comprises a single element.

43. The method as claimed in claim 25, wherein the step of inserting the insert comprises inserting an insert having at least one heel element and a forefoot pad positioned inwardly from adjacent borders of the midsole so as to permit encapsulation thereof in the midsole.

44. The method as claimed in claim 25, wherein the step of inserting the insert comprises inserting a heel cushioning element positoned inwardly from an adjacent border of the midsole to permit full encapsulation of the element in the midsole.

45. The method as claimed in claim 25, wherein the step of inserting the insert comprises inserting an

insert which includes a heel element for providing cushioning under the calcaneus portion of the foot and a separate forefoot element for cushioning the foot under the first four metatarsal-phalangeal joints of the foot.

46. An article of footwear as claimed in claim 1, wherein said elements are substantially H-shaped in vertical cross-section.

47. An article of footwear as claimed in claim 1, wherein said elements are substantially H-shaped in vertical cross-section.

48. A method as claimed in claim 25, wherein the step of forming the elements comprises forming elements which are substantially H-shaped in vertical cross-section.

49. An article of footwear as claimed in claim 1, wherein said first casing is substantially circular in horizontal cross-section and said second casing is substantially arcuate shaped in horizontal cross-section.

50. A method claimed in claim 25, wherein the inserting of said elements into the first and second casing comprises inserting said elements into a first casing having a substantially circularly shaped horizontal cross-section and into a second casing having a substantially arcuate shaped horizontal cross-section.

51. An article of footwear, which comprises:

a vamp;

a lower support connected to said vamp, said lower support including a midsole; and

at least one insert mounted in said midsole and which includes firsts and second airtight casings each having a plurality of elements positioned therein which are elastically deformable such that the biomechanics of a foot of a user are optimized, said first and second casings being interconnected by a bridging portion aligned with a flex line of the foot of a user, and said deformable elements being interconnected by integral bridging portions for permitting flexibility between the first and second castings.

52. An article of footwear as claimed in claim 51, wherein said bridging portion of said first and second casings is aligned with a flex line of the foot of the user.

53. A method of forming an insert for an article of footwear, which comprises:

forming at least one insert from a plurality of interconnected deformable elements;

inserting said elements into first and second casings so as to be positioned in a midsole portion of the article of footwear upon insertion of the insert therein, and

interconnecting said first and second casings by a bridging portion aligned with a flex line of the foot of a user.

54. The method as claimed in claim 29, wherein said bridging portion of said first and second casings are aligned with a flex line of the foot of the user.

FIG. 6

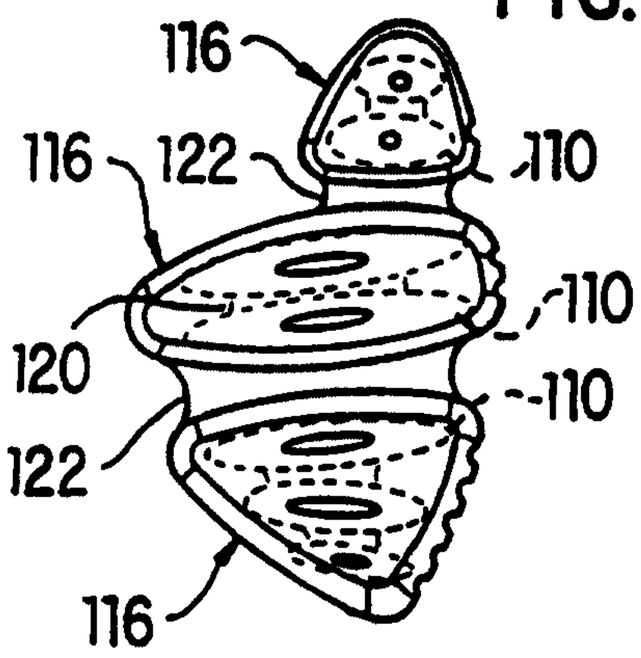


FIG. 1

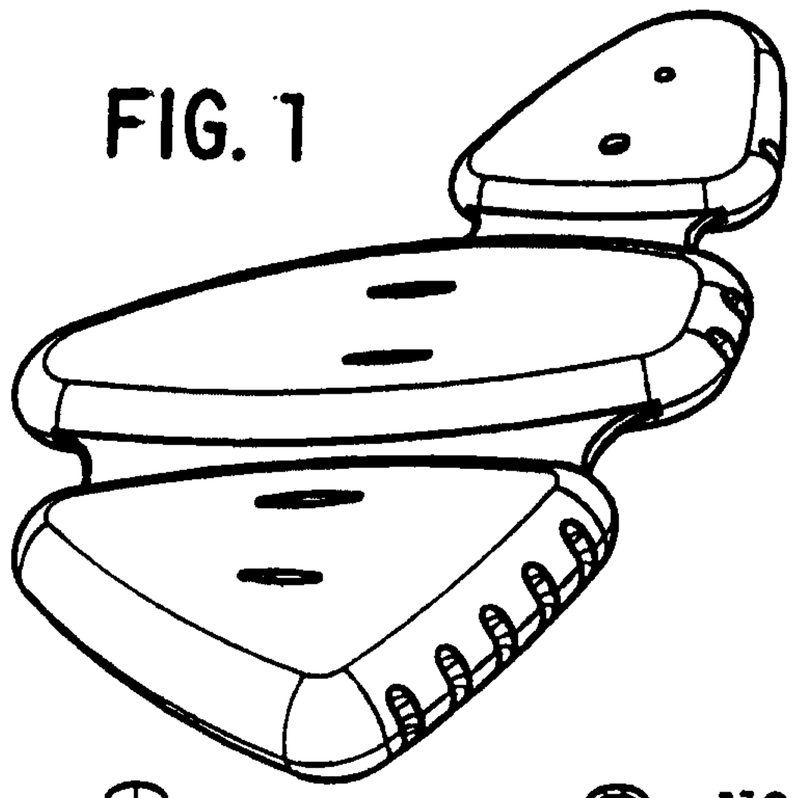


FIG. 2

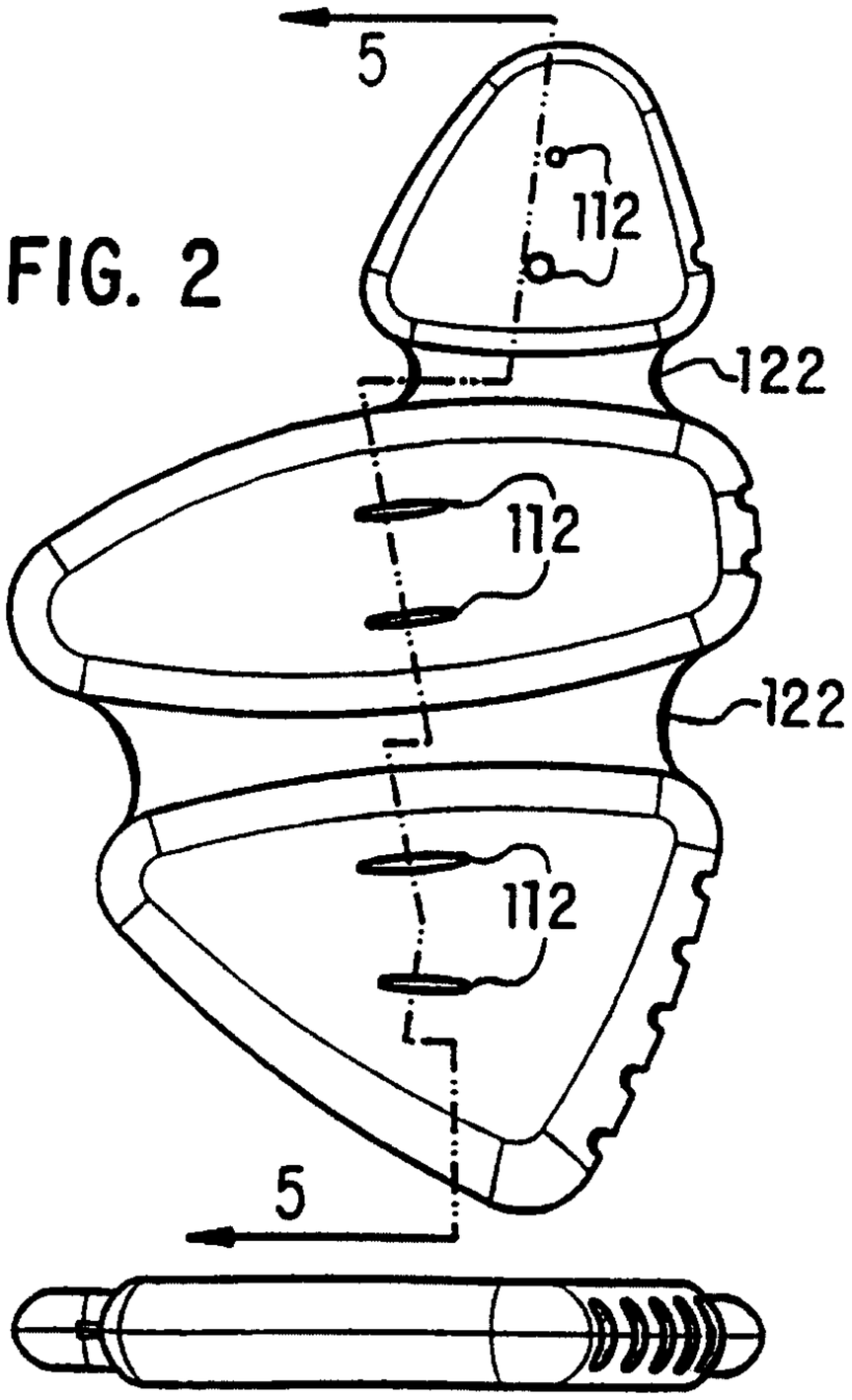


FIG. 3

FIG. 4

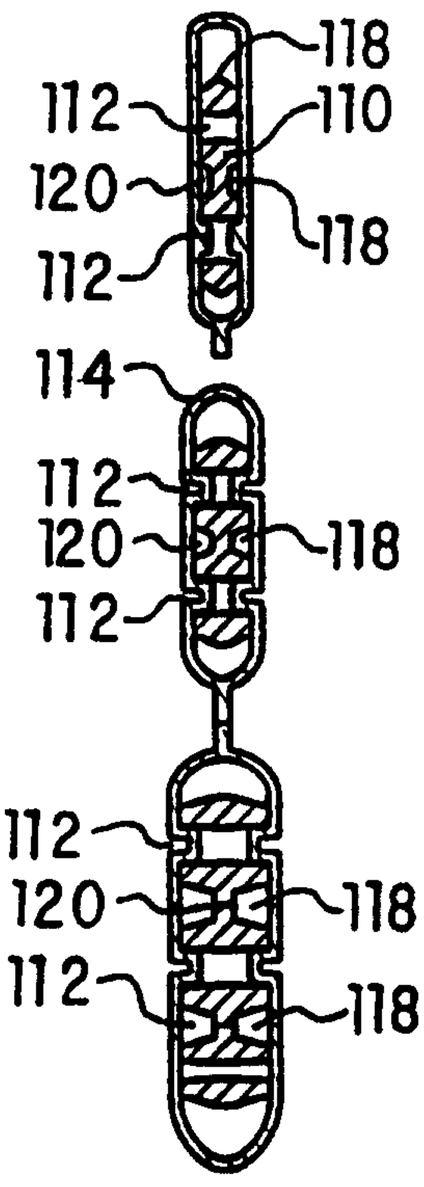


FIG. 5

FIG. 13

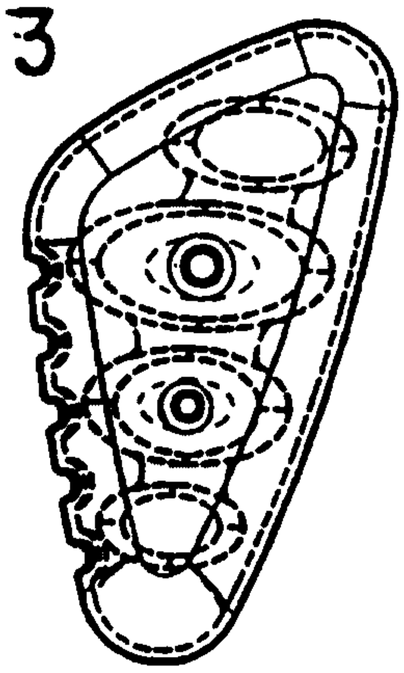
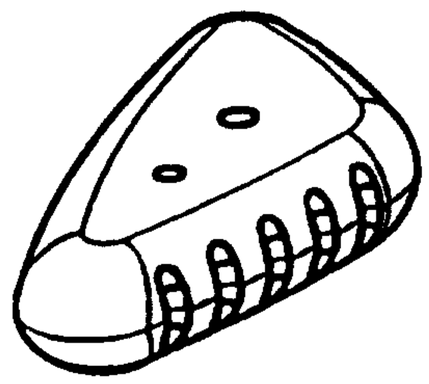


FIG. 7



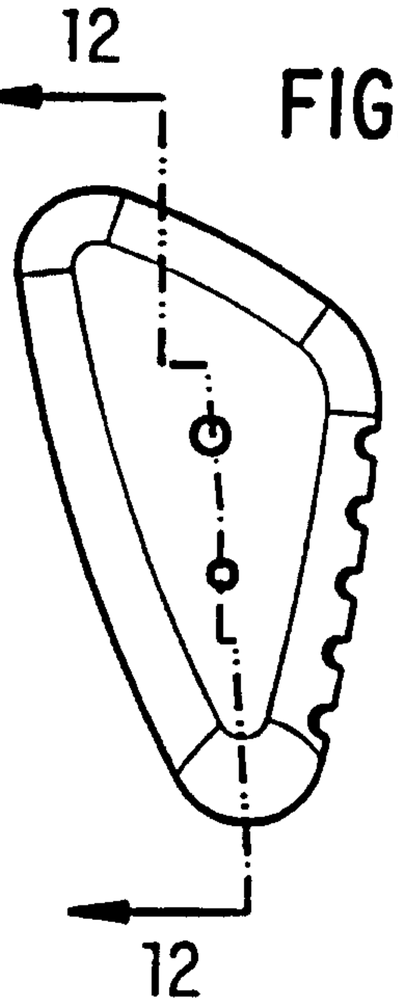


FIG. 8

FIG. 11

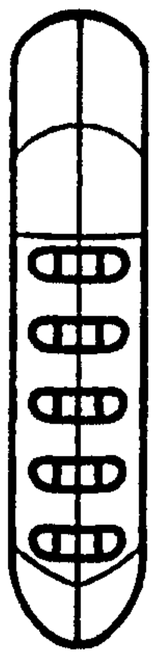


FIG. 12

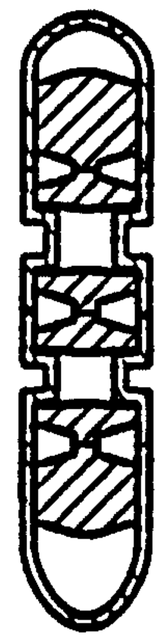


FIG. 10

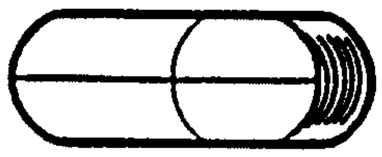


FIG. 9

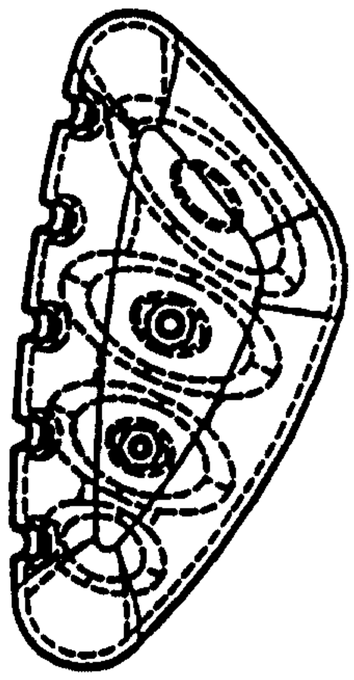


FIG. 20

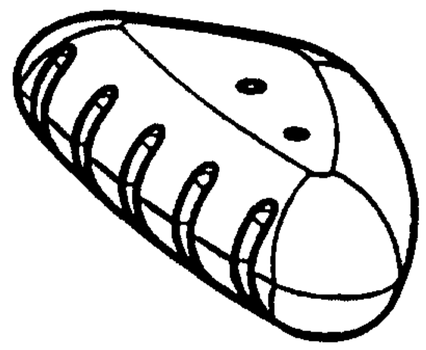
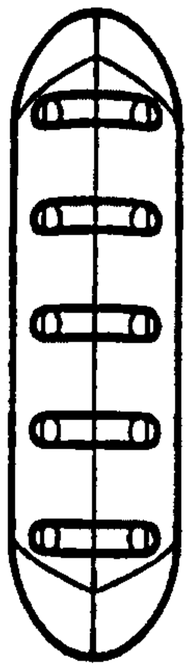


FIG. 14

FIG. 17



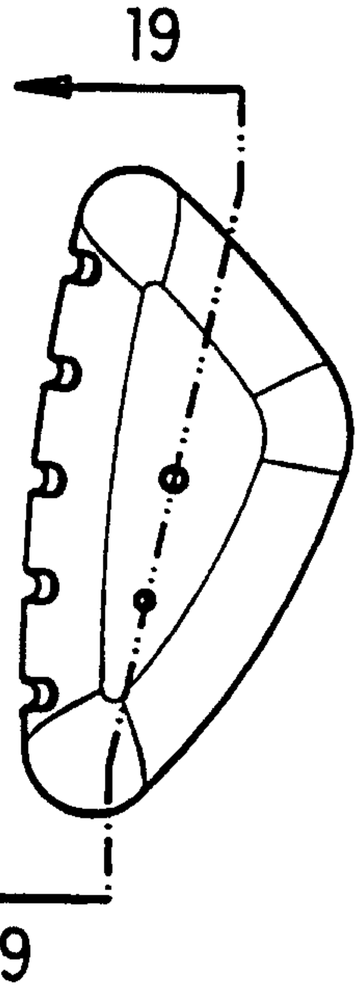


FIG. 15

FIG. 18

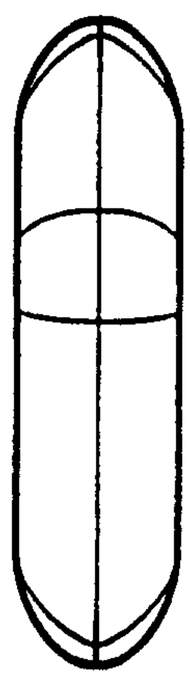


FIG. 19

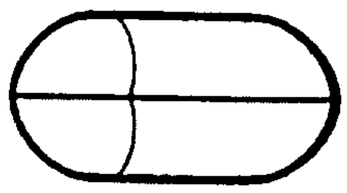
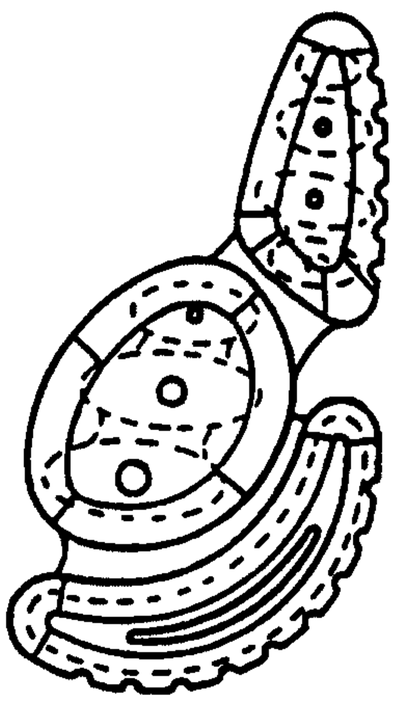


FIG. 16

FIG. 26



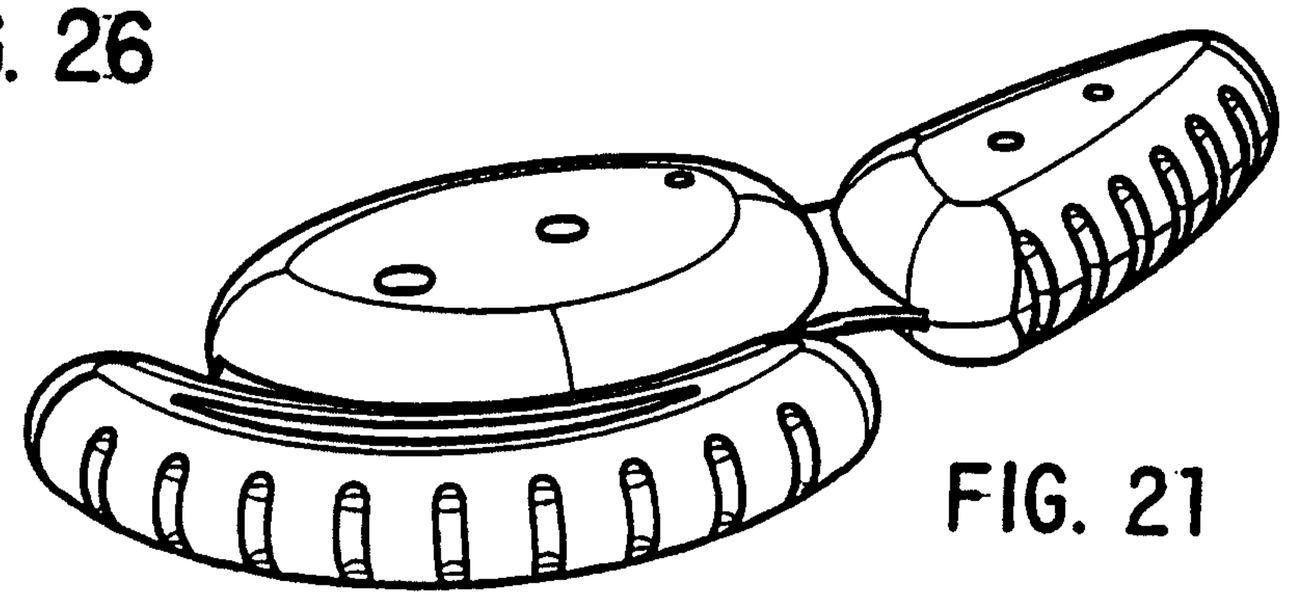


FIG. 21

FIG. 22

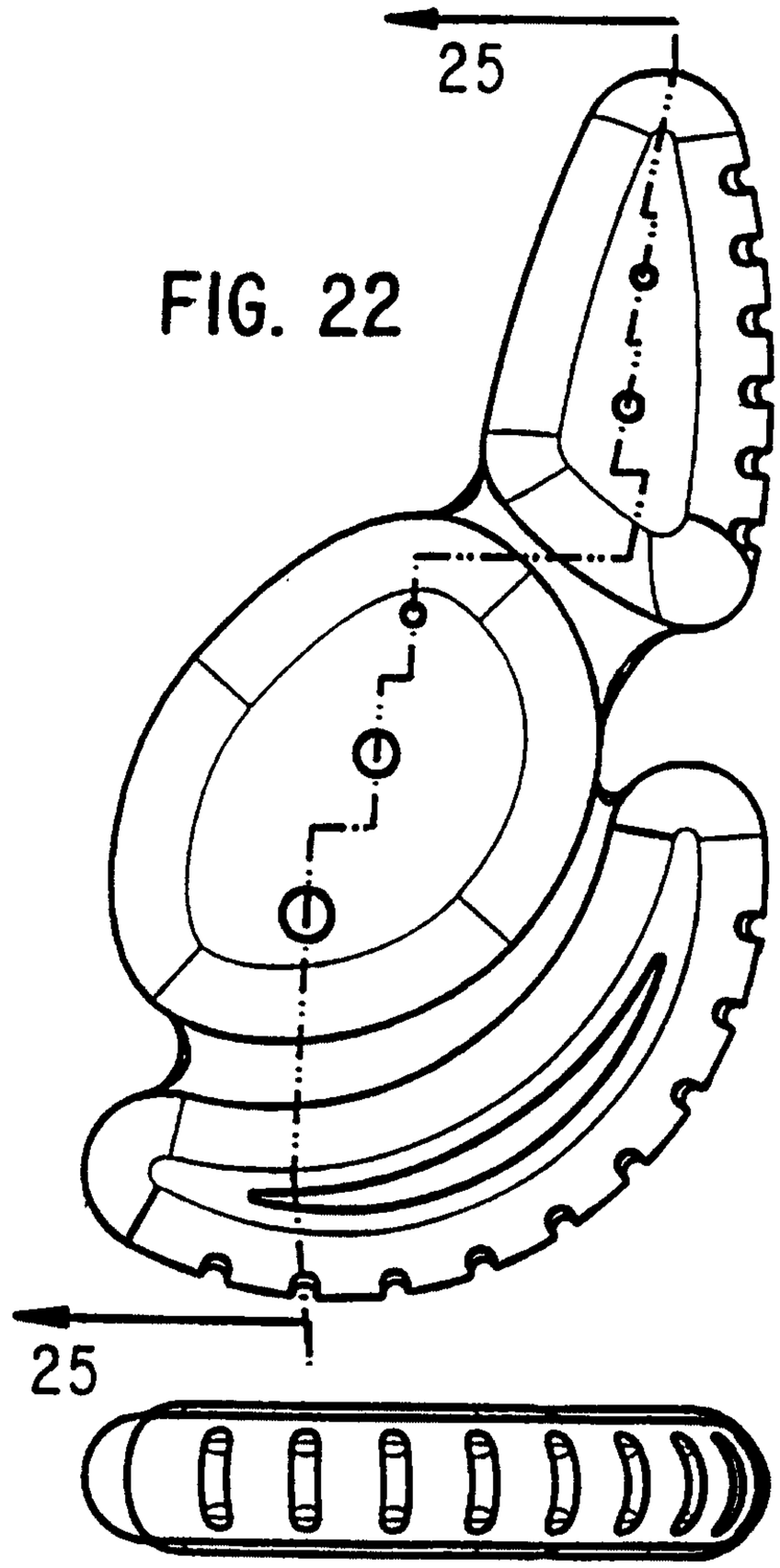


FIG. 23

FIG. 24

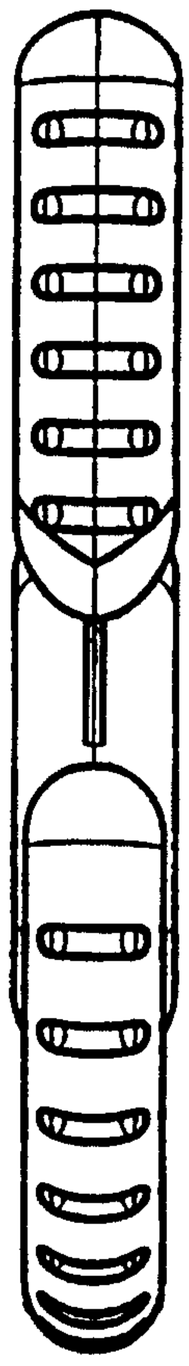


FIG. 25

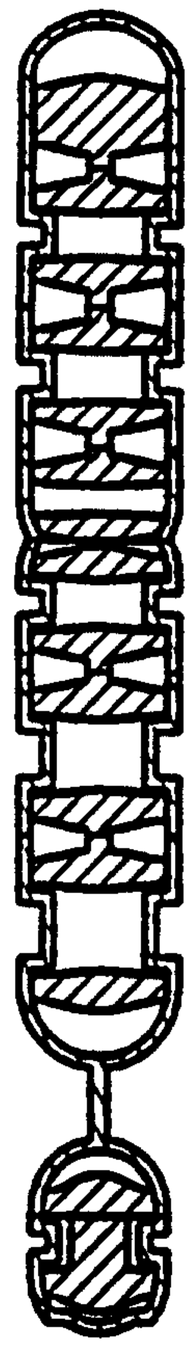


FIG. 33

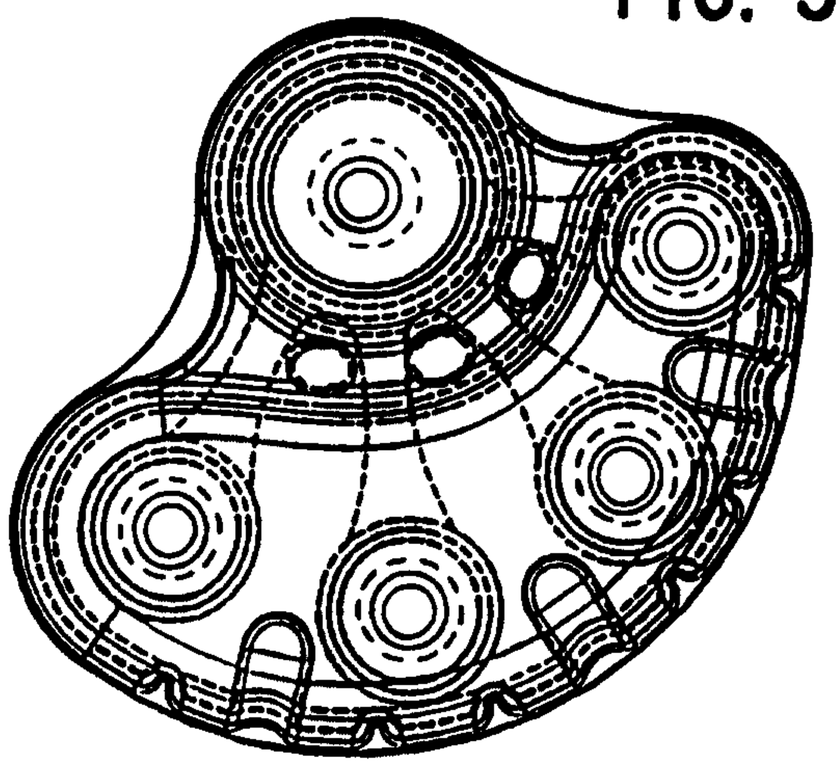


FIG. 27

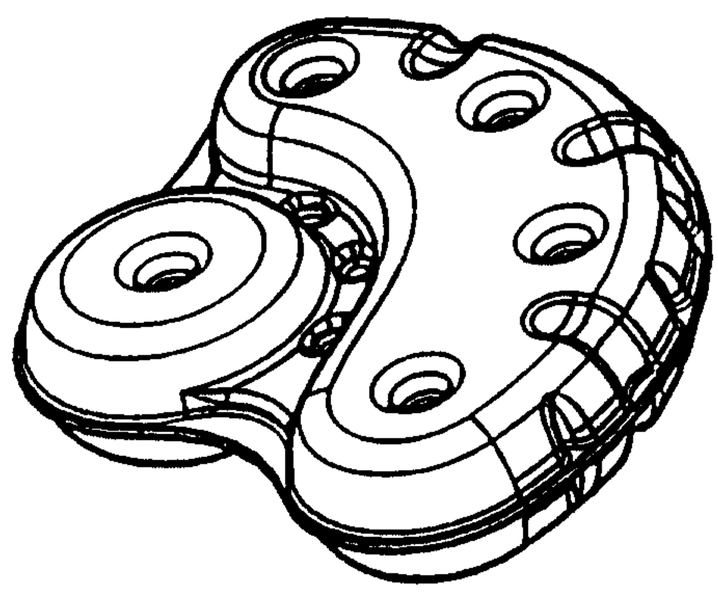
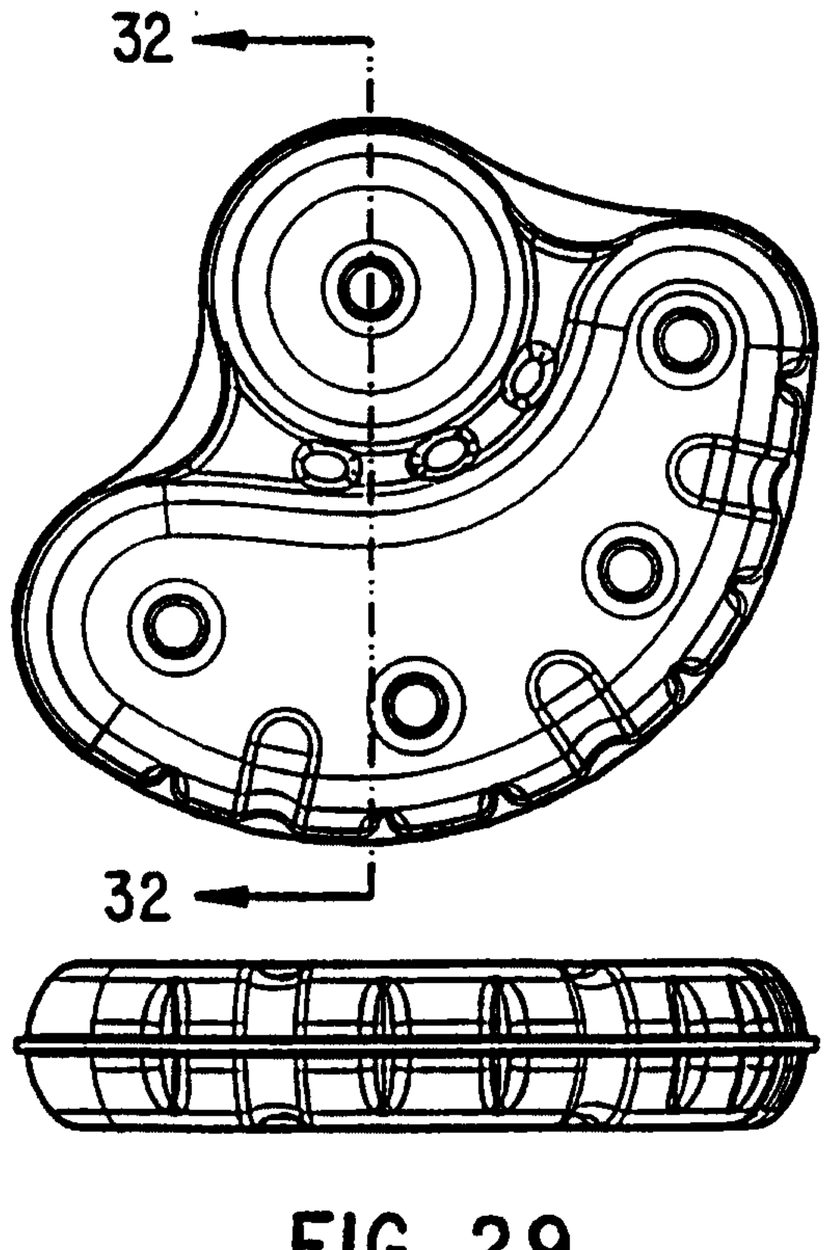


FIG. 28



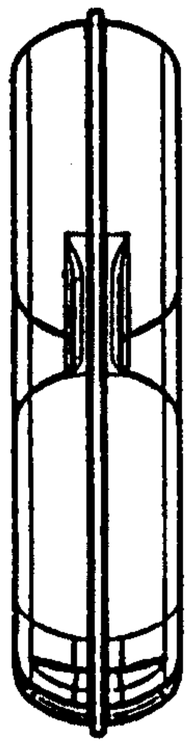


FIG. 30

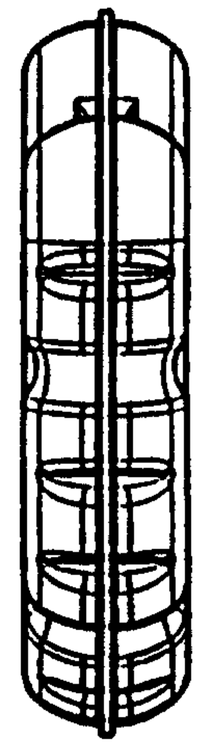


FIG. 31

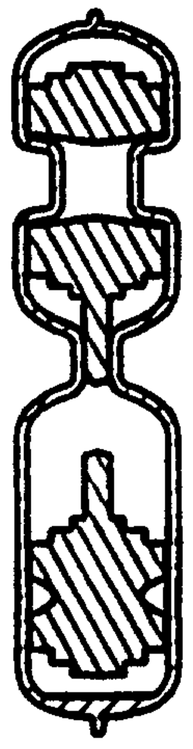


FIG. 32

FIG. 29

FIG. 40

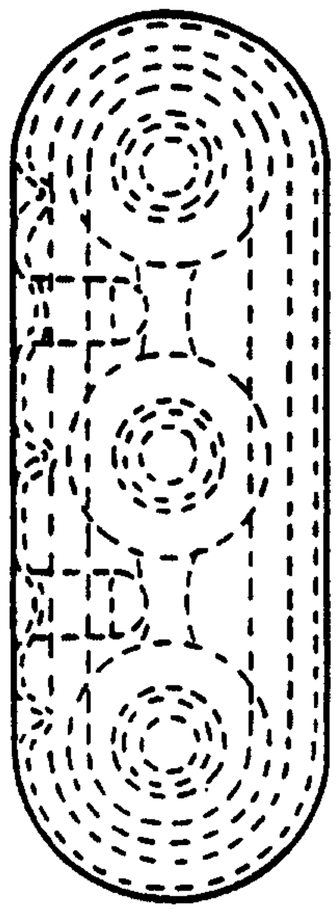


FIG. 34

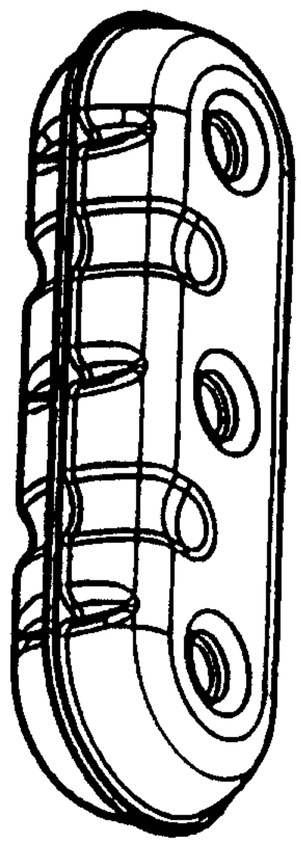


FIG. 37

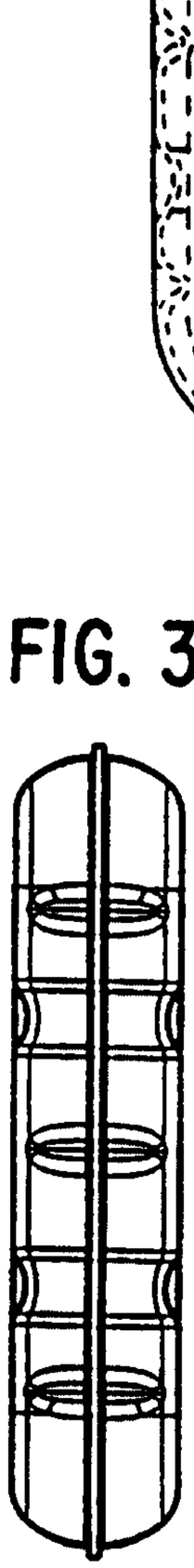


FIG. 35

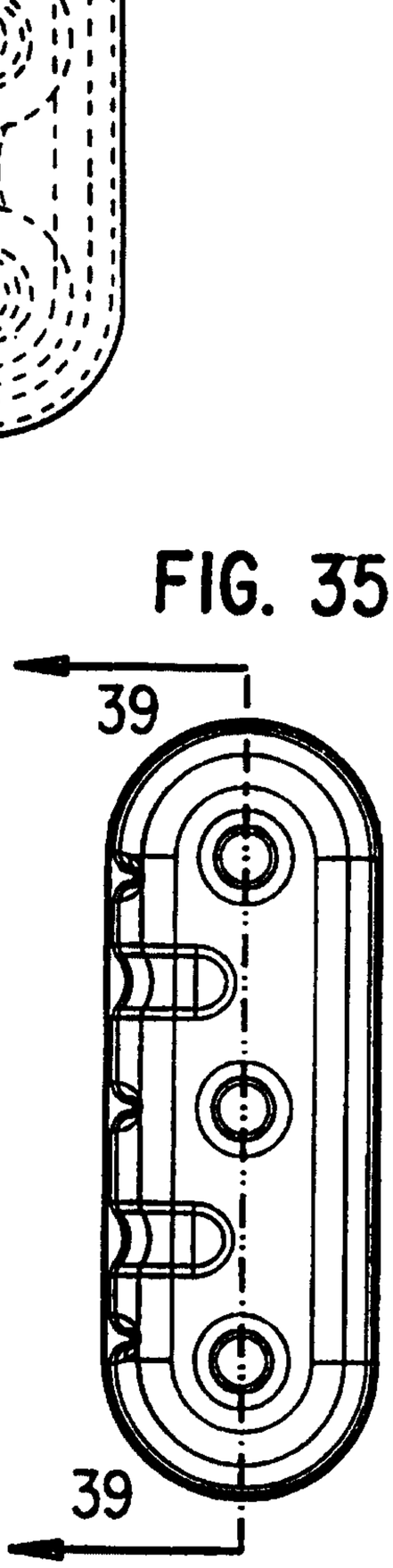


FIG. 38

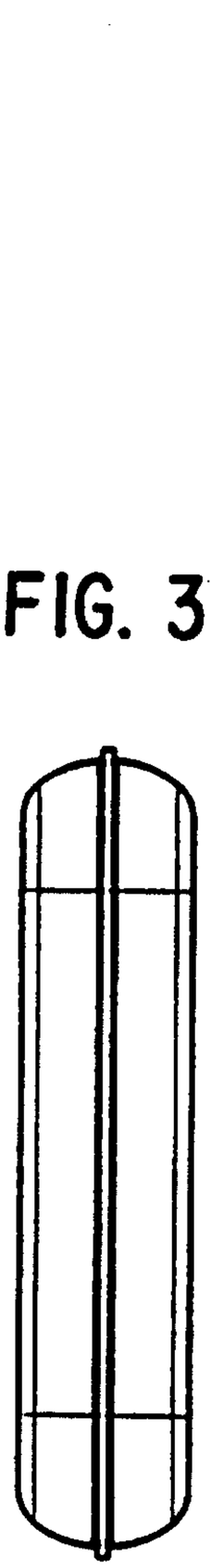


FIG. 39

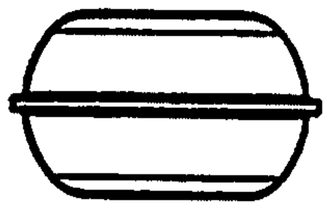


FIG. 36

FIG. 47

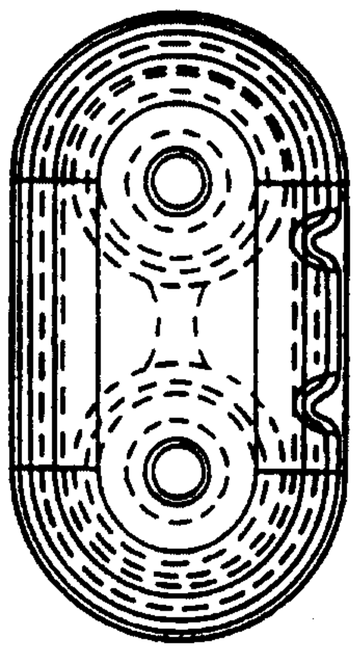


FIG. 41

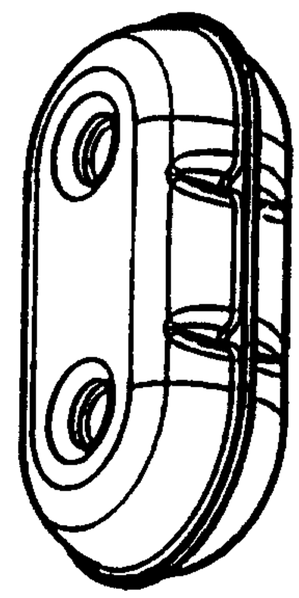


FIG. 44

FIG. 42

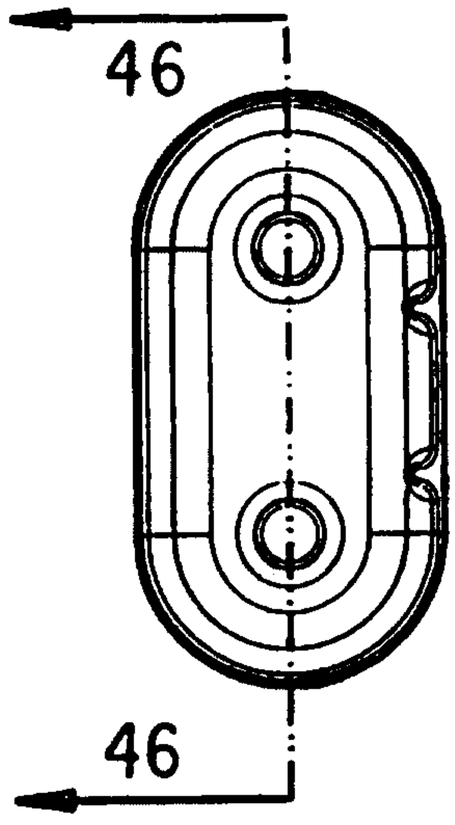


FIG. 45

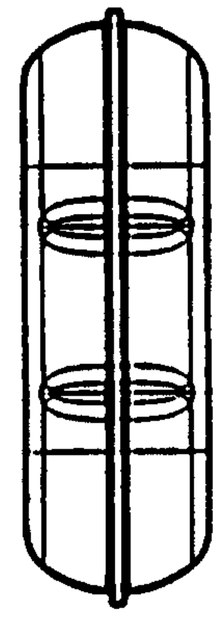
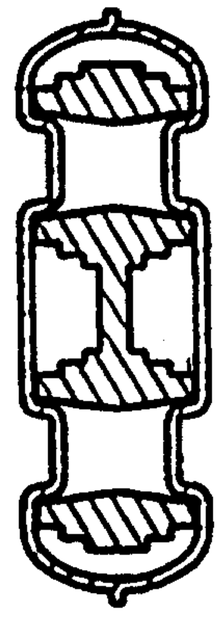


FIG. 46



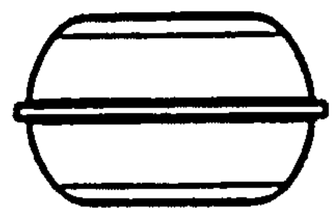


FIG. 43

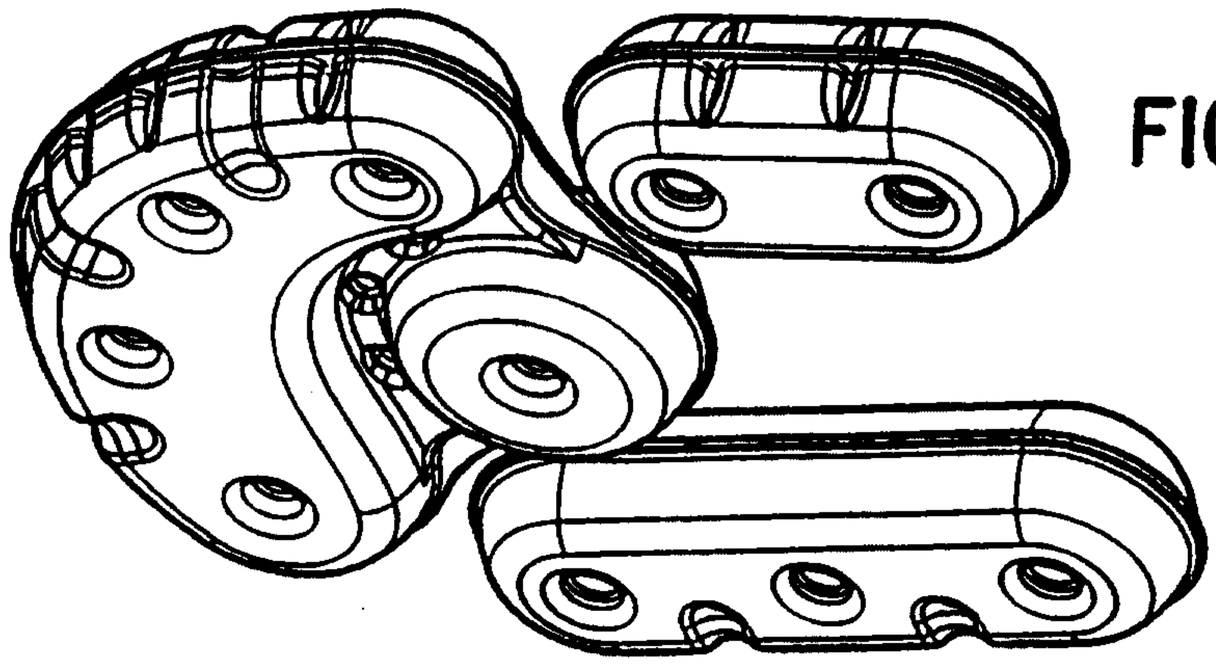


FIG. 48

FIG. 51

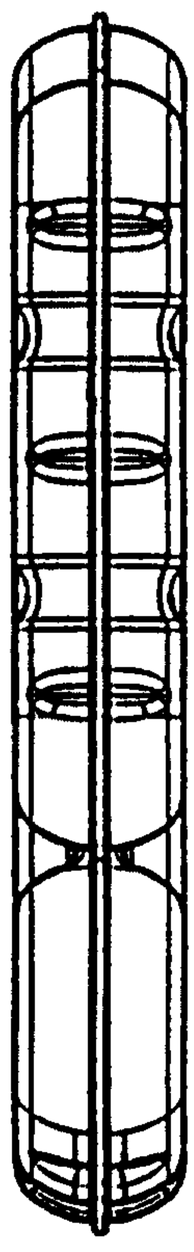


FIG. 49

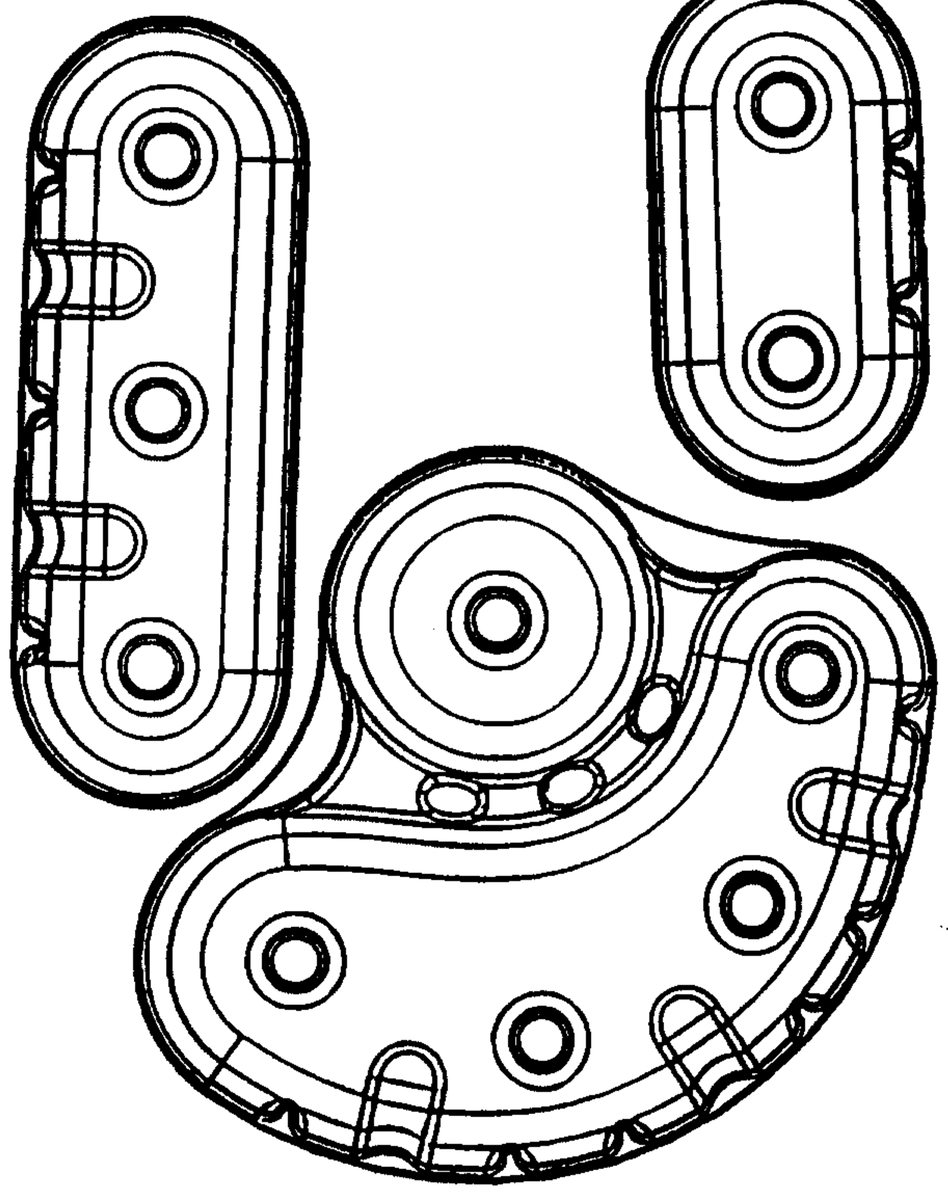
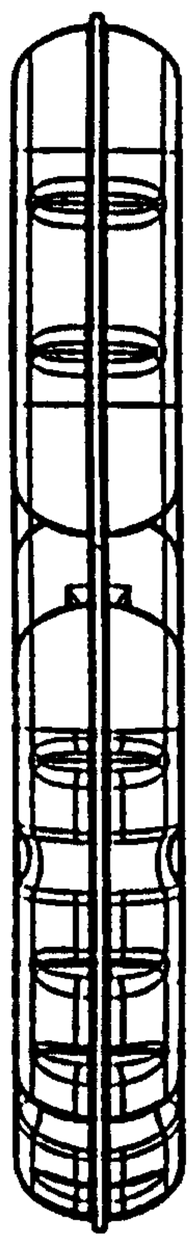


FIG. 52



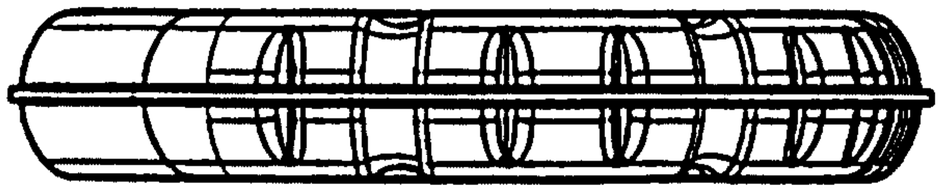


FIG. 50

FIG. 59

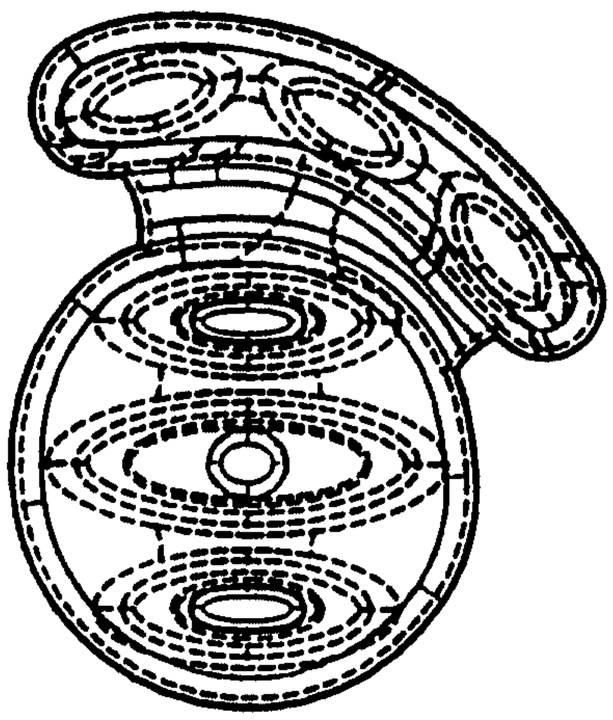
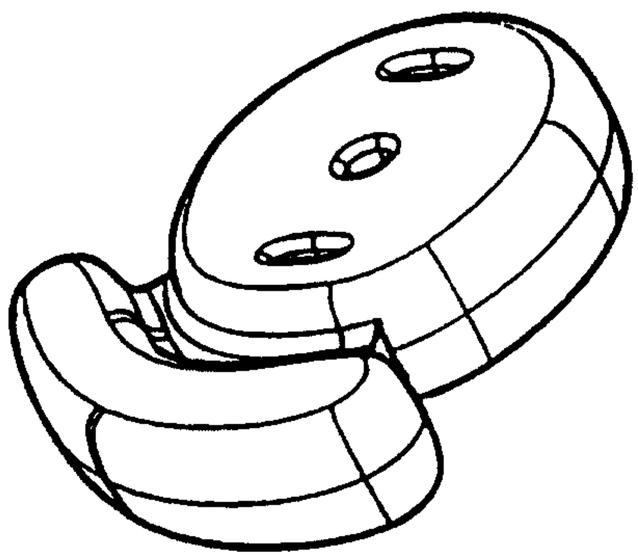


FIG. 53



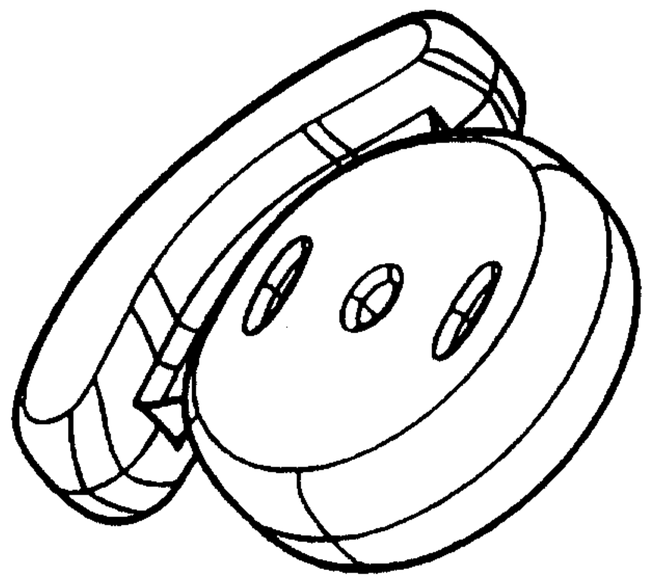


FIG. 54

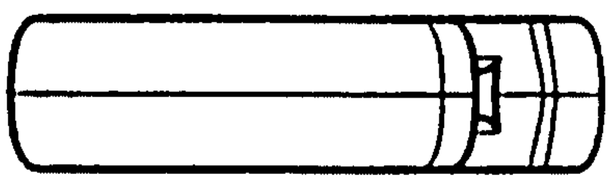


FIG. 56

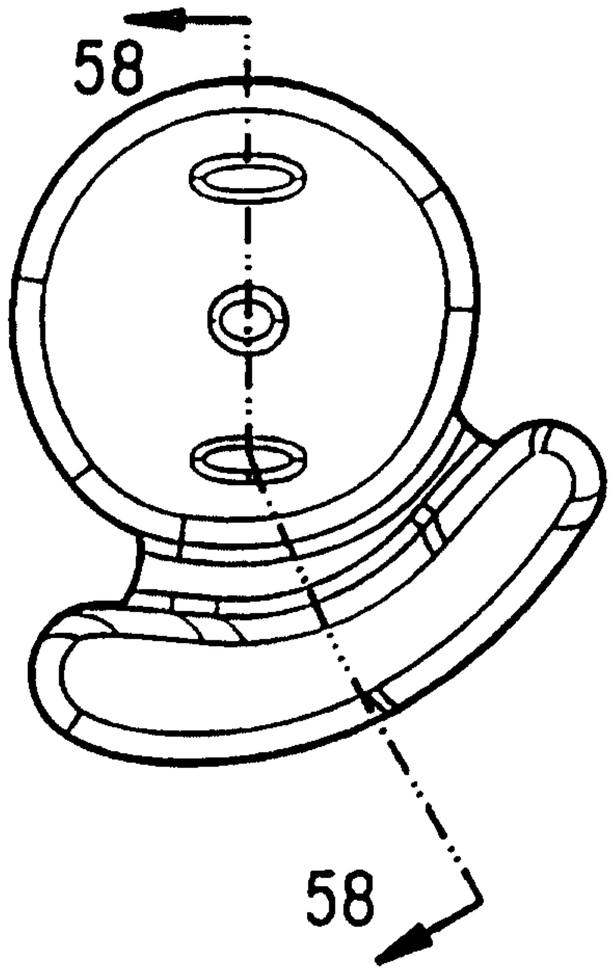


FIG. 55

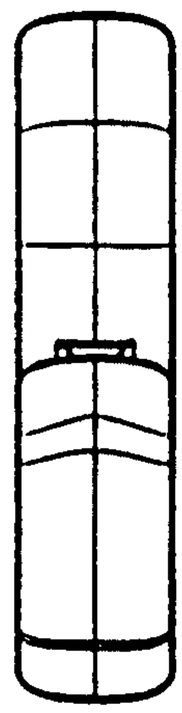


FIG. 57

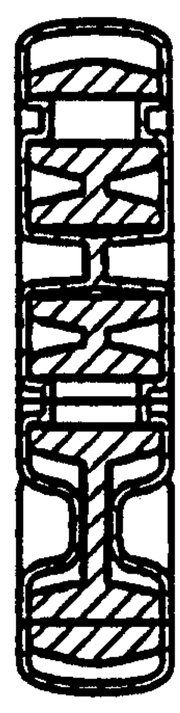


FIG. 58

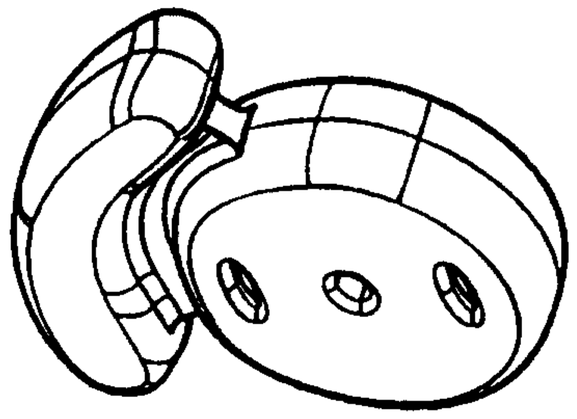


FIG. 60

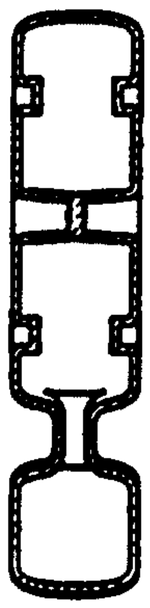


FIG. 67

FIG. 63

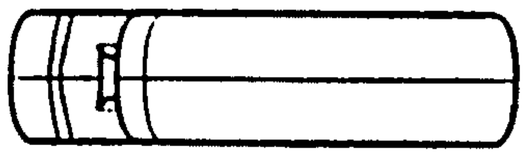


FIG. 61

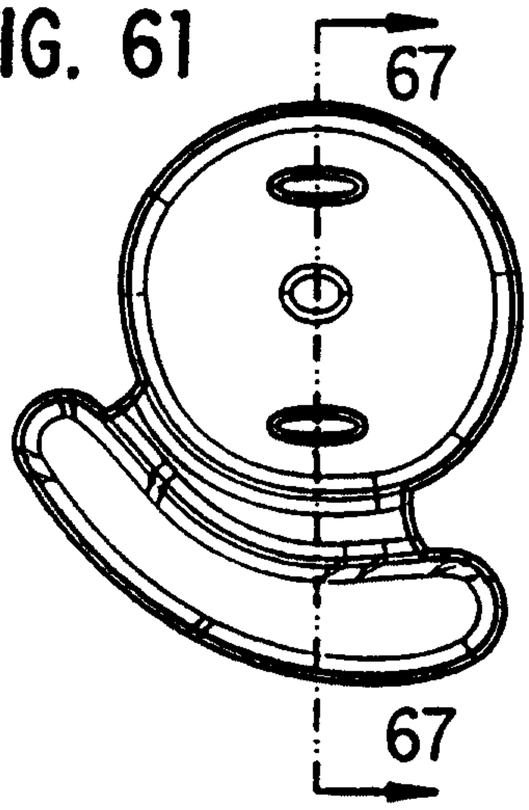


FIG. 64

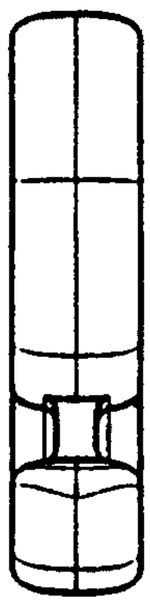


FIG. 65

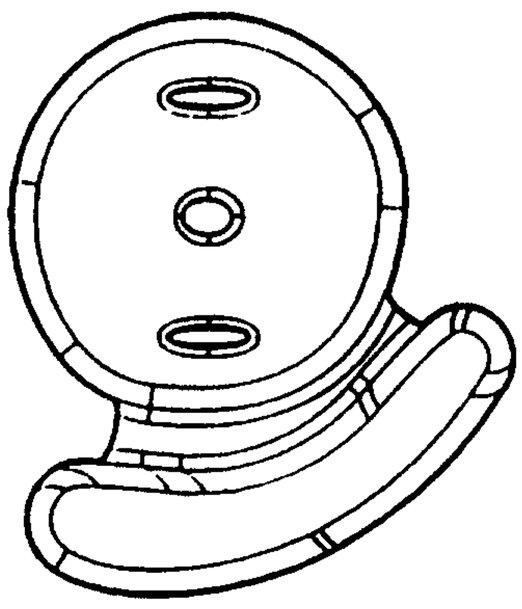


FIG. 66

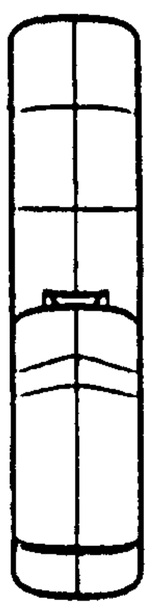


FIG. 62

FIG. 69

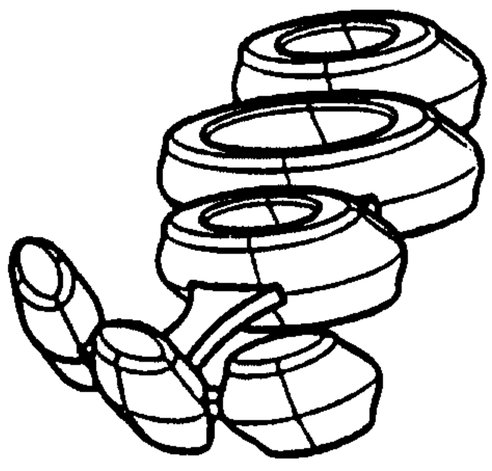


FIG. 68

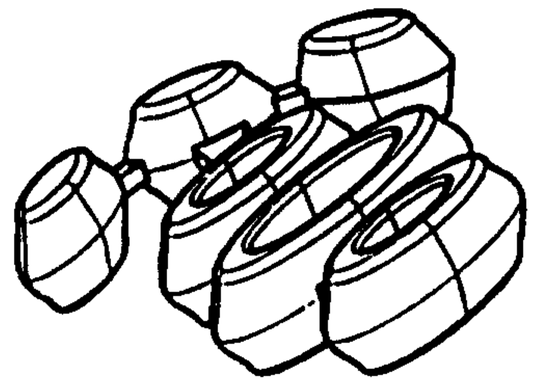


FIG. 75

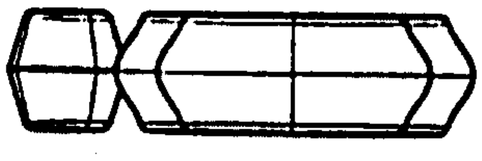


FIG. 76

FIG. 73

FIG. 72

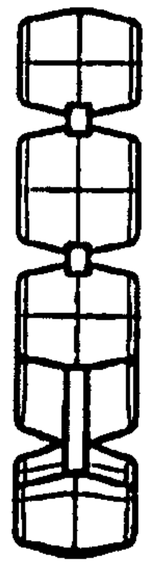


FIG. 70

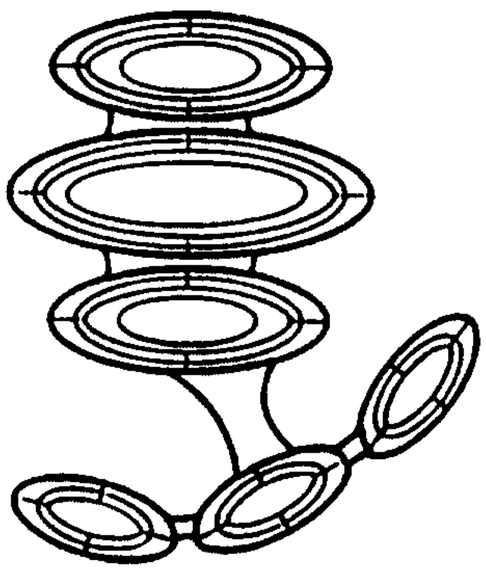


FIG. 71

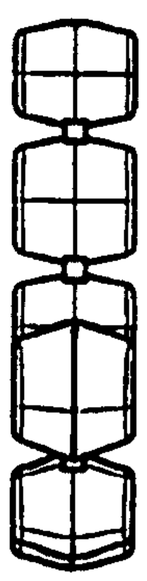
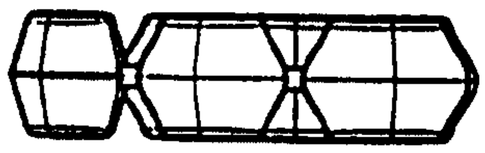


FIG. 74



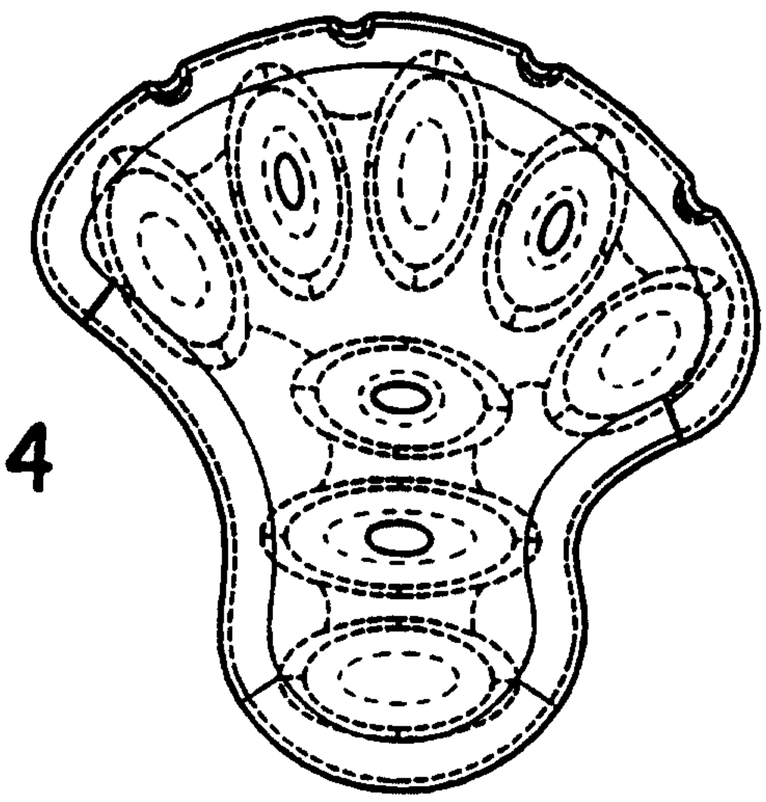


FIG. 84

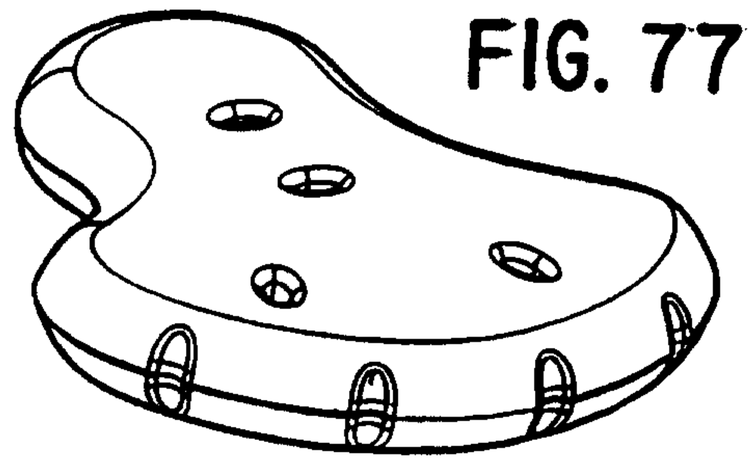


FIG. 77

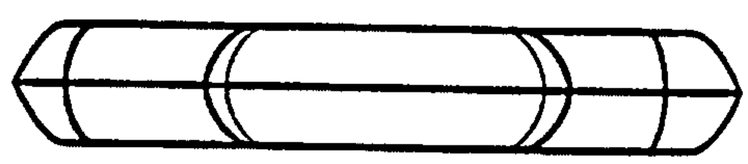


FIG. 81

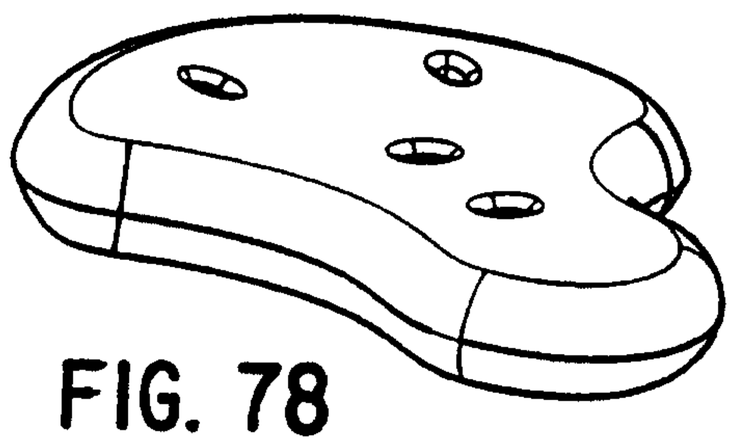


FIG. 78

FIG. 83

FIG. 79

FIG. 82

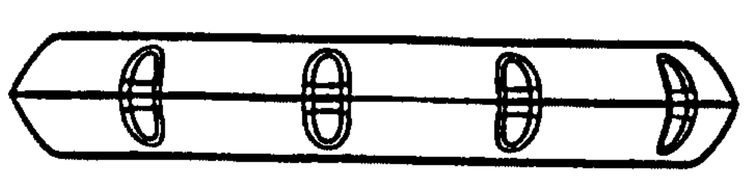


FIG. 80

FIG. 93

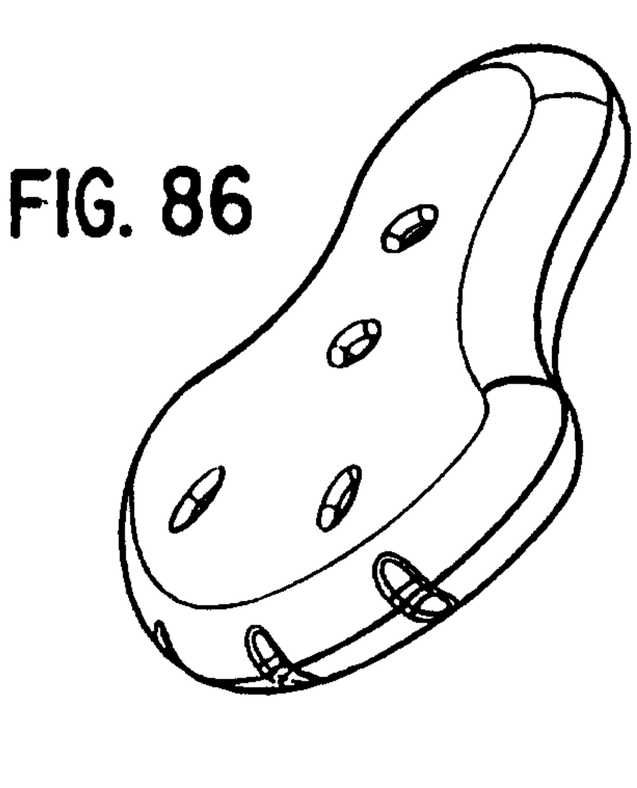
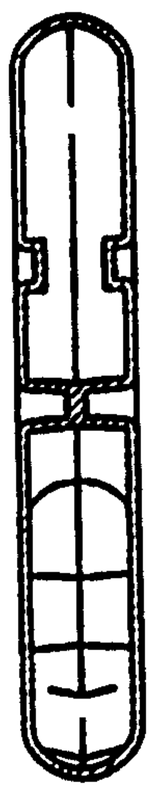


FIG. 86



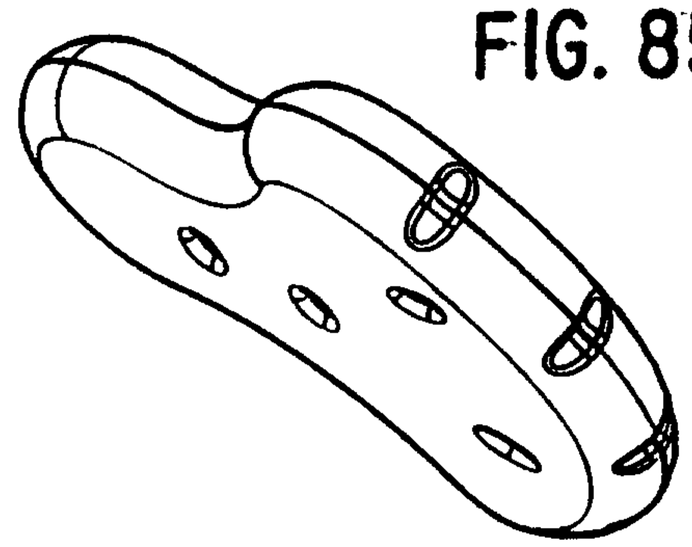


FIG. 85

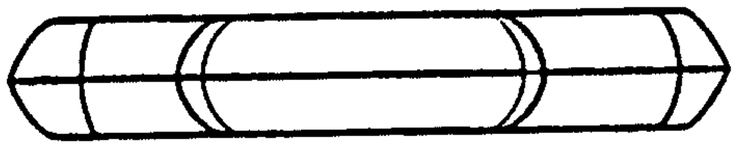


FIG. 92

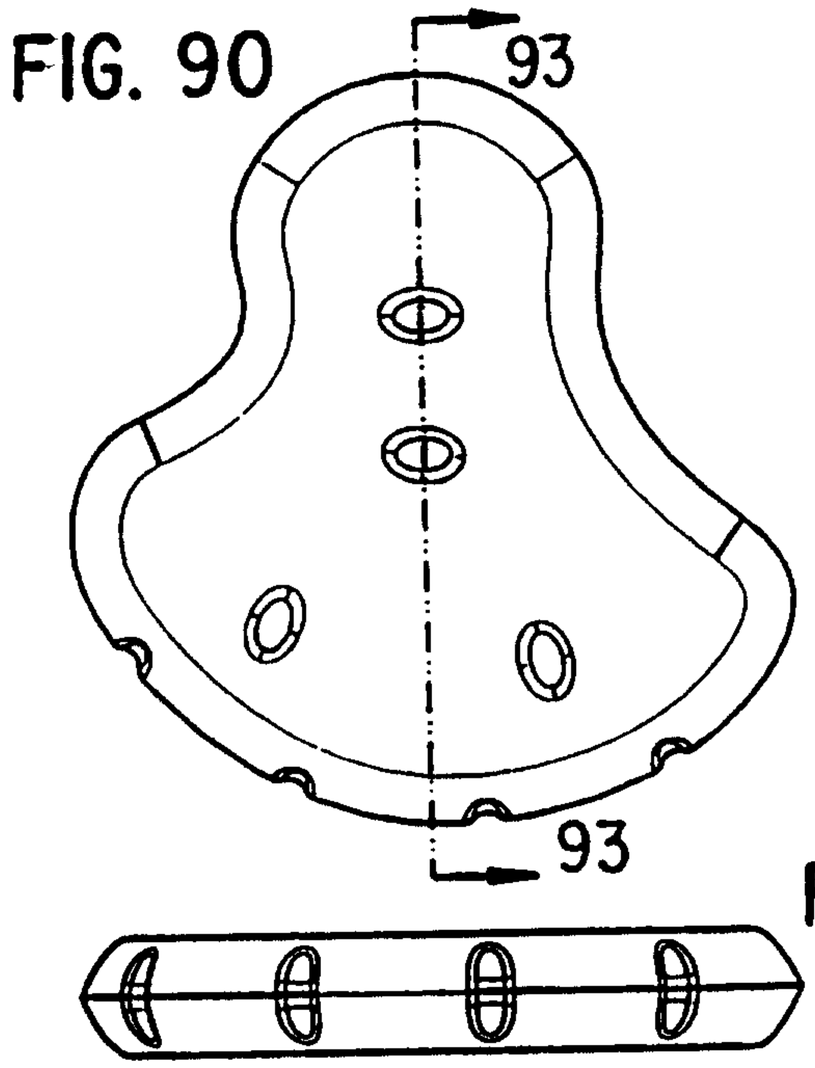


FIG. 90

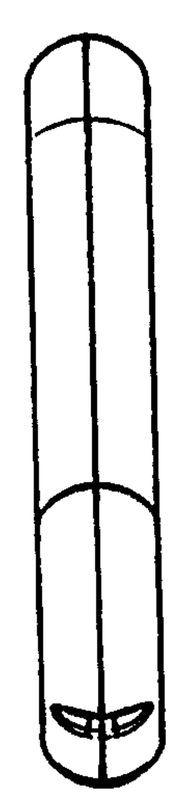


FIG. 89

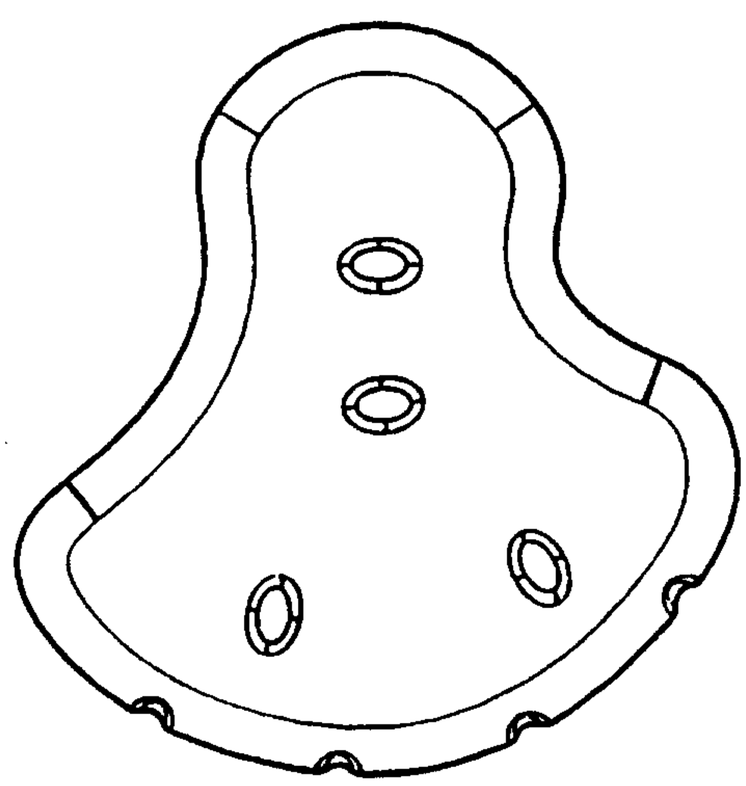


FIG. 87

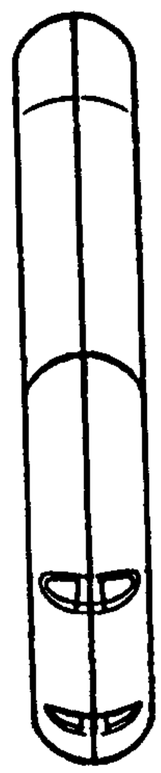


FIG. 88

FIG. 91

FIG. 95

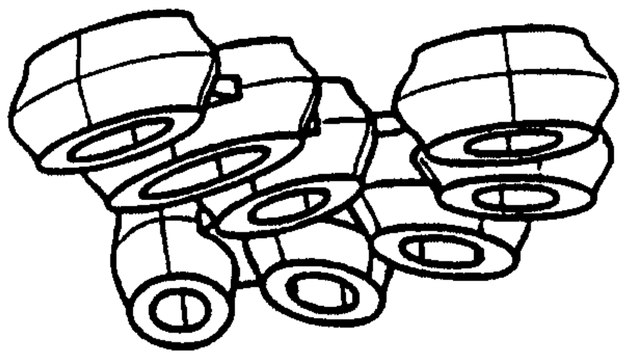
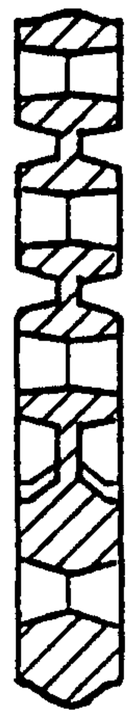


FIG. 105



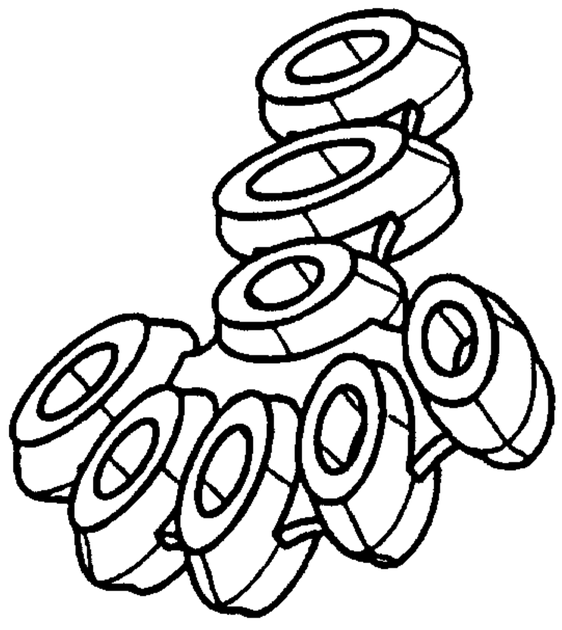


FIG. 94

FIG. 101

FIG. 99

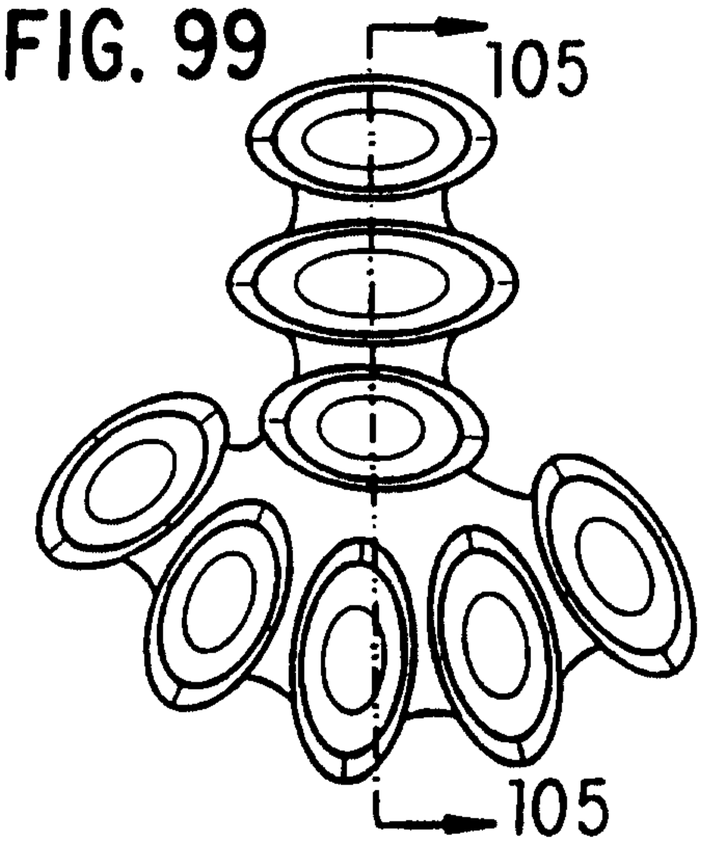


FIG. 98

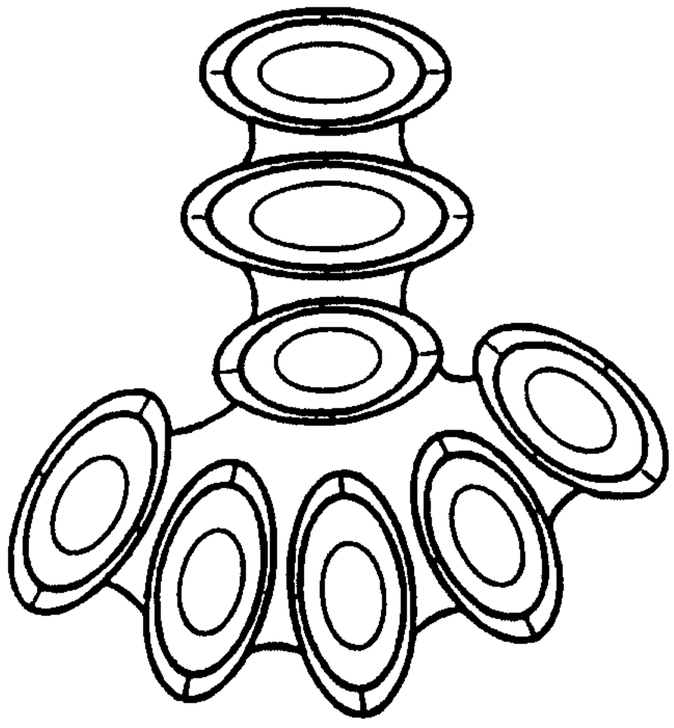


FIG. 96

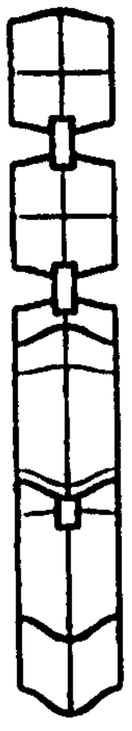


FIG. 97

FIG. 100

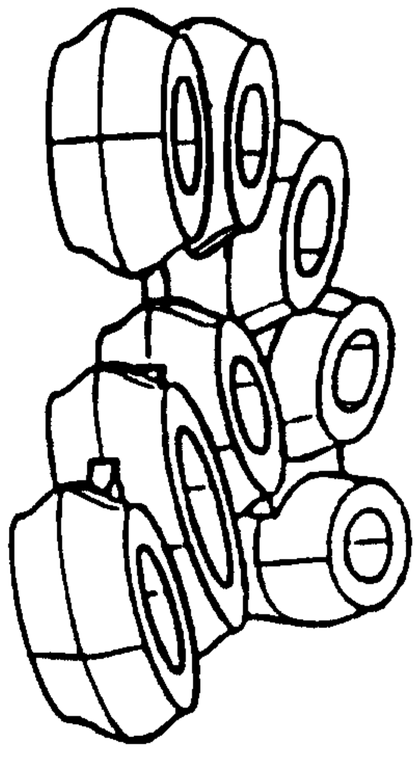


FIG. 102

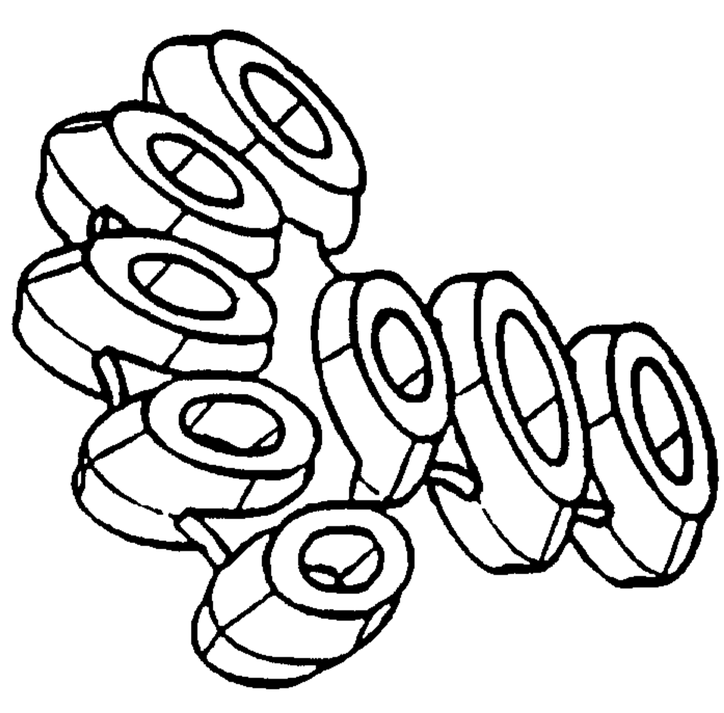


FIG. 103

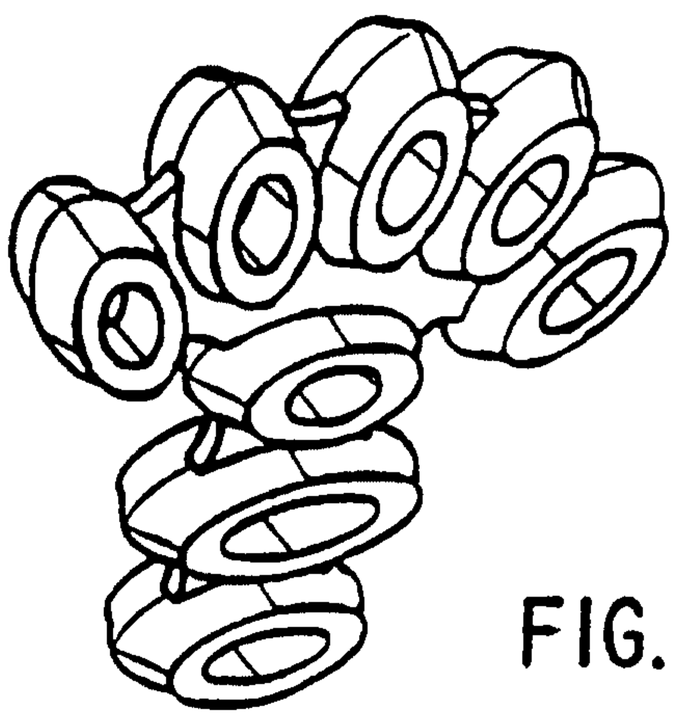


FIG. 104

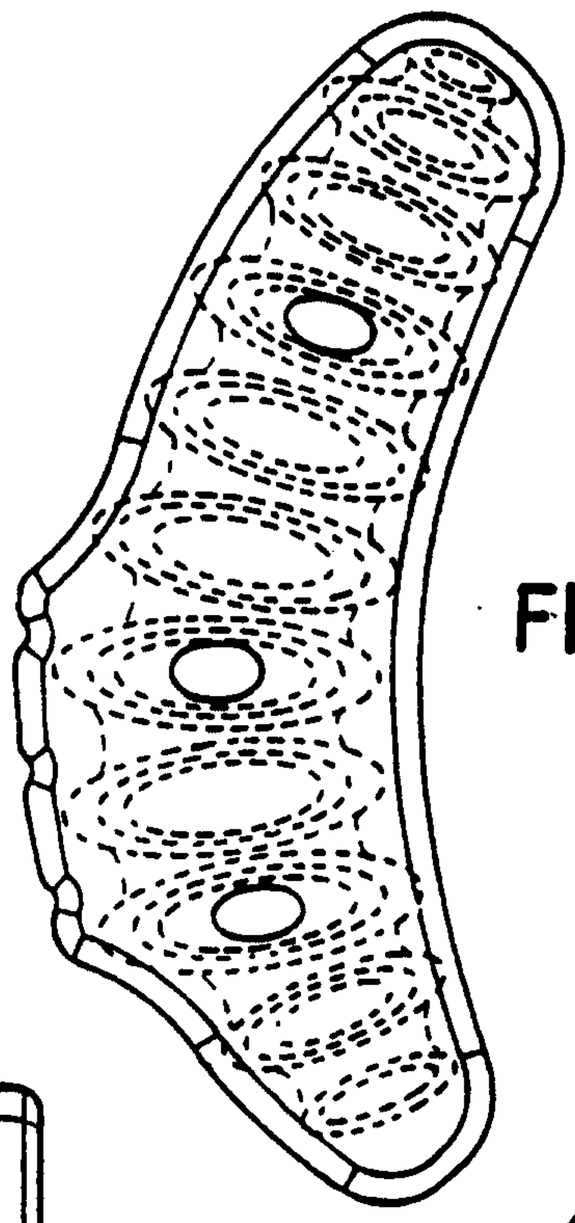


FIG. 112

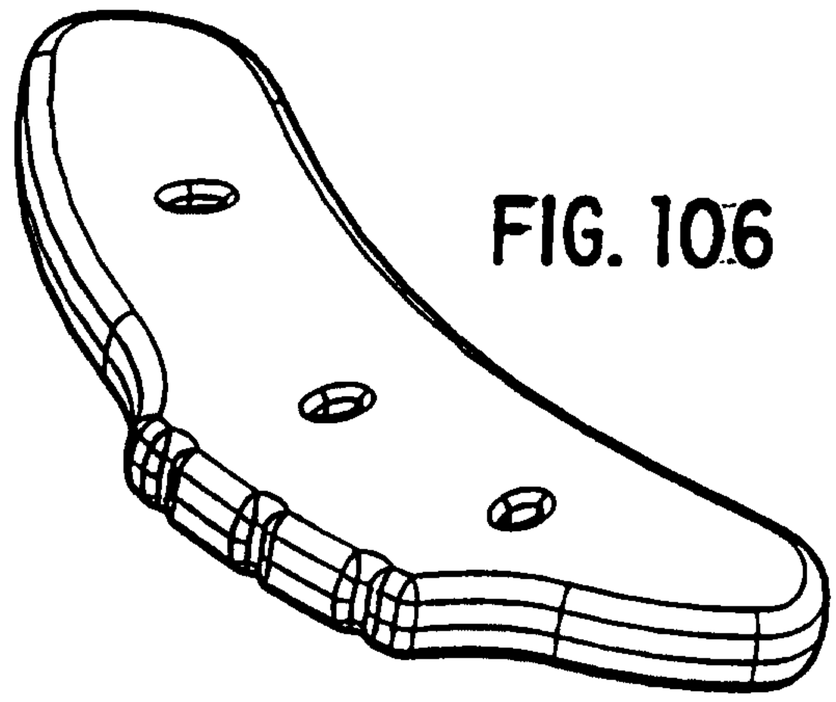


FIG. 106

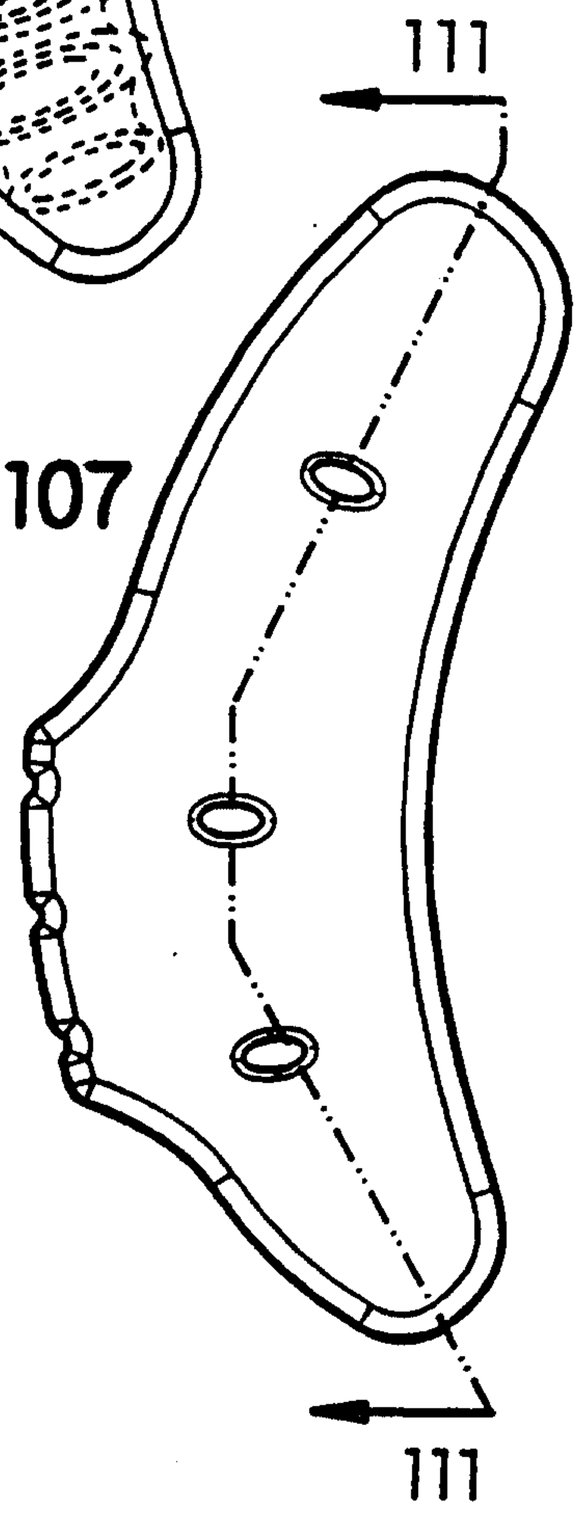


FIG. 107

FIG. 110

FIG. 109

FIG. 111

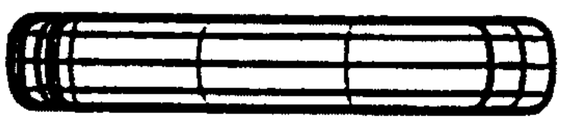


FIG. 108

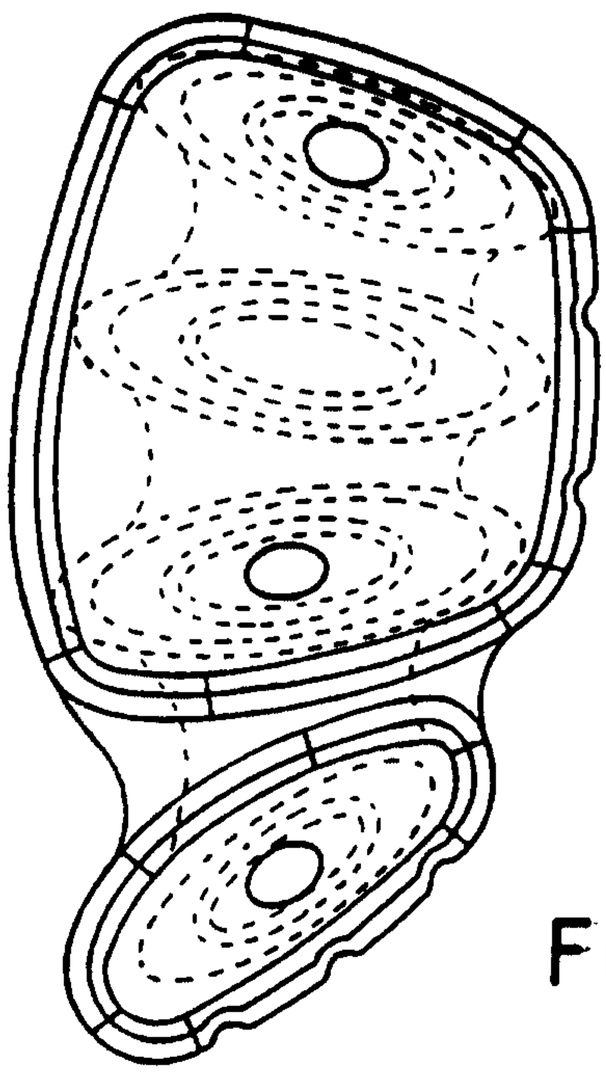


FIG. 119

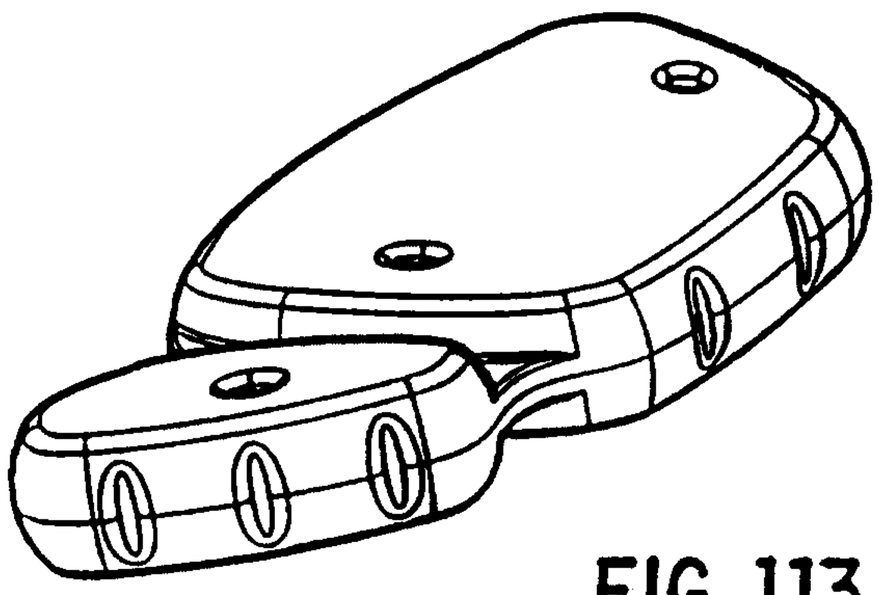
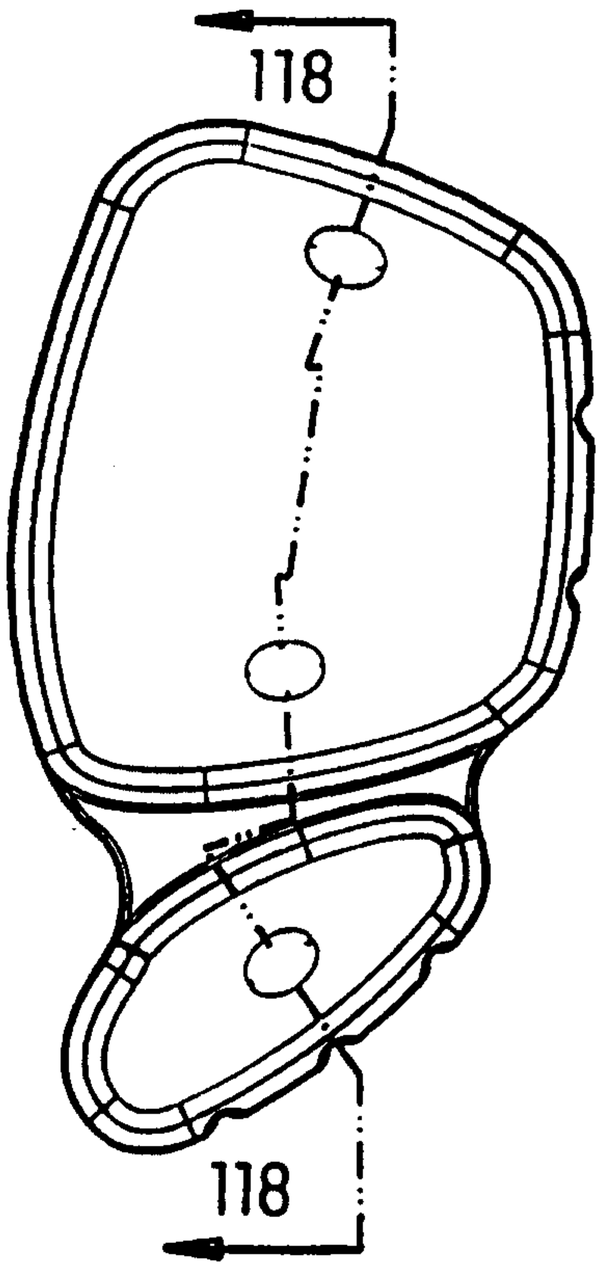


FIG. 113

FIG. 114



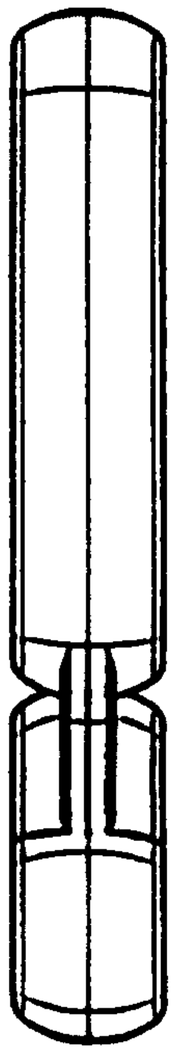


FIG. 117

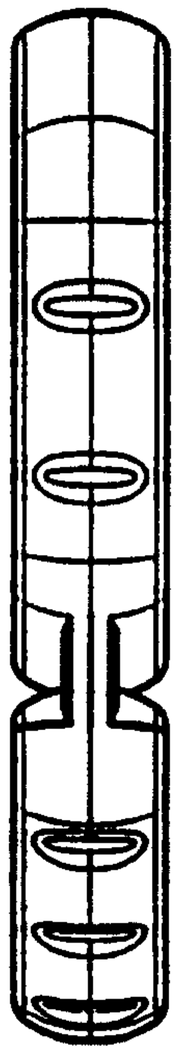


FIG. 116

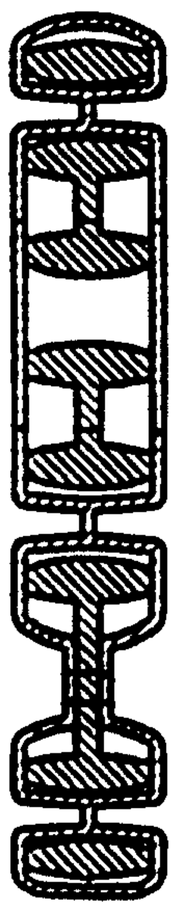


FIG. 118

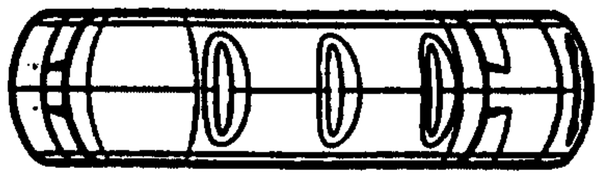


FIG. 115

FIG. 126

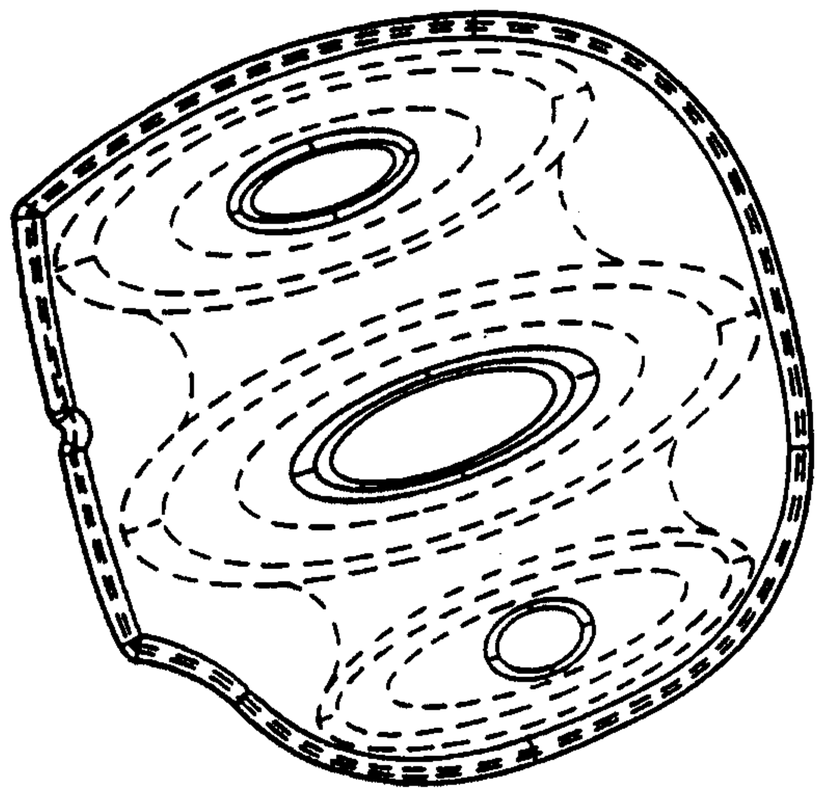


FIG. 120

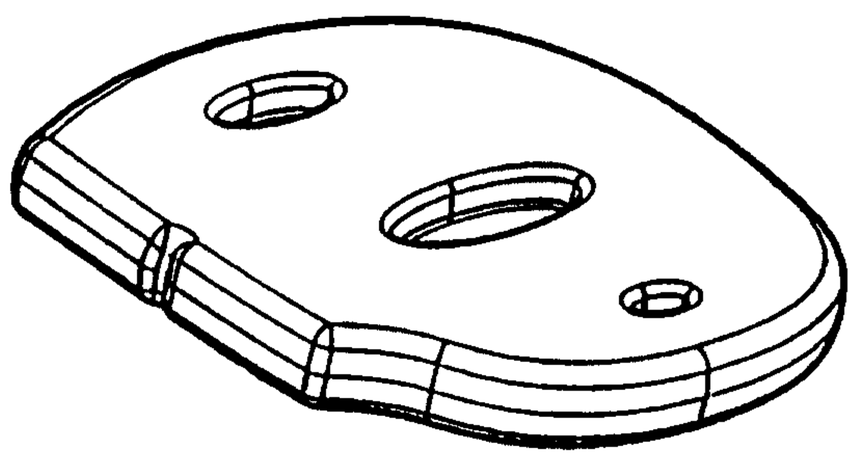


FIG. 121

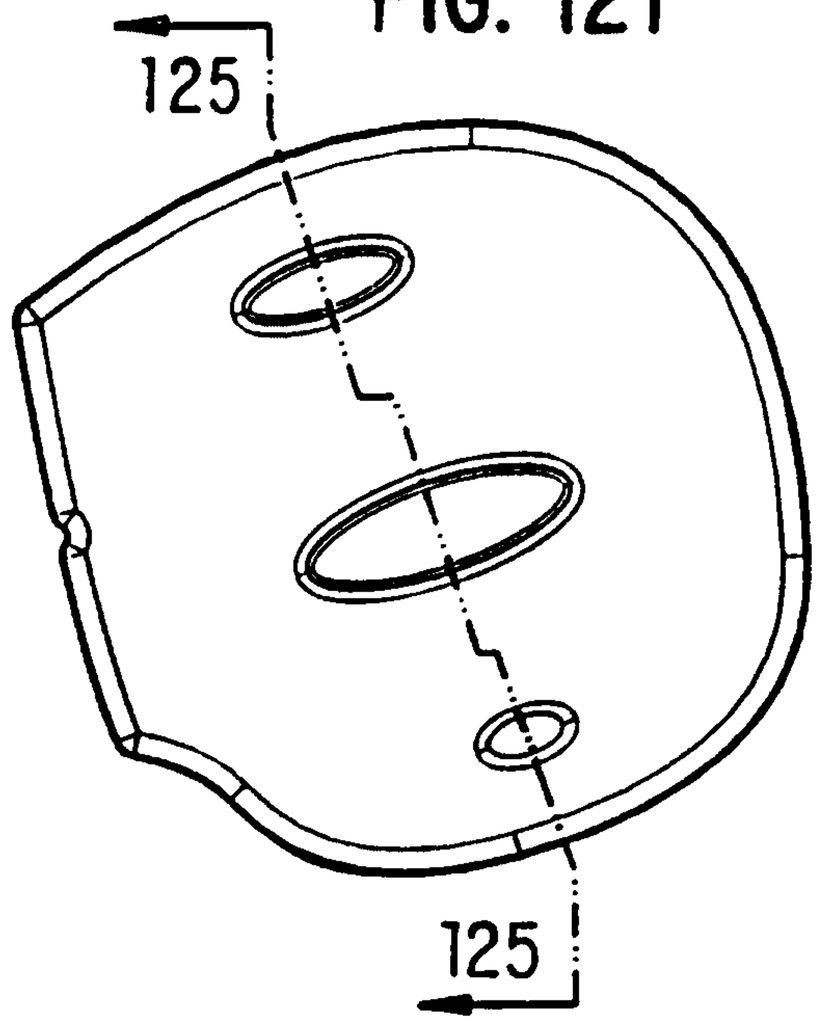


FIG. 125

FIG. 124

FIG. 123

FIG. 122

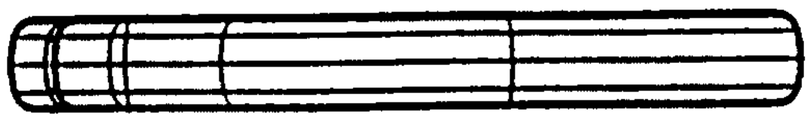


FIG. 132

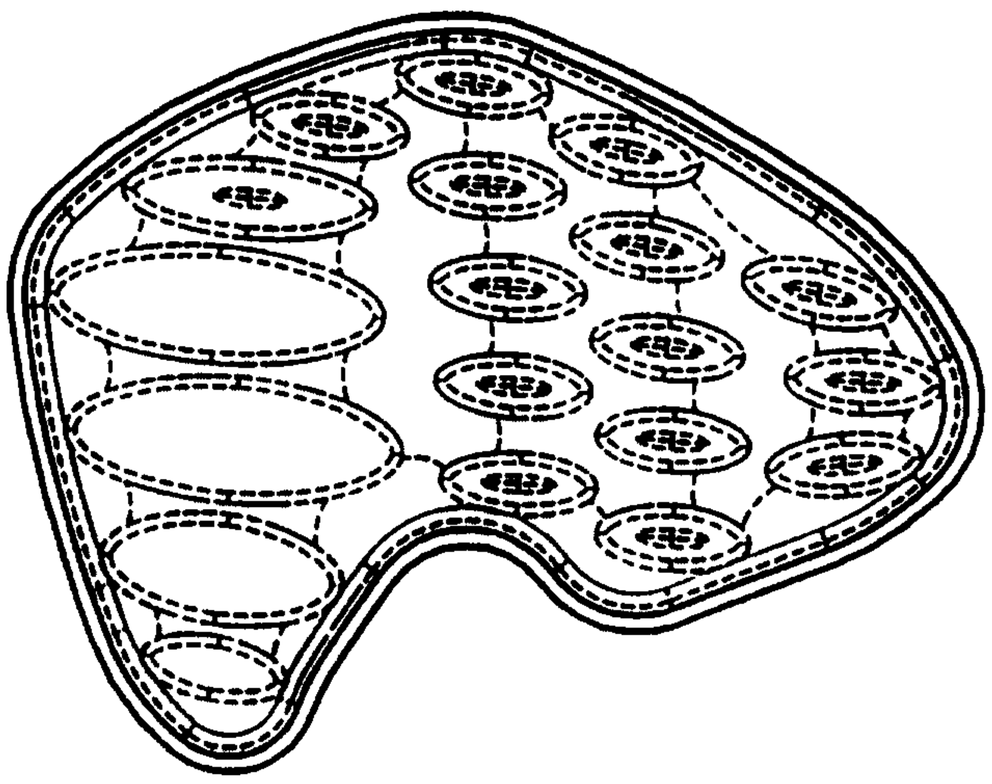


FIG. 127

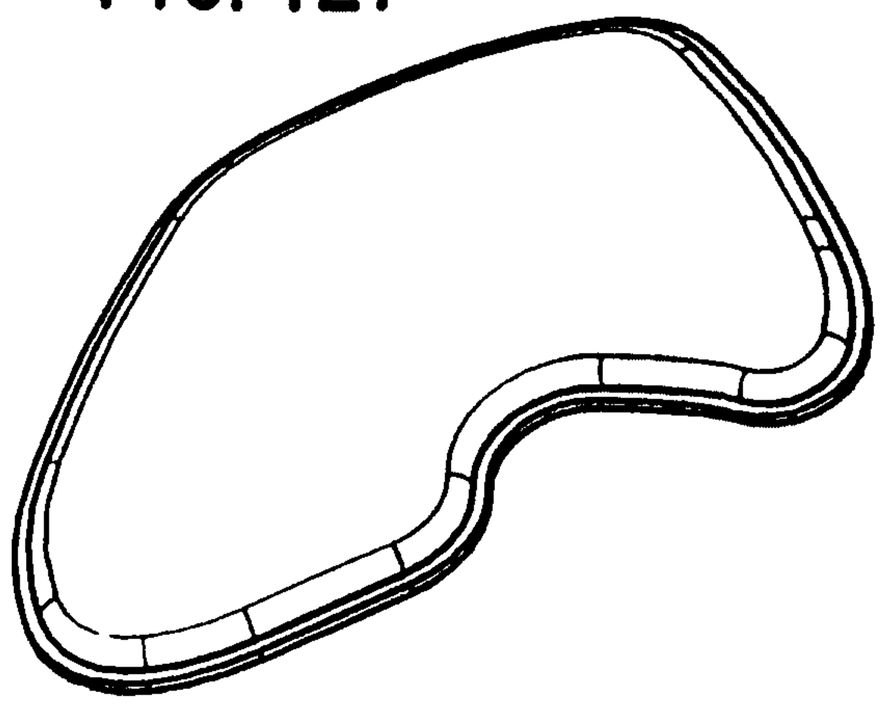
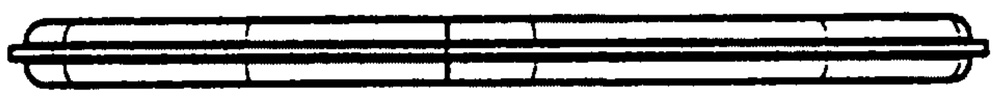


FIG. 129



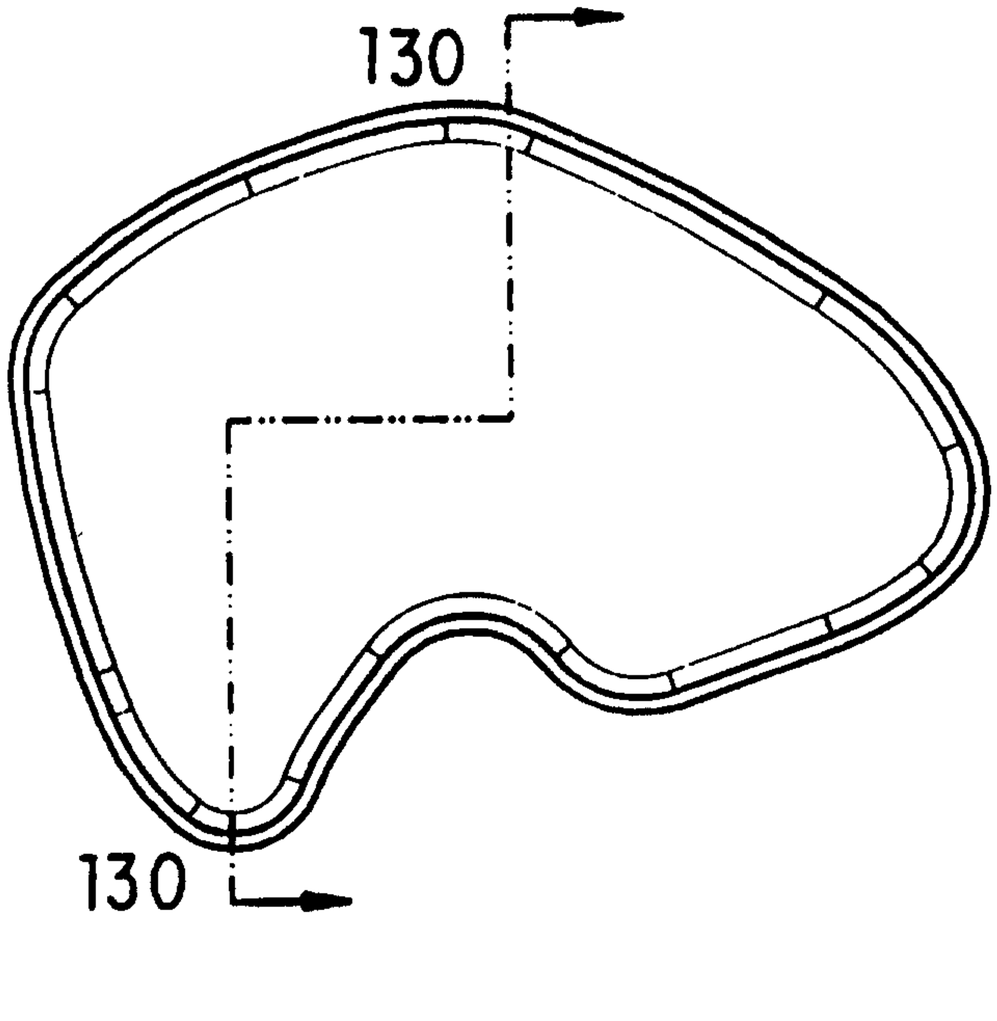


FIG. 128

FIG. 130

FIG. 131

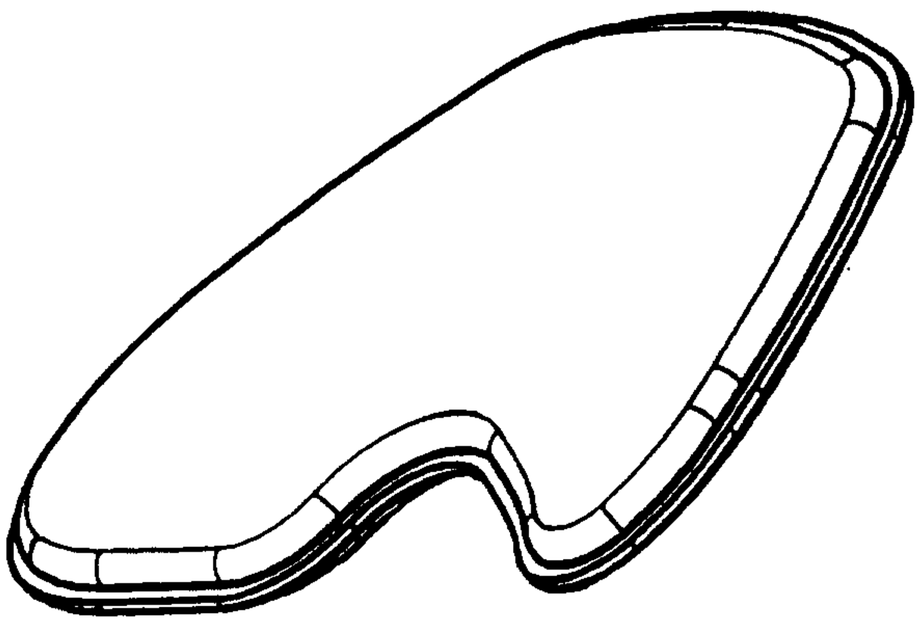


FIG. 133

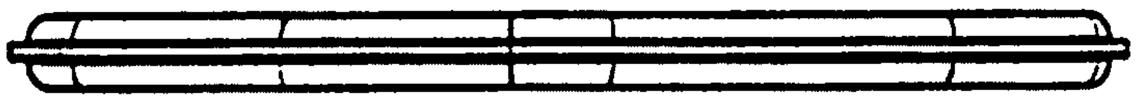


FIG. 136

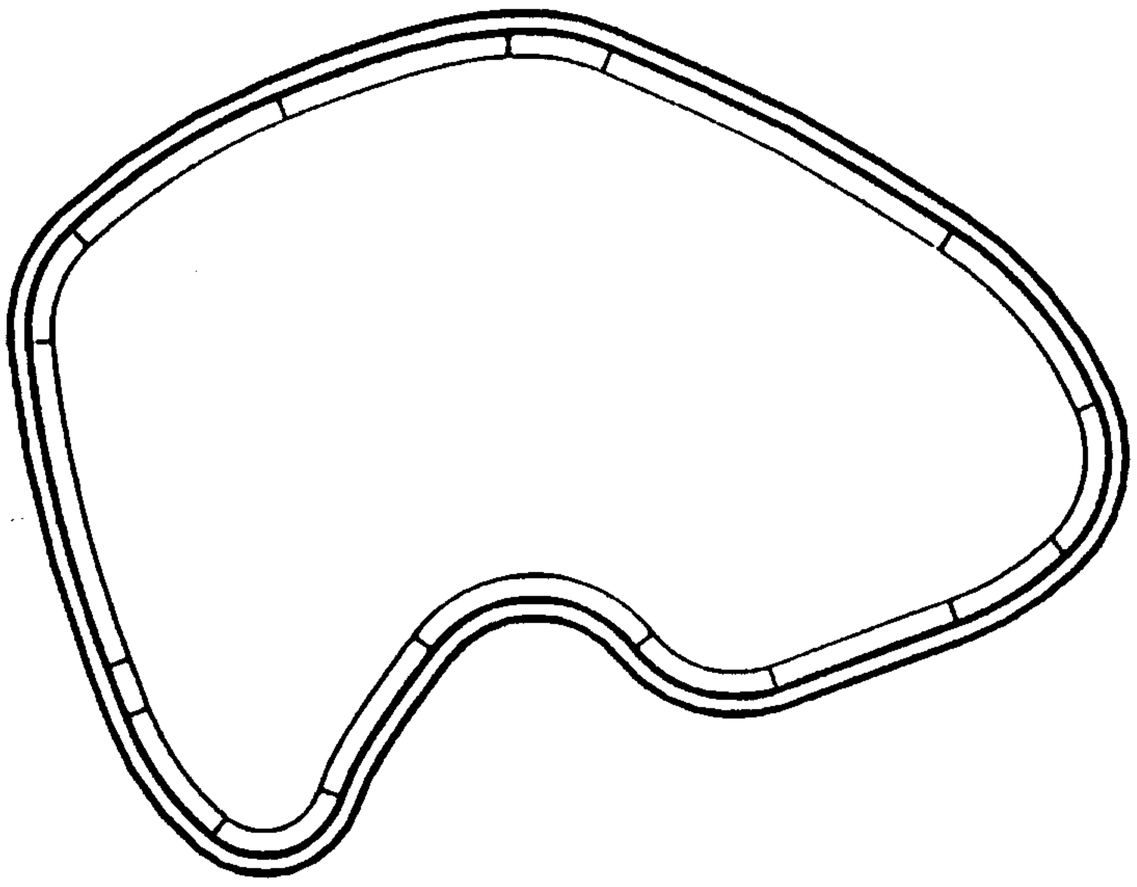


FIG. 134

FIG. 135

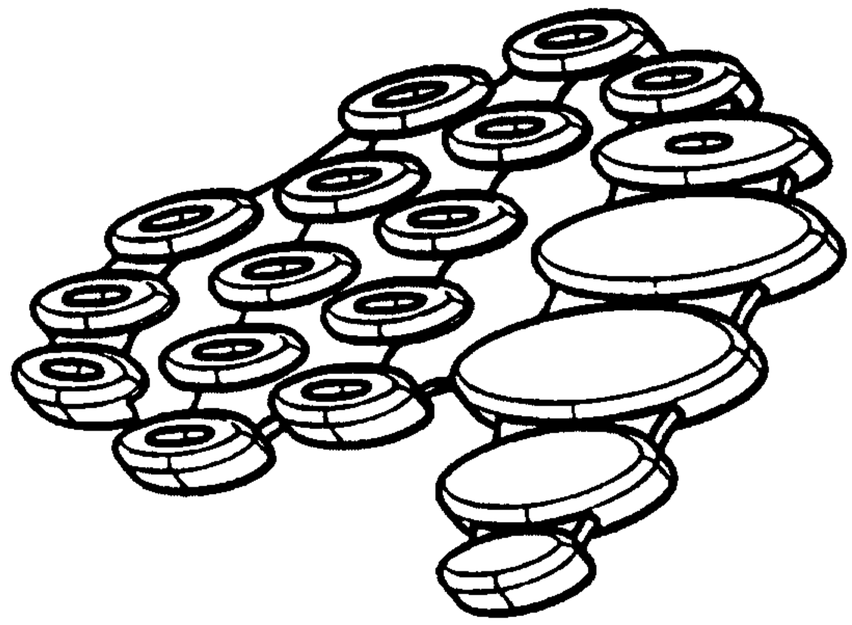


FIG. 137

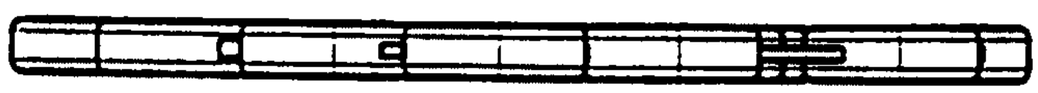


FIG. 140

FIG. 138

FIG. 139

FIG. 146

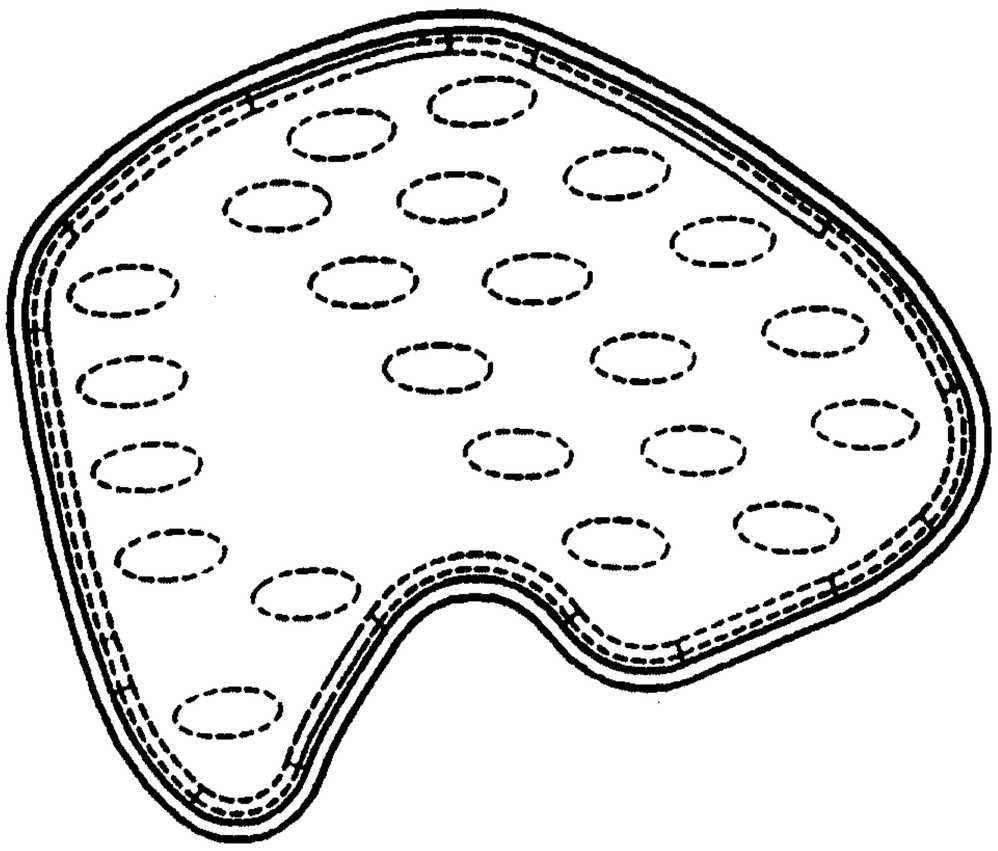


FIG. 144

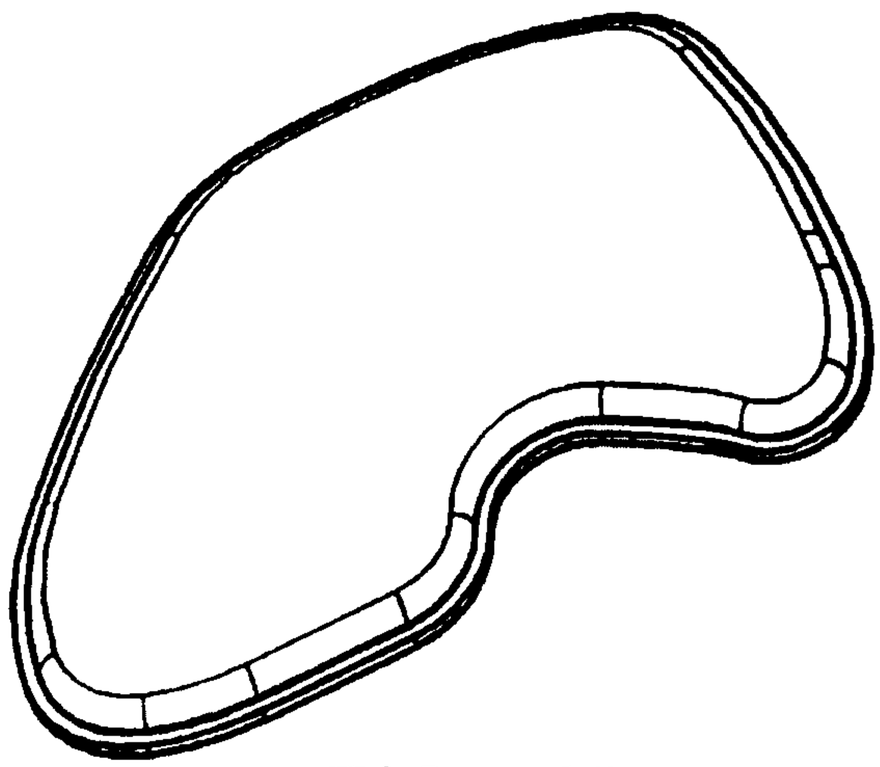


FIG. 141

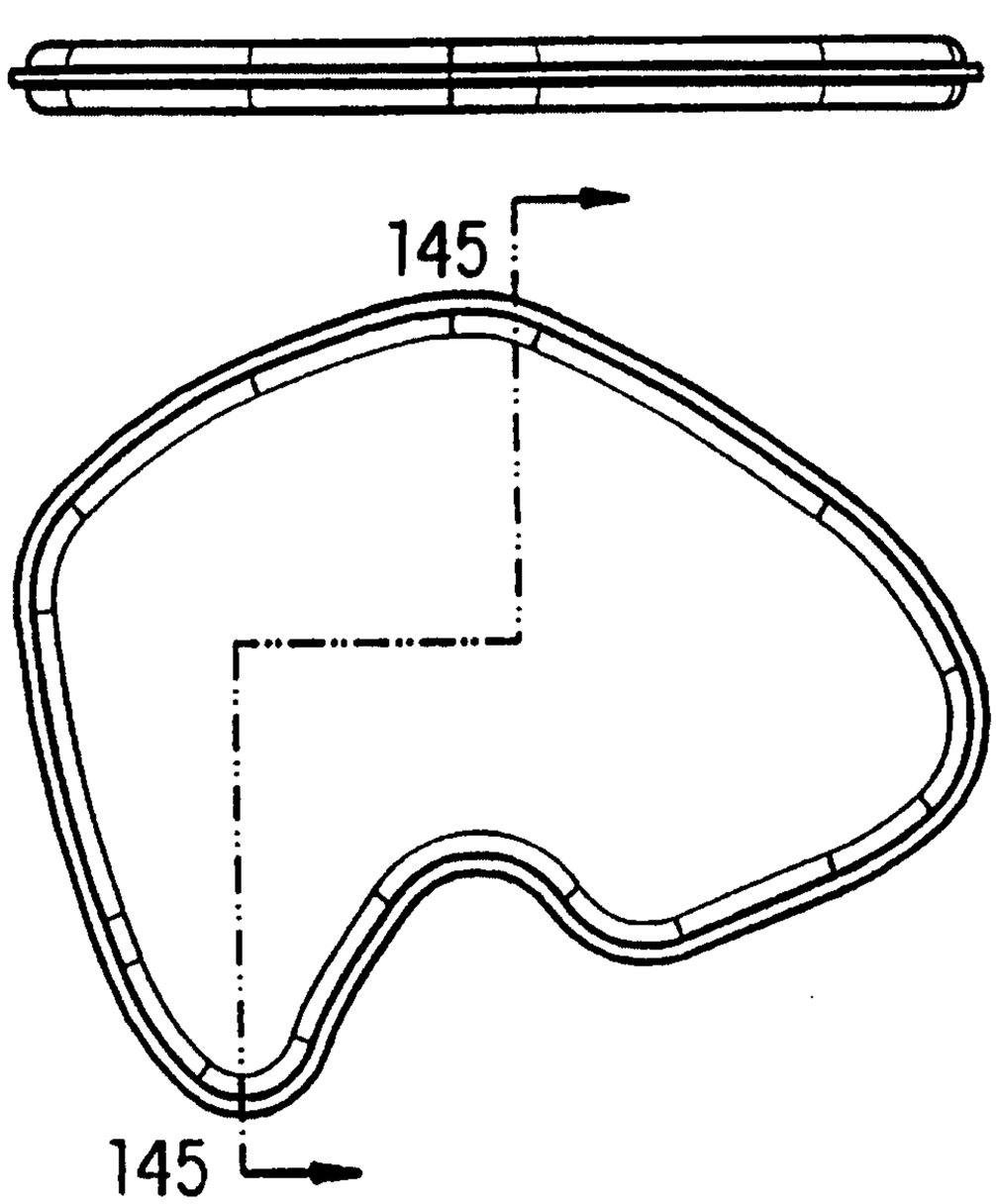


FIG. 142

FIG. 143

FIG. 145

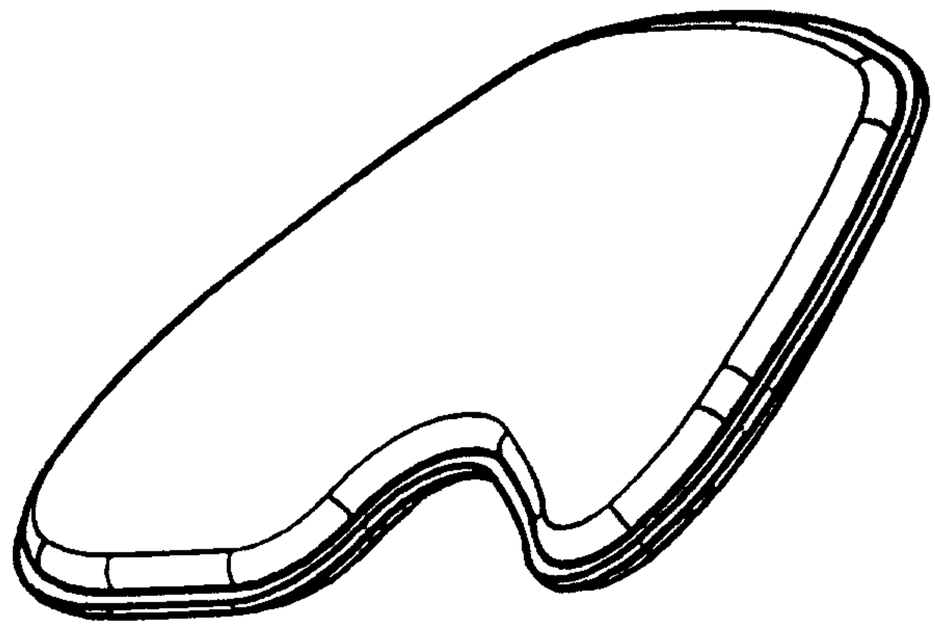


FIG. 147

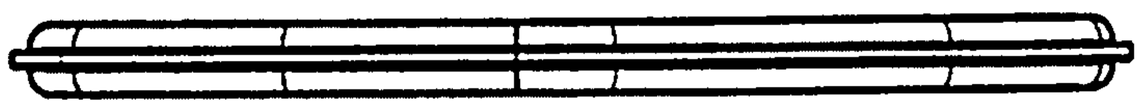


FIG. 150

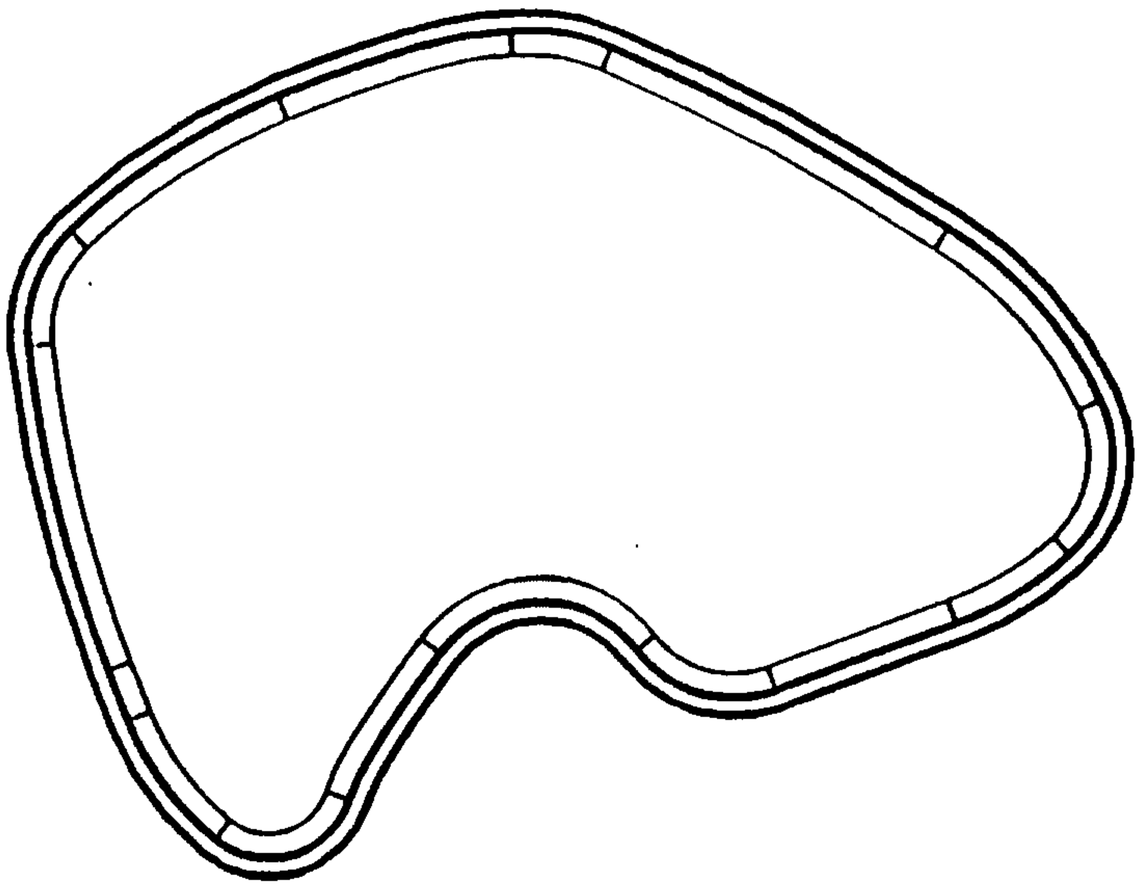


FIG. 148

FIG. 149

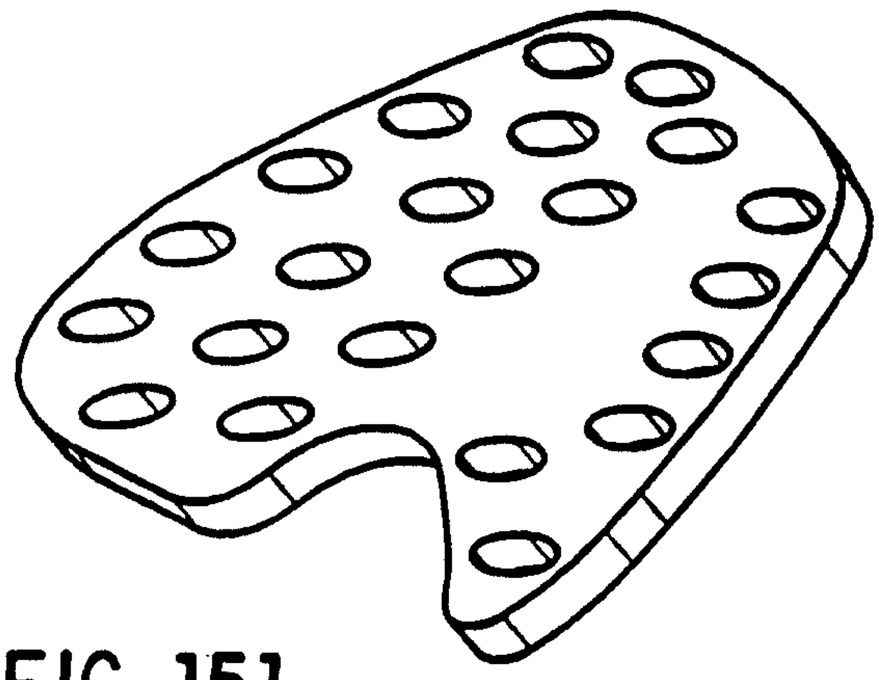


FIG. 151

FIG. 154

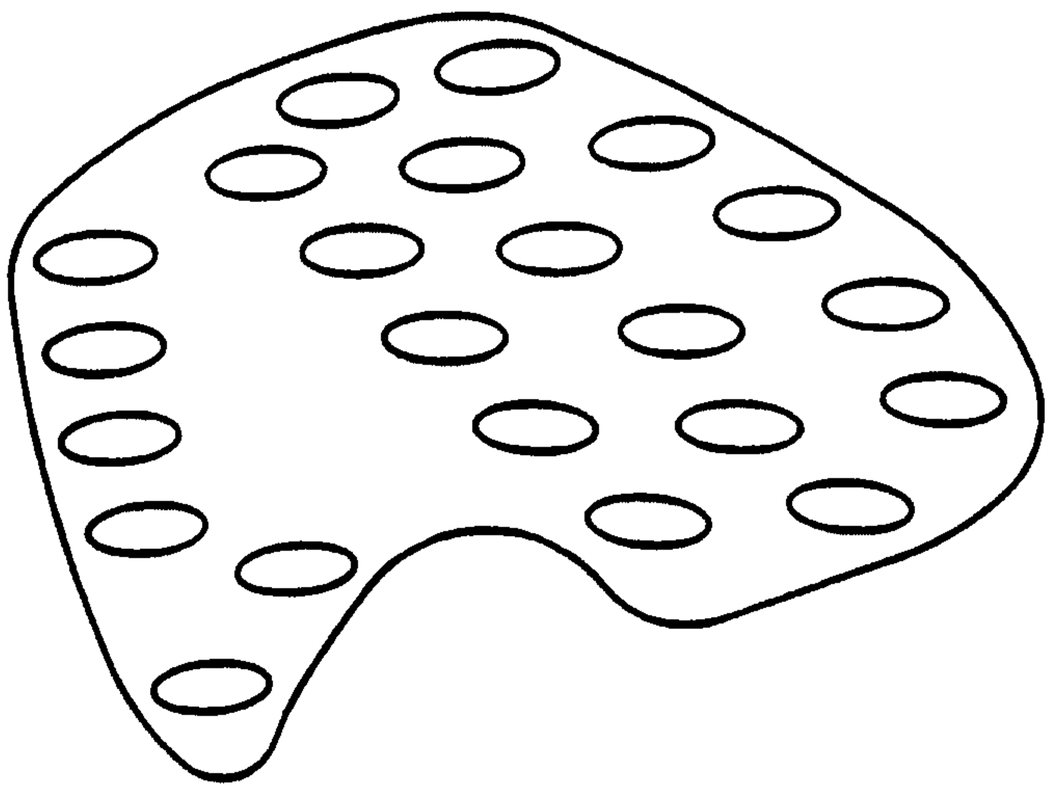
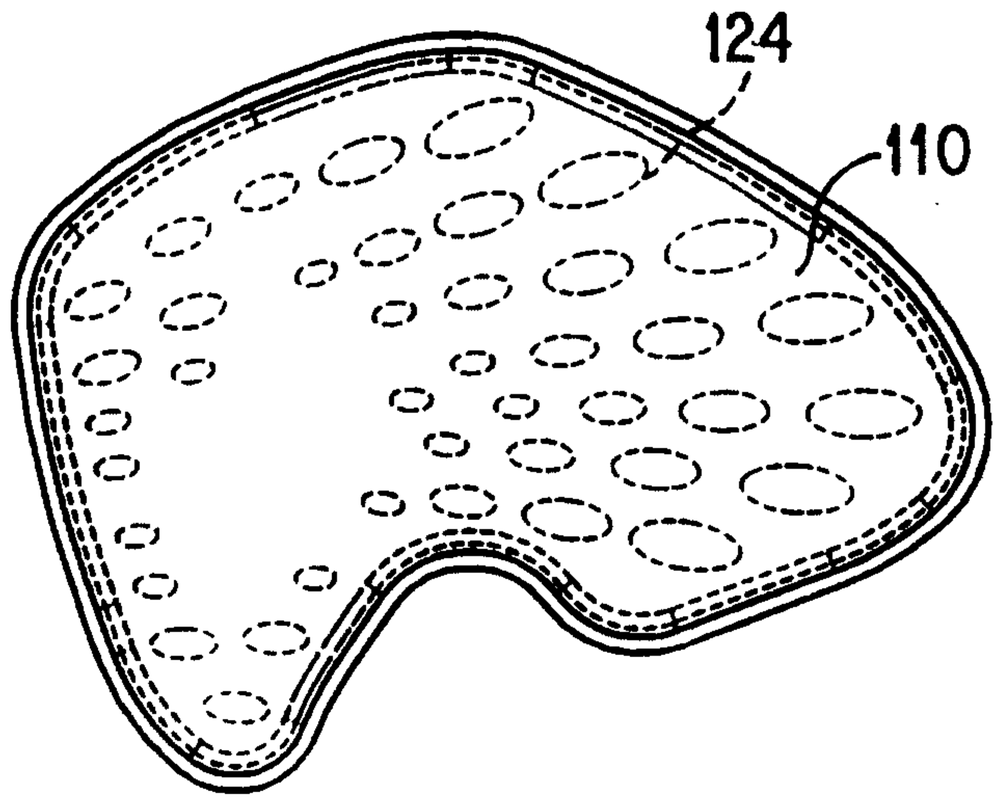


FIG. 152

FIG. 153

FIG. 160



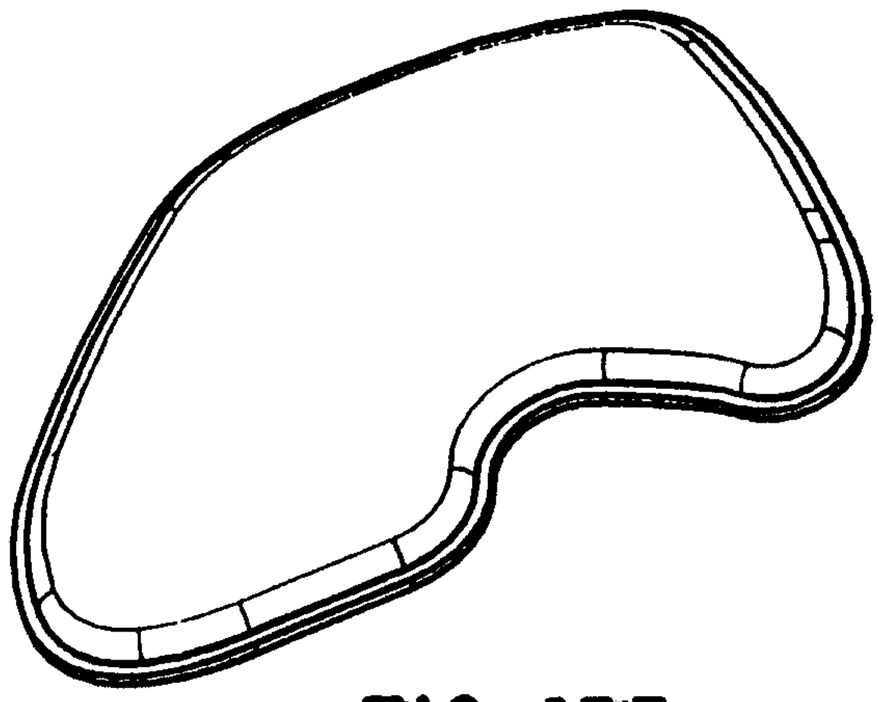


FIG. 155

FIG. 158

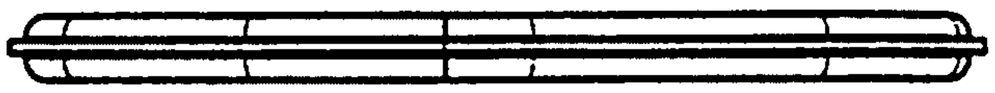


FIG. 156

FIG. 157

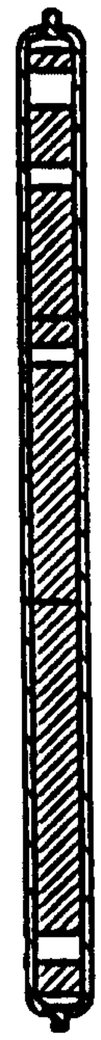


FIG. 159

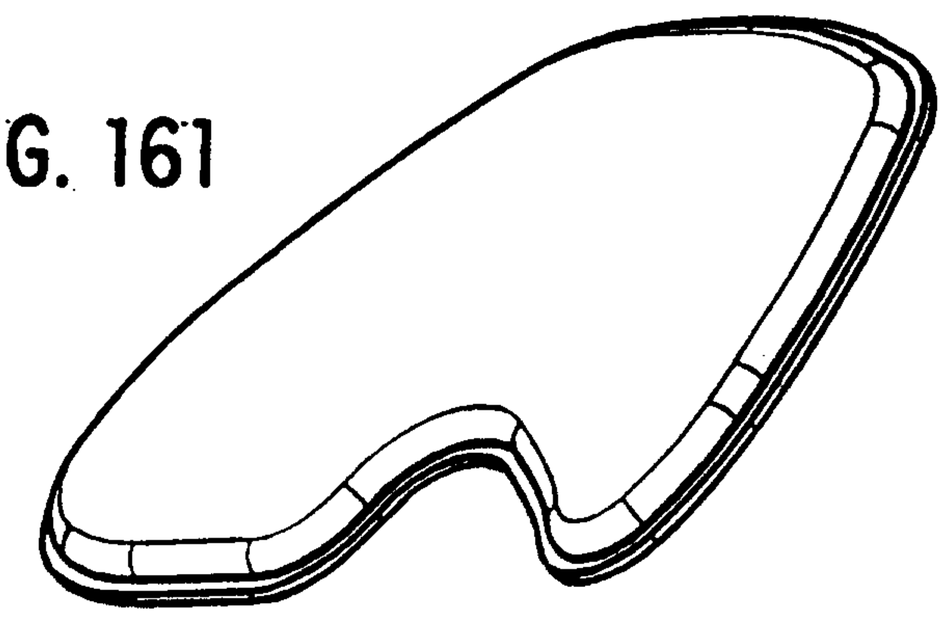


FIG. 161

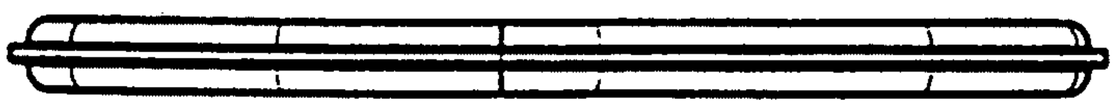


FIG. 164

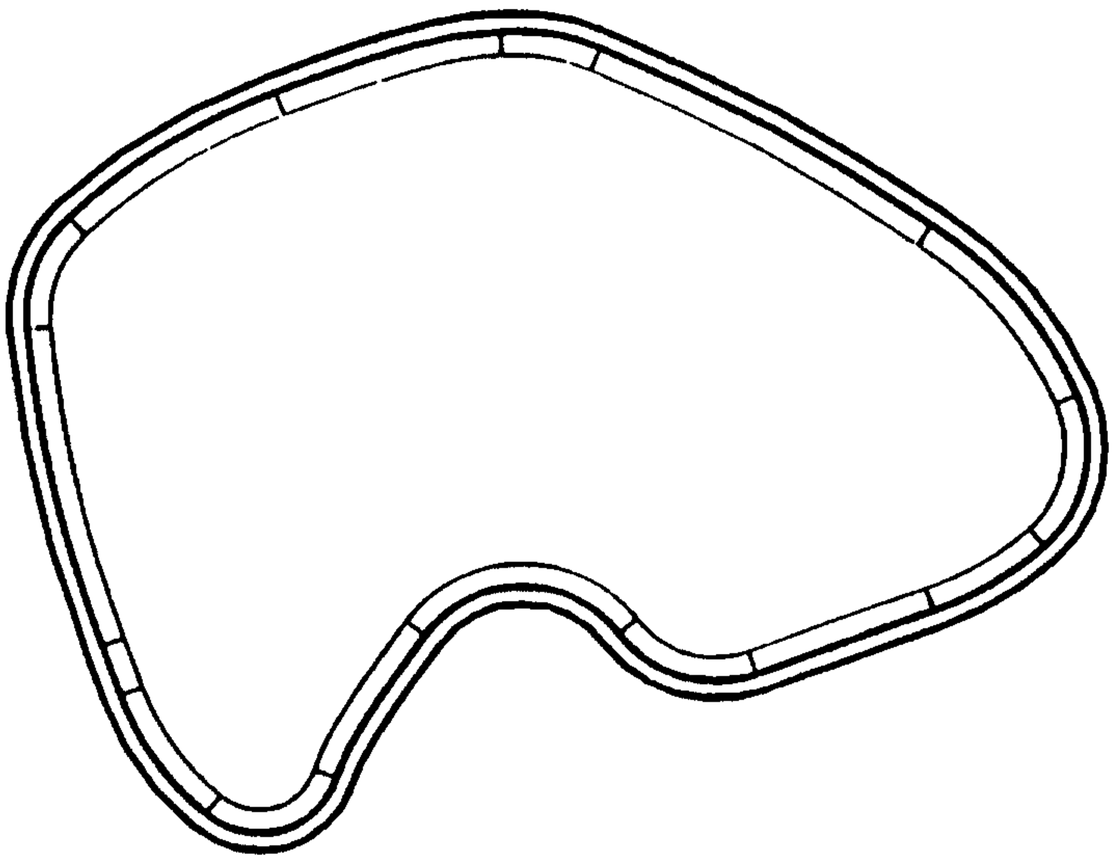


FIG. 162

FIG. 163

FIG. 165

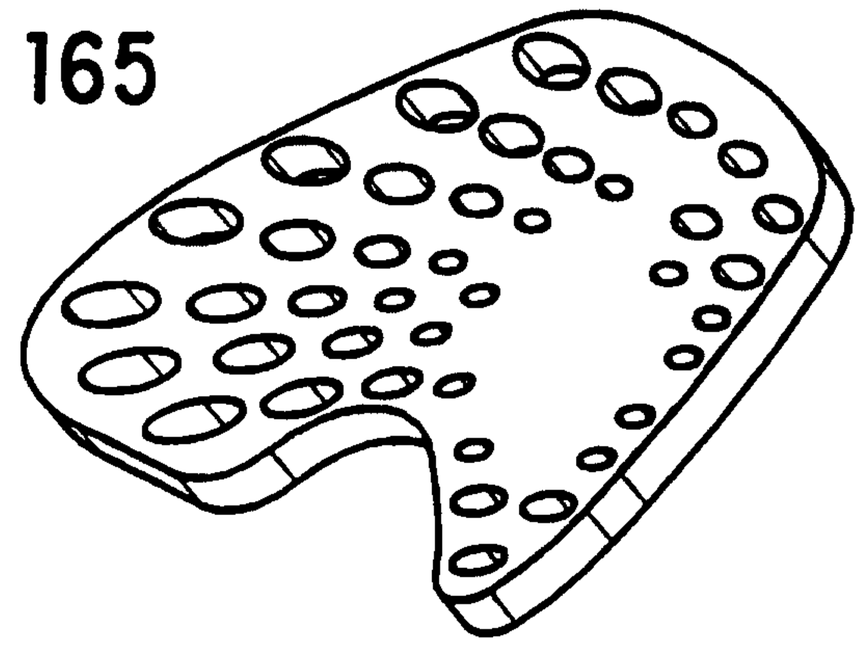


FIG. 168

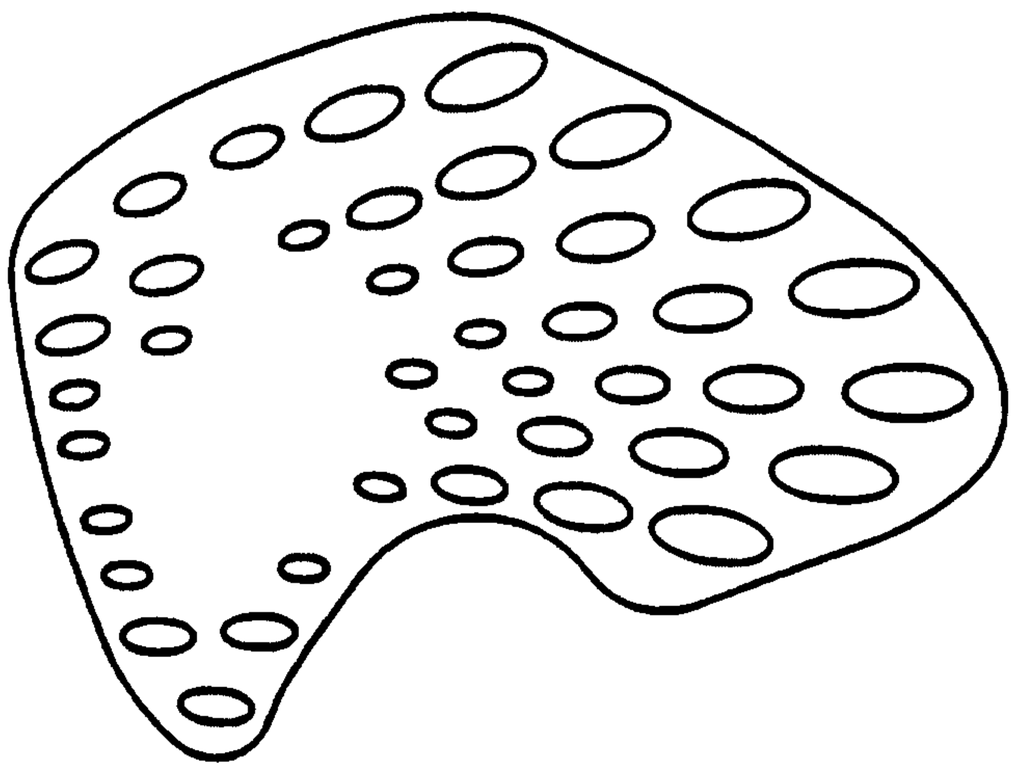


FIG. 166

FIG. 167

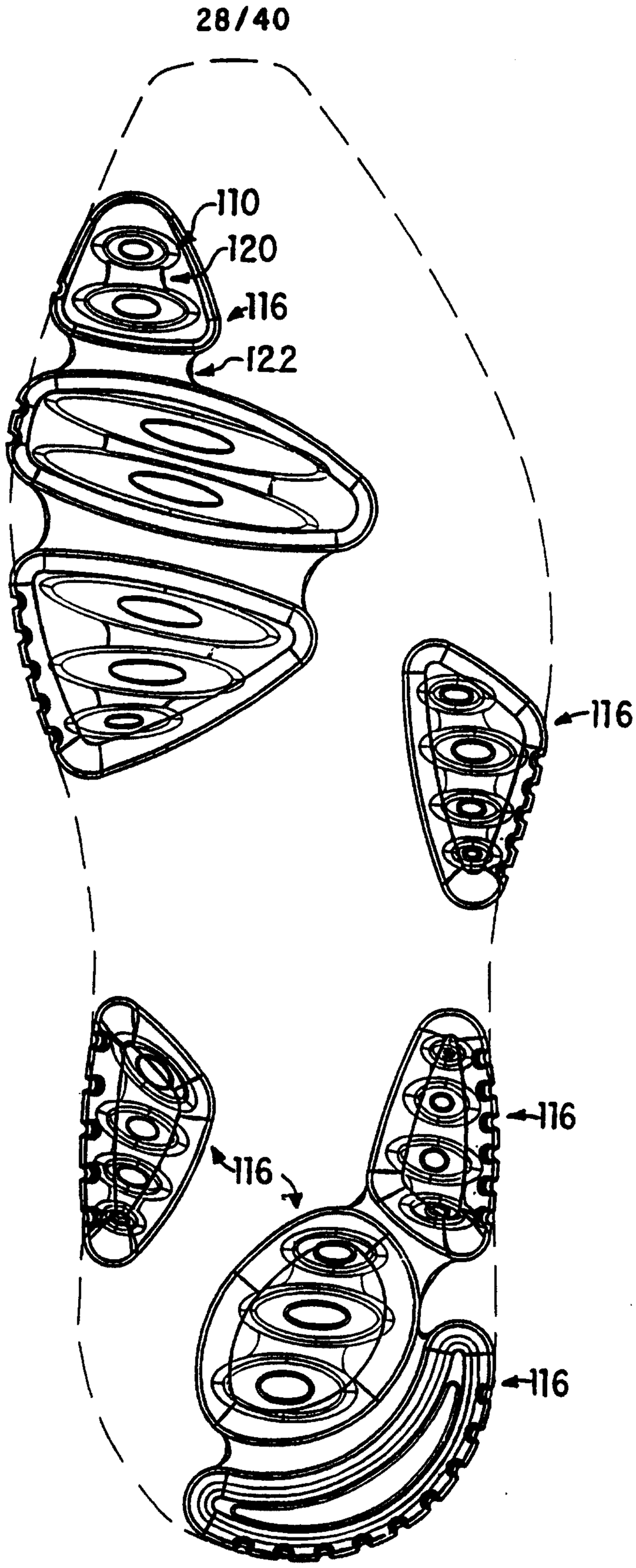


FIG. 169

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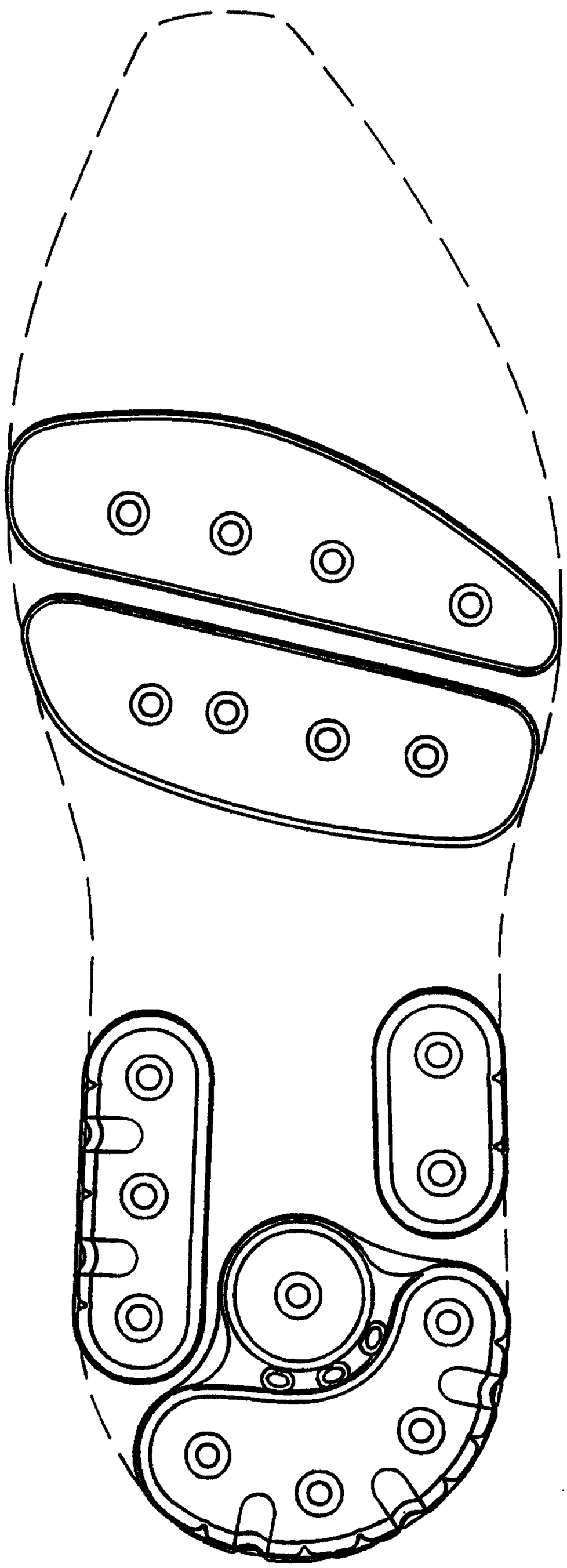

FIG. 170

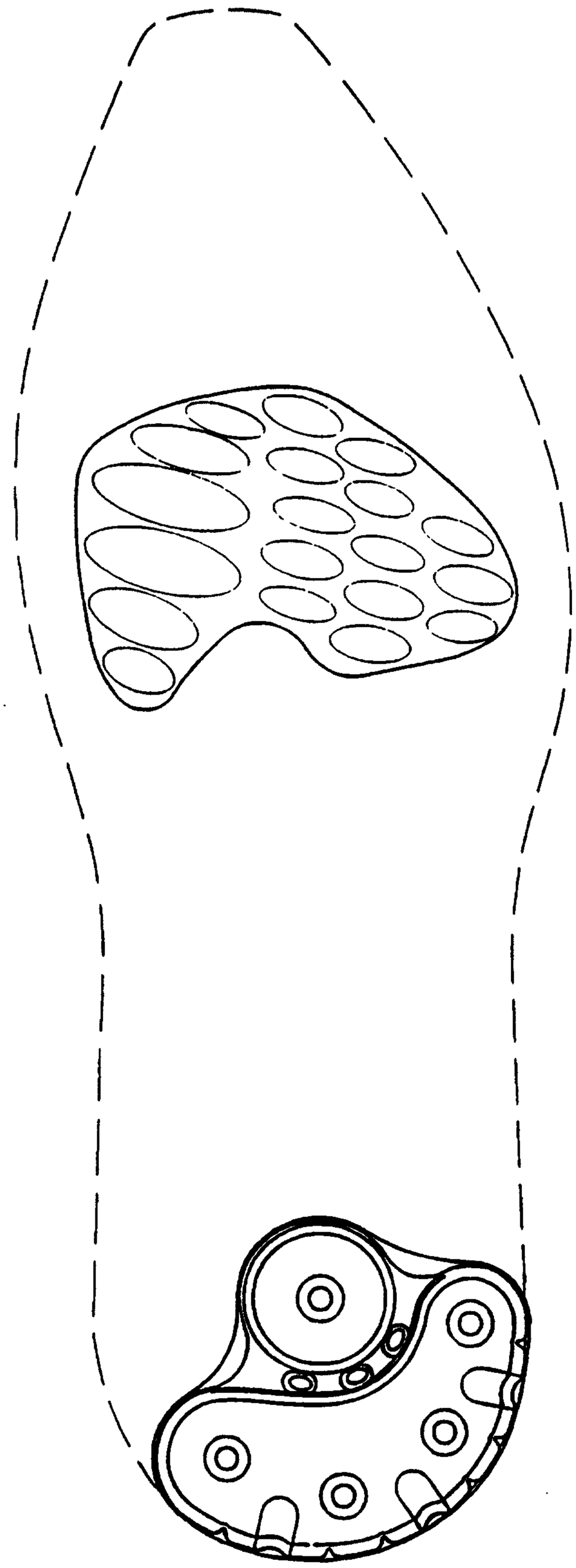

FIG. 171

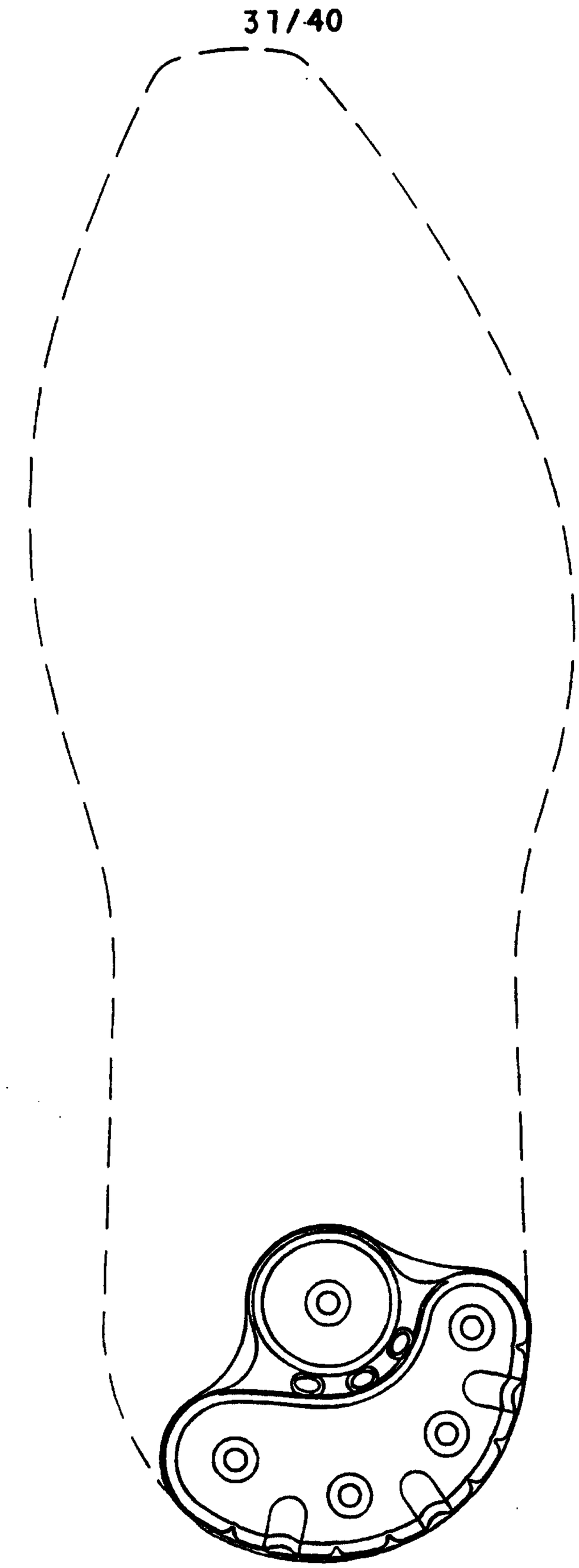

FIG. 172

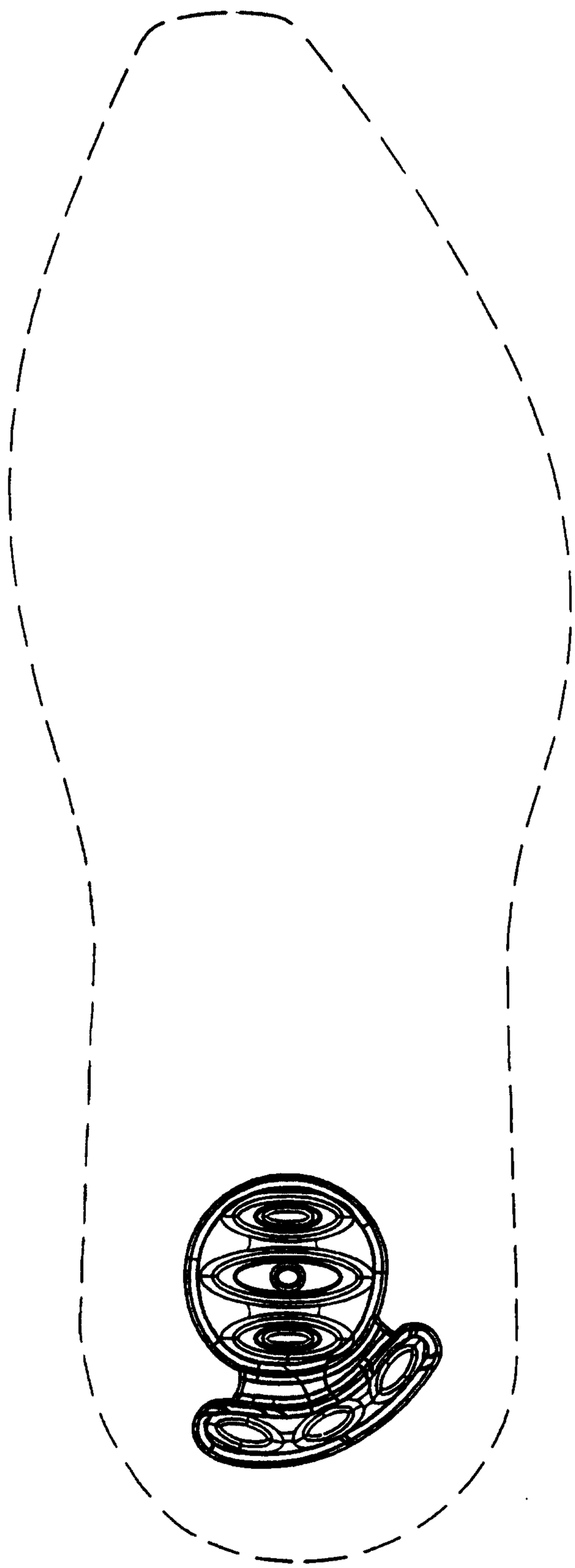

FIG. 173

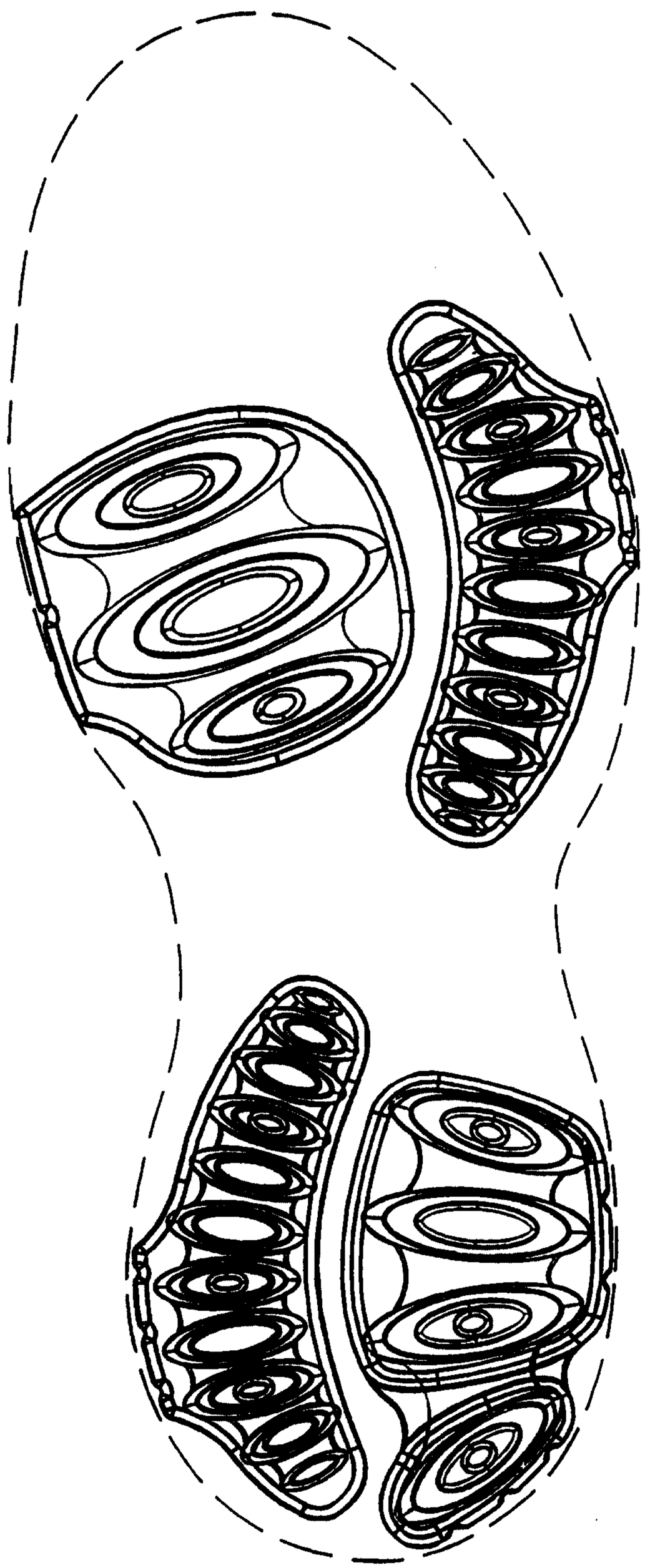

FIG. 174

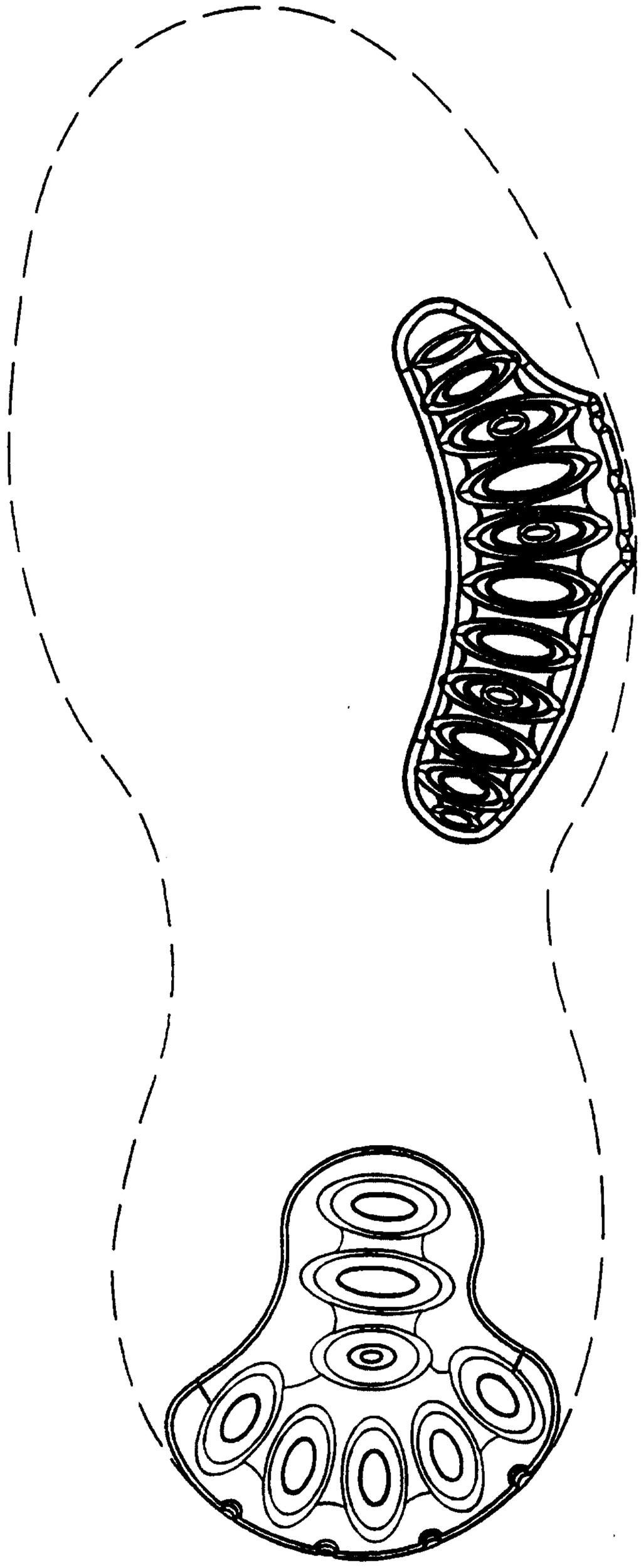

FIG. 175

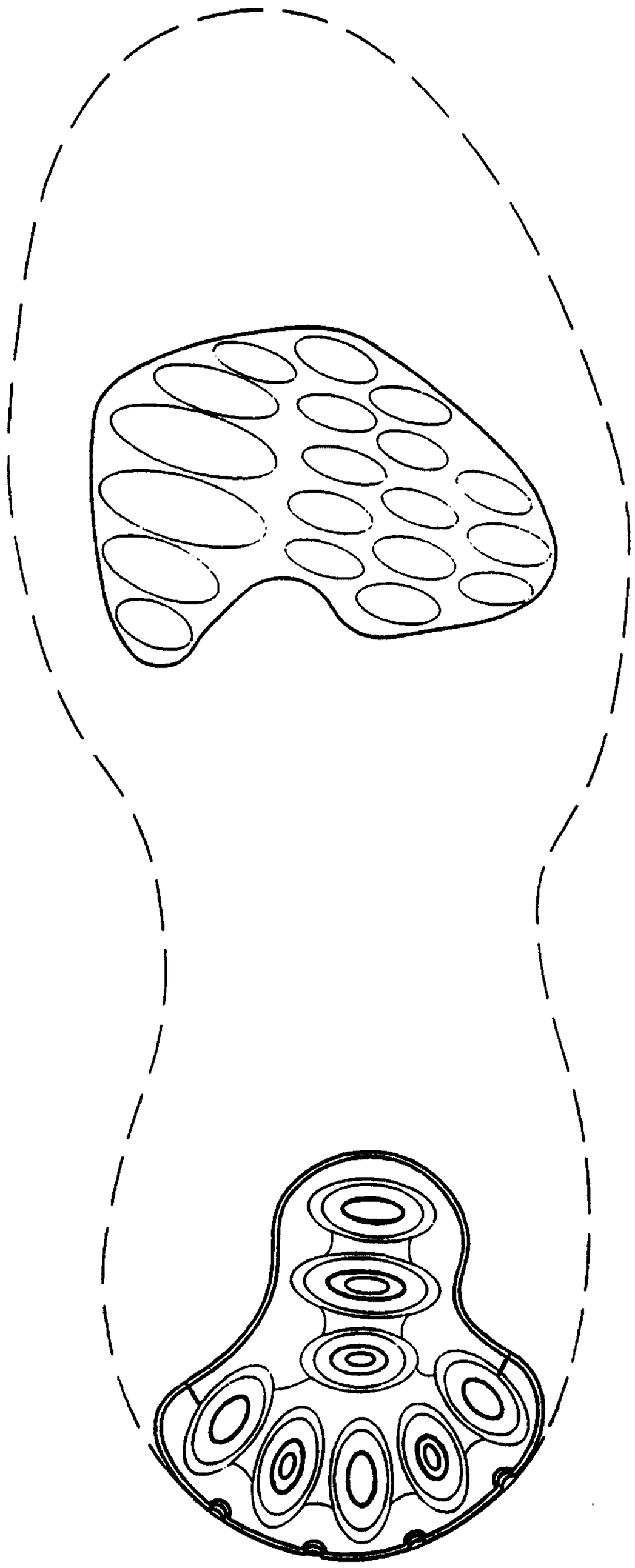

FIG. 176

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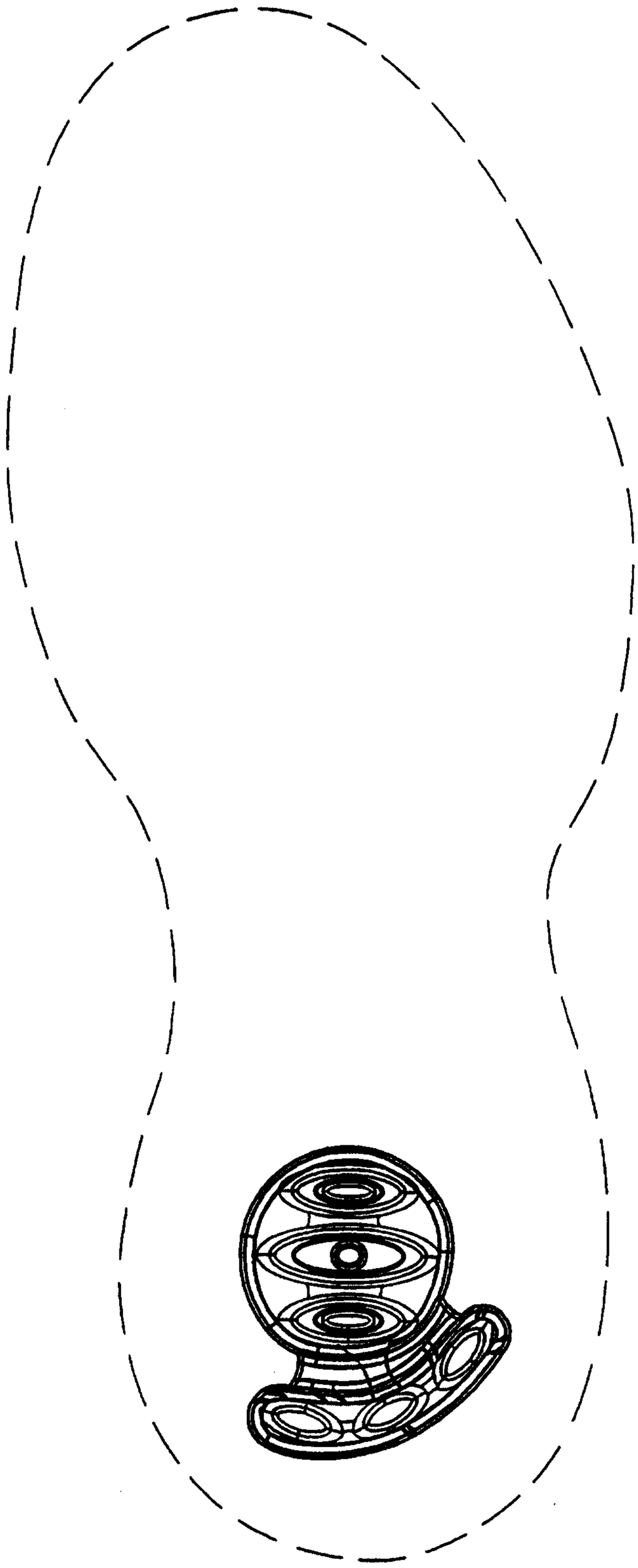

FIG. 177

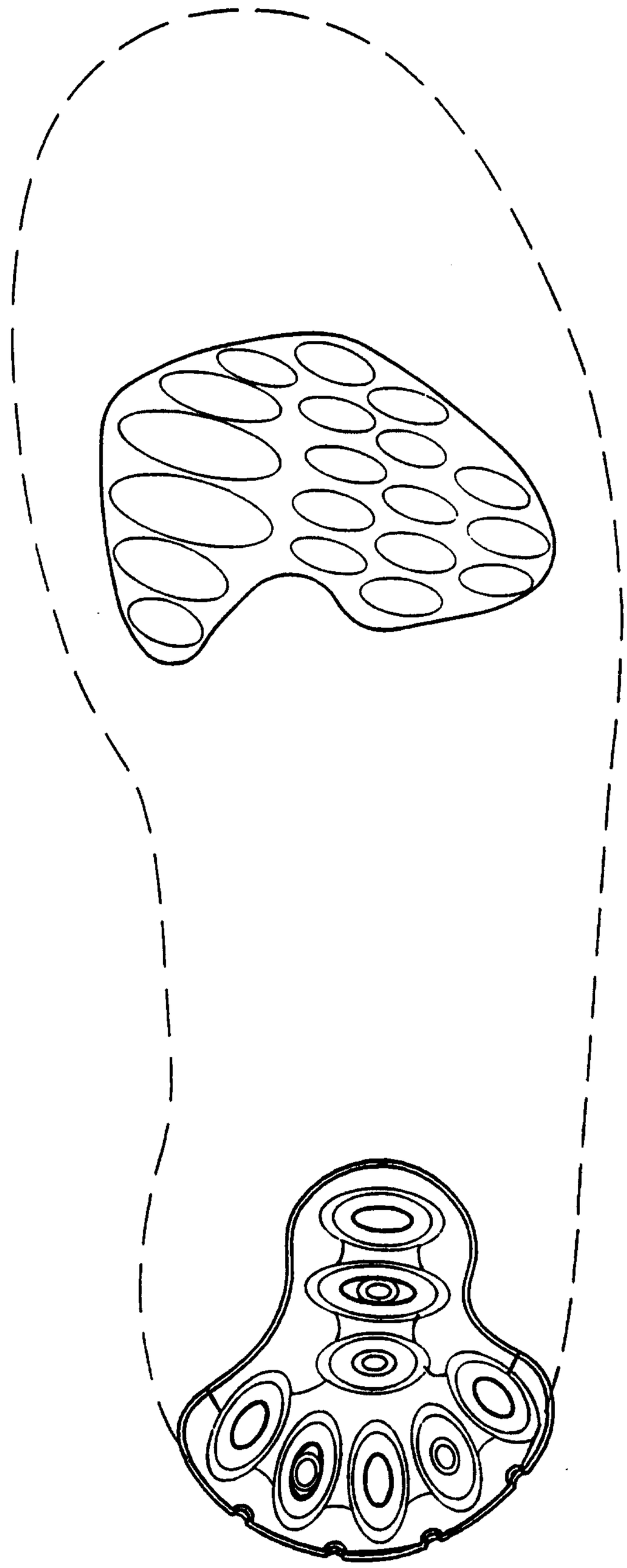

FIG. 178

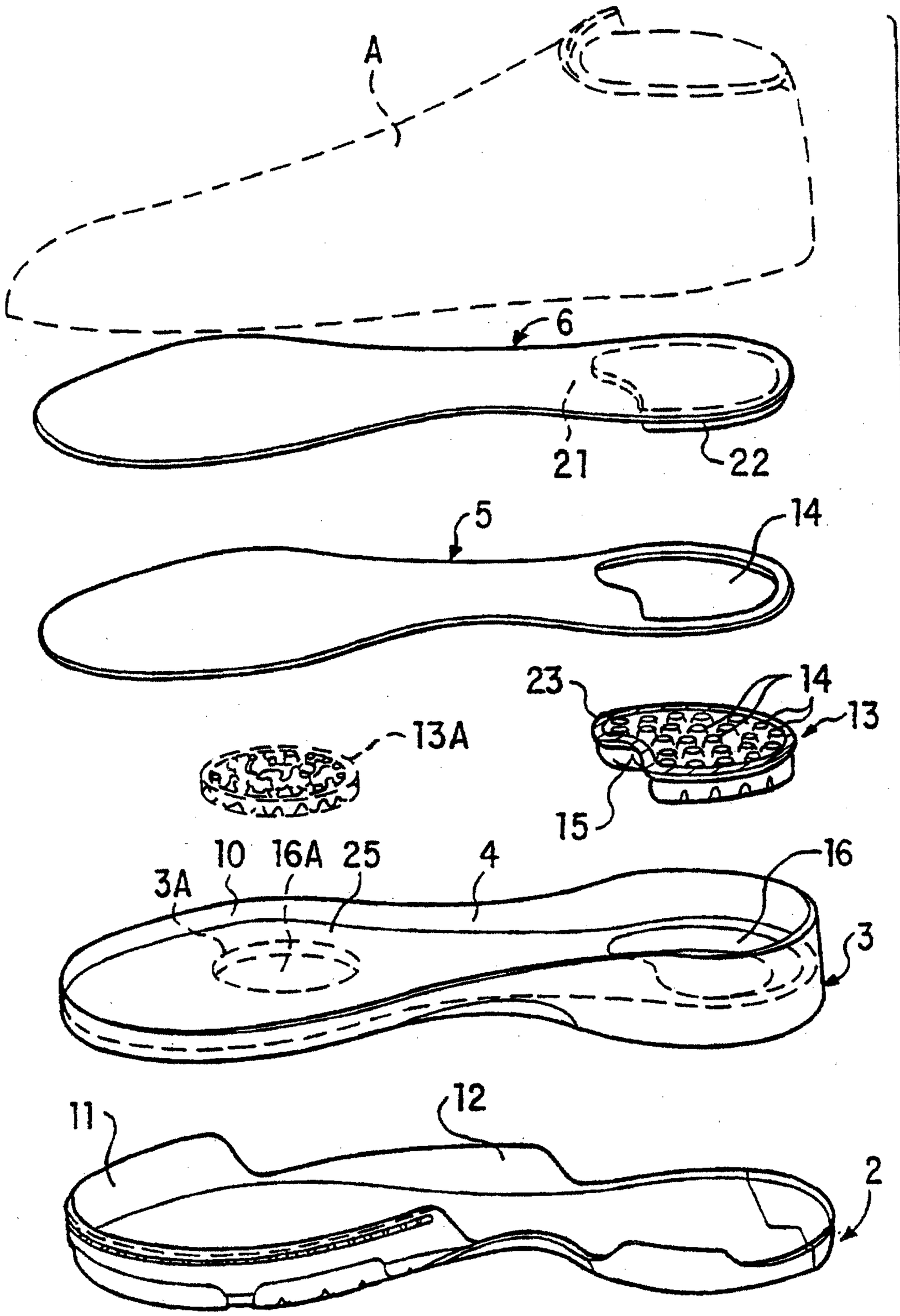

FIG. 179 (PRIOR ART)

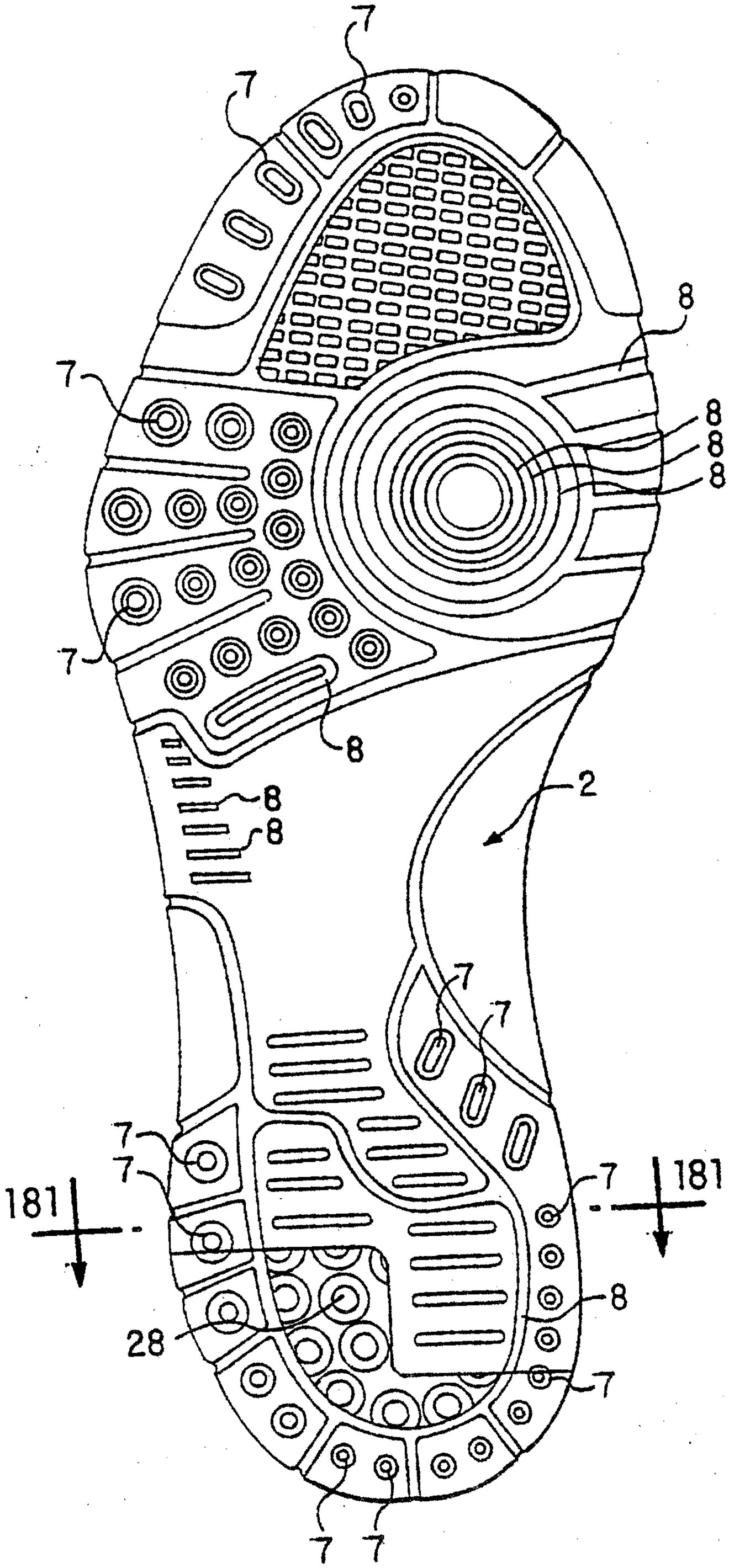

FIG. 180 (PRIOR ART)

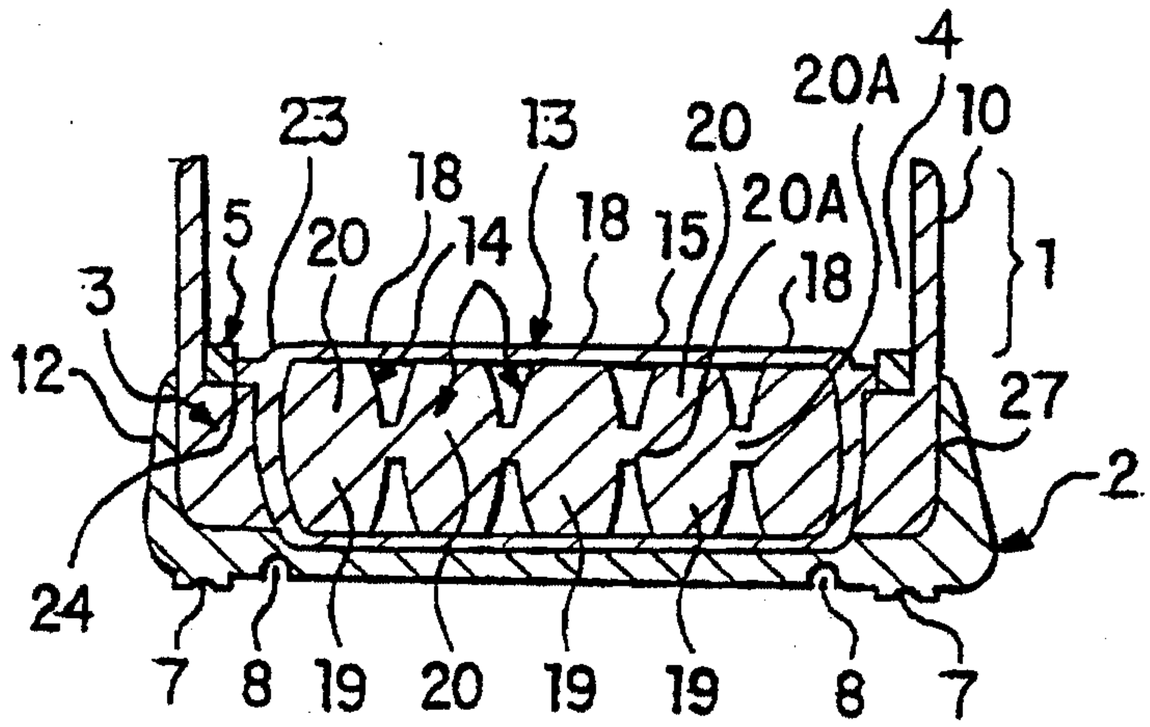

FIG. 181 (PRIOR ART)

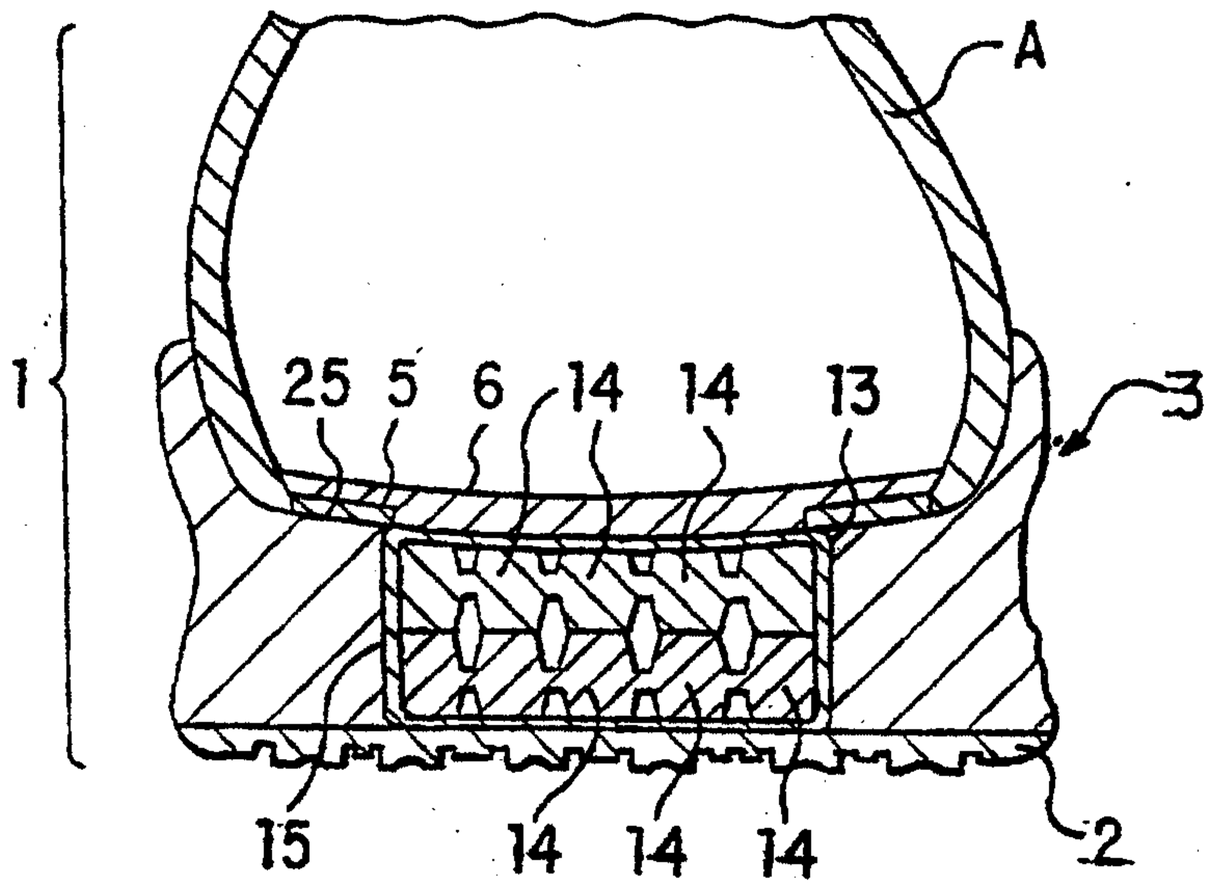

FIG. 182 (PRIOR ART)