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W. H. JONES
FABRICATION OF FOOTWEAR HAVING DIFFERENTIALLY
DEFORMABLE INSOLES

2,863,231

Filed Jan. 17, 1958

3 Sheets-Sheet 1

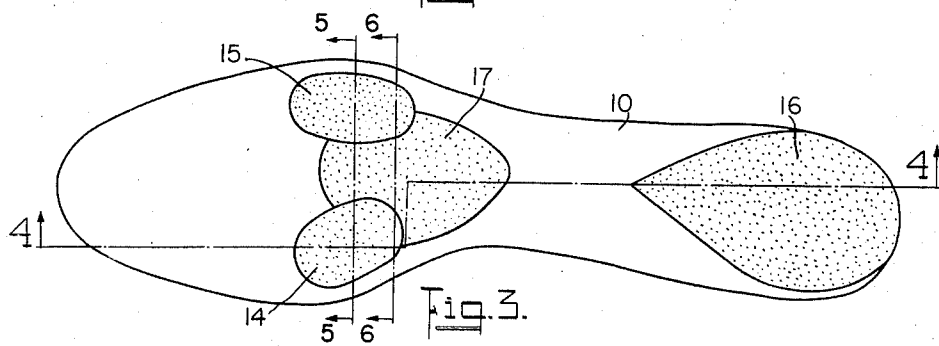
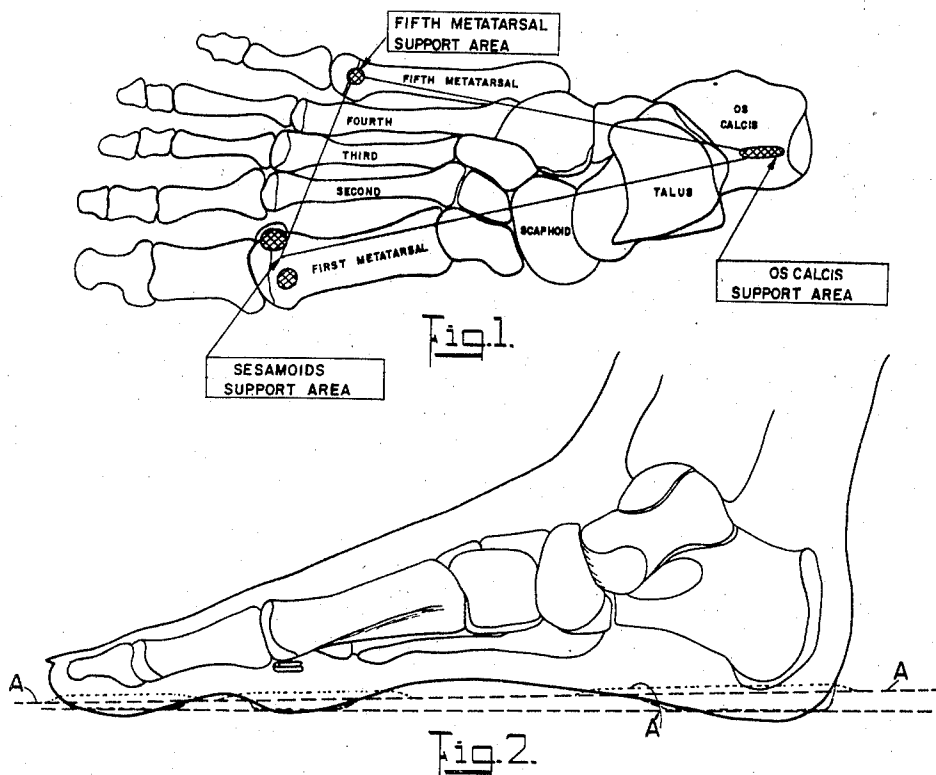


Fig. 5.



Fig. 6.



Fig. 7.

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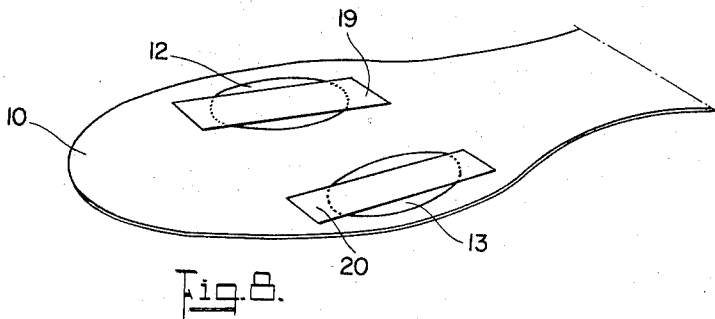
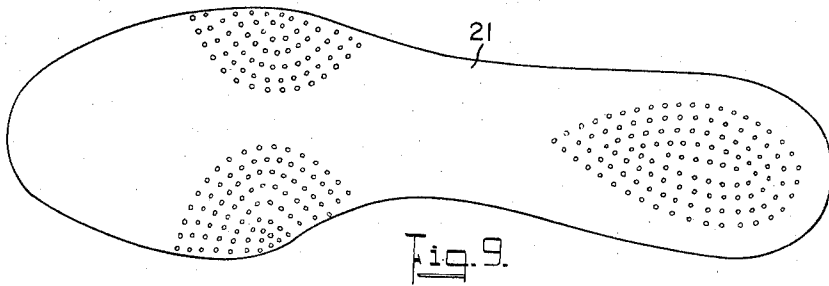
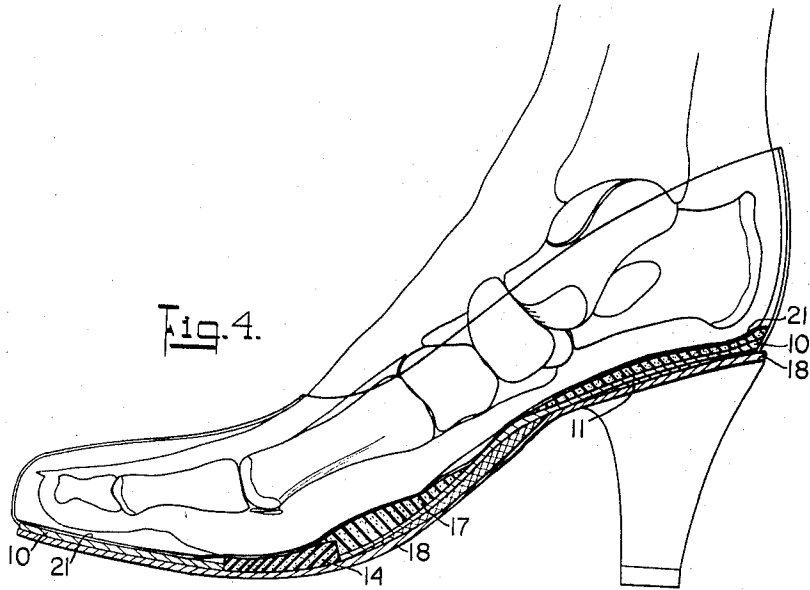
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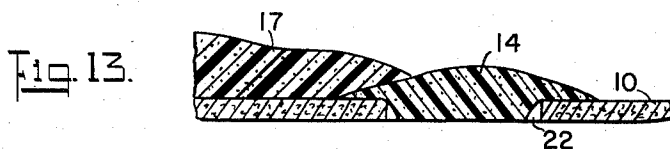
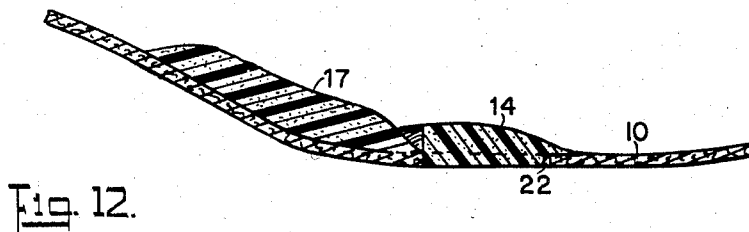
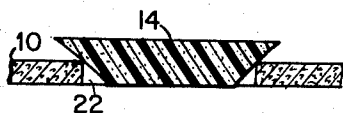
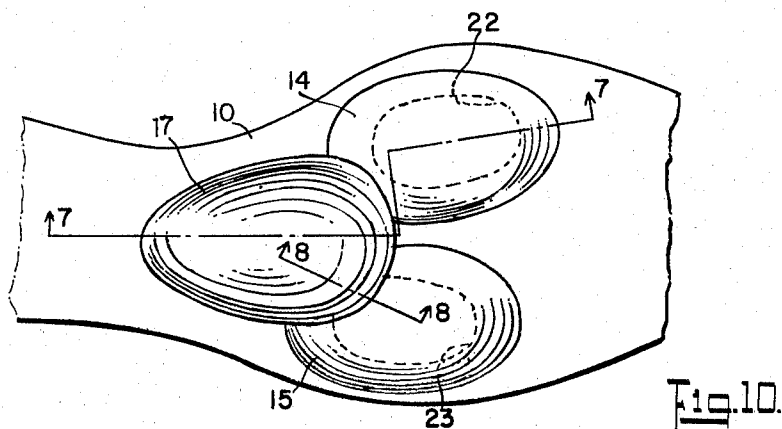
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3 Sheets-Sheet 3



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FABRICATION OF FOOTWEAR HAVING DIFFERENTIALLY DEFORMABLE INSOLES

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3 Claims. (Cl. 36—71)

This invention concerns improvements in soles for shoes, and more particularly concerns a construction of an apertured insole having resilient inserts correlated with the metatarsal support regions of the human foot, and a complementary resilient body associated therewith for controlling load distribution over the metatarsal arch.

The present application is a continuation-in-part of the invention described and claimed by me in an earlier application Serial No. 663,277, filed June 3, 1957.

In the shoe manufacturing art many compromises are made between a theoretical desired construction on the one hand which will provide a foot with a wholesome and healthy environment and a practical construction on the other hand dictated by the character of available construction materials, style demands, costs, and like factors. Soles and insoles of shoes are conventionally fabricated from sheets or slabs of materials of the class having desired rigidity, toughness and porosity, as exemplified by leather and alternative planar materials. As lasted on conventional lasts, a sole is curved simply rather than formed in three dimensions, the axes of curvatures being generally parallel and the sole being bent out of a plane into cylindric form with generally varying radius. With the limited flexure allowed by shoe constructions which attach the upper more or less firmly to the sole edges the curvature of the sole is substantially limited to the cylindric. It will be apparent therefore that the human foot resting upon the insole of a shoe is provided with a supporting base that is generally an unyielding surface having cylindrical curvatures.

Simple inspection of the underside of a human foot shows that the sole by no means conforms to a series of cylindrical curves generated about parallel axes, and in fact when the forward metatarsal joints are bent as occurs in rising up on the toes, there is scant similarity to a surface generated by a line moving parallel to and at varying radii about one or more parallel lines. A fleshy pad of epidermis, dermis, muscle tissue, ligaments and cartilages underlies the ball of the foot, and encases the sesamoid bones that lie below the forward end of the first metatarsal bones. On examining the foot structure in a direction transversely from the ball, the metatarsal arch is apparent, in which the forward ends of the five metatarsal bones are bowed upwardly from the sole. This transverse arch is apparent in each of a series of parallel vertical cross-sections that might be taken through the foot progressively towards the heel, and the fifth metatarsal bone remains generally horizontal while the others are inclined upwardly in the direction of the heel. The foot resting upon a flat surface contacts it generally at the forward ends of the first and the fifth metatarsal bones if the foot has a normally developed arch.

Provided there is no weakness of the longitudinal arch, the principal other support area of the foot is the base of the os calcis or heel bone. In the majority of human feet supported on a flat surface the weight of the body directed downwardly upon the talus bone which overlies the os calcis is applied forwardly of and to one side of

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the heel pressure area. Thereby the weight of the foot is distributed almost entirely between the heel pressure area and the sesamoid bones, and a relatively minor part of the weight is carried by the forward end of the fifth metatarsal bone. On rising to the toes and when the weight is taken off the heel, the amount of load carried by the fifth metatarsal at its forward end is much increased. The latter condition applies to the foot in high-heeled shoes, wherein an attitude of perpetually rising on the toes is maintained, hence the outer metatarsal bone support structure is greatly loaded above the average load sustained in a flat shoe.

The contact made by the unshod human foot walking upon a smooth bed of moistened fine sand or loam earth of relatively uncompacted character represents an optimum natural environment which it is desirable to simulate in a shoe. As the weight of the foot is brought down upon such natural support medium, the yielding nature of the compactable sand permits the heel to imprint itself over a relatively broad area while the sole areas under the forward ends of the first and fifth metatarsal bones embed themselves to a lesser extent in proportion to the loading on these areas. As the heel is raised in the further course of taking a step an increased load is impressed on the metatarsals, during which shift of pressure that part of the sand mass confined beneath and pressed upon by the upwardly bowed sole extending rearwardly between the forward ends of the first and fifth metatarsals is found to accept a significant share of the load, by becoming relatively unyielding. This compacted mass thereby affords a support for the transverse arch. A study of healthy unshod feet of primitive people treading earth paths and sand shows that an important share of the load is taken by the area referred to, and that this area extends heelward for a short distance. A comfortable feel is experienced in barefoot walking on turf or sand loam, and the pressure distribution over the principal and subordinate support areas of the foot on such media is a highly desirable objective to be matched by soles and insoles of shoes.

In contrast therewith conventional sole and insole constructions provide a platform upon which the three main support areas of the foot bear with relatively limited contact areas and high pressure gradients across such areas. The human foot in a shoe with a firm sole, as the majority of walking shoes are constructed, is in no better position in regard to pressure intensity and gradient than when standing on a smooth slab or a solid rigid body. The development of callus around such areas is a common ailment while the collapse of the metatarsal arch is a frequent consequence of wearing conventional shoes in walking on pavements and floors.

Heretofore a very great number of forms of arch support, pads, special insoles, and the like modifications of shoe members receiving pressure of the foot have been evolved for the adjustment of pressure distributions over specific areas of the sole of a shoe. Specific prior art forms are known wherein an apertured insole or sock liner provides resilient inserts of the character of sponge rubber presented beneath the three principal contact points of the foot. The fabrication of such forms as have heretofore been proposed presents serious difficulties in the lasting of shoes since the aperturing changes the self-support characteristics of the insole material under the stresses of lasting. Moreover the insertion and attachment of inserts as previously proposed has been difficult and certain forms have not permitted relatively free insertion and withdrawal of the foot into a shoe so constructed.

The present invention therefore seeks to improve the construction of a shoe so that the pressure gradient over the principal support areas and in the area of the trans-

verse metatarsal arch is more nearly uniform and concentrations of pressure are alleviated.

It is another object of the invention to modify a slab sole construction of a shoe to achieve non-uniform resilience over its area and which under pressure of a human foot is differentially deflectable in accordance with the loads on each of the principal support areas of the sole, and by which the subordinate support areas accept their due share of the load.

Yet another object is the construction of the insole of a shoe to include a sock liner having an upwardly domed resilient projection disposed between the first and fifth metatarsal bones and extending rearwardly and bounded by relatively more deformable resilient portions presented beneath the ends of the first and fifth metatarsal bones.

The present invention has for its principal object to simplify manufacture of a shoe with an aperture insole and to facilitate the making of final adjustments of the several inserts before sealing the sock liner retaining member.

The invention has also the object of arranging a transverse metatarsal arch support body upon an apertured insole in relation to inserts filling the areas under the principal pressure points so as to provide a co-operative load-distributing action and to control the transverse arch curvature of the forward ends of all metatarsal bones as loaded in walking in high heeled shoes.

The following description of the invention is to be read in conjunction with the accompanying figures of drawing whereof certain ones illustrative of human foot structure are included for a better understanding of the relation of the invention thereto, the figures are:

Figure 1, showing in plan view the disposition of bone structure and the principal support areas of the foot;

Figure 2, showing in elevation comparative phantom sections of the foot as embedded in a compactable sand loam and as resting on an unyielding slab;

Figure 3, diagramming the relation of the apertures and the transverse arch cushions in an insole according to the invention;

Figure 4, a section elevation of a foot in a high-heeled shoe embodying the insole of Figure 3, as designated by the line 4—4;

Figure 5, a transverse section taken on line 5—5 of the insole of Figure 3;

Figure 6, a transverse section taken on the line 6—6 of Figure 3;

Figure 7, a longitudinal section of part of an insole as laid in the flat, taken on line 4—4 of Figure 3;

Figure 8, an illustration of the manner of retaining punched portions within the apertures of the insole;

Figure 9 is a plan view of a perforated sock liner for use with the insole according to the invention;

Figure 10, a plan view of an alternative construction employing cushions having tapering margins and a metatarsal pad adhesively secured partly overlapping the cushion edges;

Figure 11, a cross section of an insole through an aperture showing an alternative cushion prior to adhesion;

Figure 12, a cross section of the alternative insole taken on line 7—7 of Figure 10; and,

Figure 13, illustrating a cross-section taken along line 8—8 of Figure 10.

Figure 1 is a self-explanatory drawing, which in conjunction with the other figures of drawing serves to illustrate the weight distribution and proportional loading of areas of the sole of the human foot, the body weight being principally borne under the os calcis and a lesser part being borne under the forward end of the first metatarsal, when the body weight is directed downwardly upon the talus bone. The deformation of a sand loam earth mass having a smooth plane surface designated A by the foot in taking a step to impress the body weight thereon may be understood by referring to Fig-

ure 2, wherein the solid line contour denotes the foot outline under the distributed loading effected. The dotted line A' denotes the displaced surface of the earth mass adjacent the foot and under the arched portions. It will be seen that forwardly of the heel support area of Figure 1 there is an inclined slope of relatively broad extent conforming to the foot contour which contributes support. Both in front of and rearwardly of the ball of the foot a domed body of loam is formed by compaction and due to the sinking of the sesamoid area. There is thereby created a broadened support area tending to hold up the transverse arch for some distance heelward of the line joining the forward support points of Fig. 1.

There is also shown in Fig. 2 the effect on the foot of stepping on a smooth rigid slab support. The loading at each of the principal support points of Fig. 1 is concentrated over relatively small areas of the foot, and the deflection of the heel and ball as indicated by the dashed outline of the foot shows considerable lateral stretching due to high gradient of pressure across such areas.

An embodiment of the invention particularly described with reference to Figs. 3 and 4 includes an improved insole 10 which may be realized as a single piece of leather or other suitable flexible non-resilient material and may include a shaped fibre base laminate 11 under the arch and heel. That part of the insole which underlies the ball of the foot is apertured by punching out ovoidal or elliptical bodies 12 and 13, in place of which cushioning bodies 14 and 15 are received. The thickness of the latter bodies will generally be substantially twice the thickness of the insole into which these are set. The bodies preferably comprise a rubber sponge of fine cellular character although numerous combinations of materials having desired resilience might be employed. The heel area of the insole supports a tapered cushion 16 of soft spongy rubber cemented to the upper side. Lying immediately adjacent between the inserts 14 and 15 and extending rearwardly therefrom is a yielding upwardly bulged cushion body 17 cemented to the insole and to the edges of the inserts. This cushion is formed preferably of a sponge rubber more dense than that used in forming the inserts and having a bulk modulus of the order of at least two and one half times that of the insert material. The inserts are cemented to the sole 18.

In the manufacture of a shoe having an improved insole according to the invention, the insole body 10 is prepared as by cutting it out with a clicker die shaped to the outline required, to the heel and arch portions whereof may be applied suitable stiffening devices. The blank insole is then placed between dies of the type including shaped punches reciprocable toward a correspondingly apertured sole plate in the apertures of which spring-loaded followers are slidable vertically to apply restoring force to return the sheared-out bodies to their original positions in a sheet of stock, when the punches move clear. Numerous prior art mechanisms of a type suitable to carry out this step are known and it is believed this step will be sufficiently understood by practitioners in the art without further elaboration.

The insole with its separable sheared portions 12 and 13 is removed as a unit from the die bed and one or more strips of adhesive tape such as 19, 20 are placed in bridging relation across the insole 10 to hold the free ovoid portions during further handling, as shown in Fig. 8.

The areas which are punched out correspond to the bearing points of the ball of the foot and underlie the joints at the forward ends of the first and fifth metatarsal bones. In general the outer edge of the aperture which lies nearest to the edge of the insole will be spaced inwards about $\frac{3}{16}$ inch. The areas are elongate ovoids and generally are directed in line respectively with the first and the fifth metatarsal bones of the foot. The

ovoids may be shaped irregularly if desired, however a preferred plan form has a major axis approximately twice the length of the minor axis, and the inner edge of each aperture extends to the joint of the adjacent metatarsal but does not substantially underlie it.

The construction of the shoe is carried out substantially identically as for the conventional unmodified shoe, the placing of the inserts 14, 15, and the cushions 16, 17 being effected near the end of the fabrication prior to the cementing down of the sock liner 21. In carrying out one modern constructional procedure the insole with its punch slugs held in place is secured as by tacking to the underside of a wooden last, after which the last machine pulls the upper over the last, the edges being secured by cementing and tacking to the insole margins. In this operation the strength of the insole is a critical factor in assuring freedom from buckling and wrinkling. It has been found that a single broad aperture is disadvantageous and impractical and moreover that the retention of the sheared plugs is essential to successful results in modern manufacturing operations. The parts of the shoe are built up on the last, the shank is attached and lasting allowances are trimmed. The outsole is cemented to the insole when the upper is adequately bonded and the tacks used to hold the insole in place have been removed.

After the last is removed from the shoe, the sheared-out plugs are manually lifted out by pulling off tapes 19, 20. Each of the metatarsal pads 14, 15 are then cemented on its underside and affixed in an aperture against the exposed outsole 18. The body 17 which has been cut to conform to the plan outline of the inserts 14, 15 is cemented on its base and positioned against the inserts before it is pressed down against the insole. Similarly, heel cushion 16 is cemented down.

A sock liner 21 which is preferably a thin split leather member with smooth side up and cut to conform to the shape of the insole is preferably pierced over the forward ends of the first and fifth metatarsals and over the heel cushions. The sock liner is then cemented down over the insole and cushions.

The sock liner may be formed as a composite structure whereof each of the pierced areas is realized in any very soft pliant material and the pieces are taped to the main body of the liner or its underside.

An alternative to the foregoing completed shoe construction may omit the body 17 until the final fitting of the customer's foot, at which time a body may be specifically shaped from a blank form, as by shaving and wire wheel scratching.

In an alternative construction described with reference to Figures 10 to 13 inclusive, cushion bodies 14 and 15 have bevelled margins, providing an upper face whose area and extent is greater than the area of the aperture 22 or 23. Preferably, the lower face of each cushion lies about one insole thickness inwardly from the aperture edges, while the upper face extends by two to three insole thicknesses beyond the aperture. It is also useful and is preferred to have the bevel curved in cross-section as in Figure 11 to feather the edges of the cushion bodies. Such arrangement facilitates the location of the bodies 14 and 15 in the apertures, particularly when very soft sponge bodies are employed.

In fabricating a shoe having the alternative insole according to Figure 10, a suitable flexible cement which may be a self-vulcanizing latex base type is applied to the surface of the insole around each of the apertures, in an amount sufficient to spread slightly down the aperture sides, and the cushions are registered on the openings with the insole laid flat on a surface. When the cement has set the insole and the attached cushion bodies having their marginal portions firmly adhered to the surface of the insole may be handled as a unitary element and nailed to a last. It has been found that even with relatively soft and thin cushions their attach-

ment over the openings serves to prevent undue deformation and stretching during the lasting operation.

At any time after the shoe is built, the metatarsal transverse arch pad 17 may be adhesively applied before the sock liner is attached, its position being adjusted to suit the wearer, as for example at the point of retail sale, in accordance with fitting observations and experience. It will be observed that the forward edge of the pad overlaps the rearward edges of each cushion body, by an amount which maintains the region of greatest pad thickness oriented generally under the second metatarsal shaft midlength.

The pad 17 is made without cut-out edge configuration since the cushion bodies with bevelled edges do not provide any shoulder for registration. The pads are accordingly similarly tapered in thickness towards the centers of the openings 22 and 23, as best shown in Figure 13. The material for pad 17 is preferably a firmer resilient material such as sponge rubber, having a hardness selected to suit the wearer. The pads have a planar underside and an upwardly domed convex form, and generally ovoidal outline in plan view. Their thickness may range widely, inasmuch as the height of the transverse arch and the amount of fleshy padding on the soles of wearers may vary widely.

The attachment of pad 17 to the insole may be carried out at any time, as has been indicated, and an adhered pad may be replaced by another, provided that the sock-liner 21 may be raised and provided that a rubber cement of the solvent type has been used for temporary securing of these parts to the insole. The sock liner of Figure 9 may take the form of a front portion and a rear portion (not shown) in overlapping relation to facilitate raising it to uncover the pad 17.

Cushion bodies 14 and 15 as shown in Figs. 10 to 13 may comprise a wide range of materials and the invention is not necessarily limited solely to sponge rubber. For example, combinations of rubber and solid resilient fillers such as cork, hair, fiber and cellular materials may be employed, these combinations providing resilience and freedom from undue tendency to compressive setting and compaction, while offering a desired springiness and firmness. The pad 17 may similarly be realized in a wide variety of materials, to provide a resilient relatively non-compactable support for the transverse arch of the metatarsal bone group, having a thickness and hardness which ranges from substantially that of the cushions 14 and 15 to relatively thick and hard forms, as required to fit each specific foot condition.

I claim:

1. A shoe insole comprising a flexible sheet of a shoe construction material conforming in outline to the sole of a shoe and formed with a pair of elliptical apertures substantially centered under the forward ends of the first and the fifth metatarsals and aligned with the length of the respective bones, a resilient cushion plug thicker than the insole positioned within each aperture and secured to the sole, each plug having marginal upper portions tapering to the edges extending beyond the apertures and secured to the upper surface of said insole, and a resilient pad domed upwards and thicker than the cushions having an elliptical outline and flat under side secured upon the insole to underlie the second, third, and fourth metatarsal shafts rearwardly of a line joining the centers of the apertures, forward tapering marginal portions of said pad overlapping rearward tapering marginal portions of the plugs.

2. A shoe insole comprising a flexible sheet shaped in the outline of the sole of a shoe having two spaced ovoid apertures centered to underlie the forward ends respectively of the first and fifth metatarsals and aligned respectively with their lengths, resilient cushion bodies thicker than the insole positioned in the apertures and secured to their margins and to an adjacently underlying sole, and a resilient upwardly convex pad of ovoid out-

line which is firmer and thicker than the cushion bodies having rounded tapering edges and a flat underside secured to the insole to underlie the metatarsal shafts, and having forward marginal portions overlapping and secured on rearward tapering marginal portions of the bodies. 5

3. An insole as in claim 2 wherein said pad is centered substantially under the midlength regions of the second and third metatarsals and has its forward margin terminated rearwardly of the forward ends of said metatarsals. 10

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