June 6, 1939. R. P. SCHWARTZ 2,160,991

SHOE CONSTRUCTION AND LAST

Filed May 12, 1937 2 Sheets-Sheet 1

Fig. 1

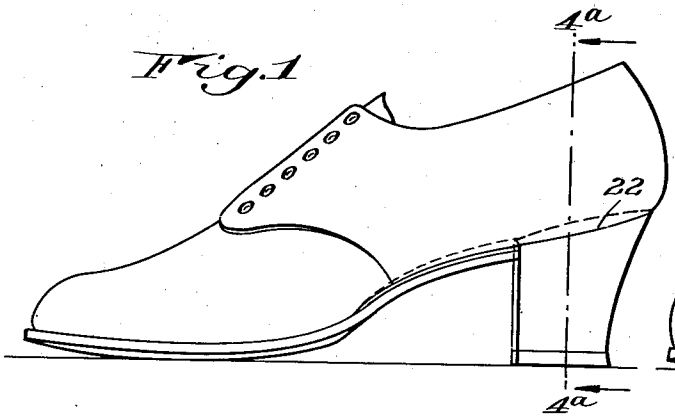

Fig. 2

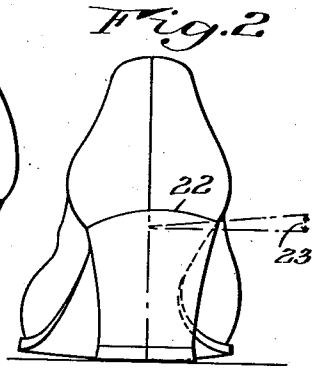

Fig. 3

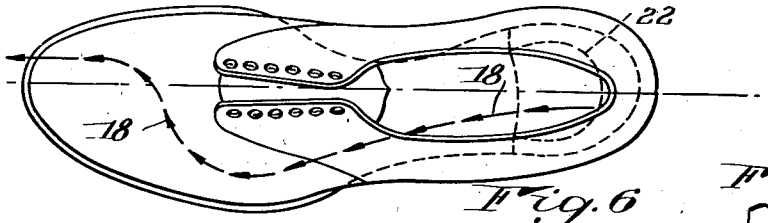

Fig. 6

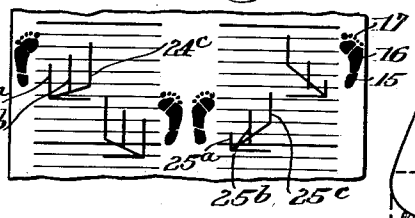

Fig. 5

Fig. 4

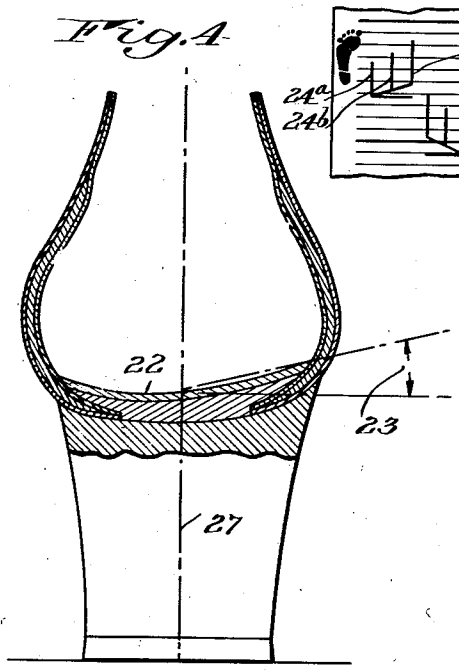

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Fig. 7

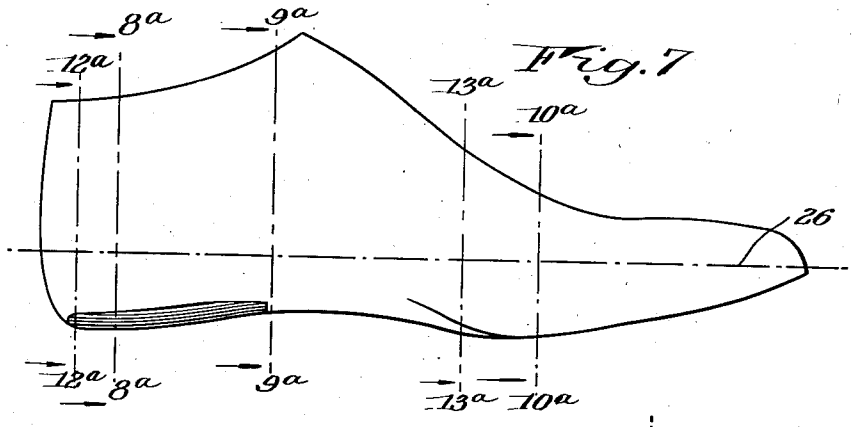


Fig. 8

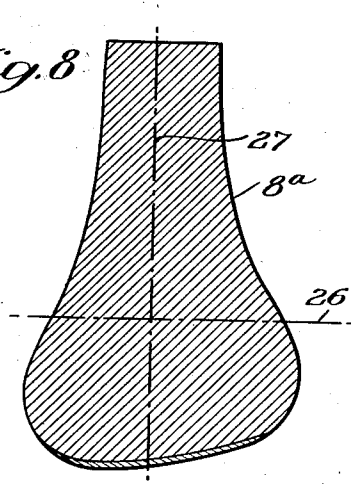


Fig. 9

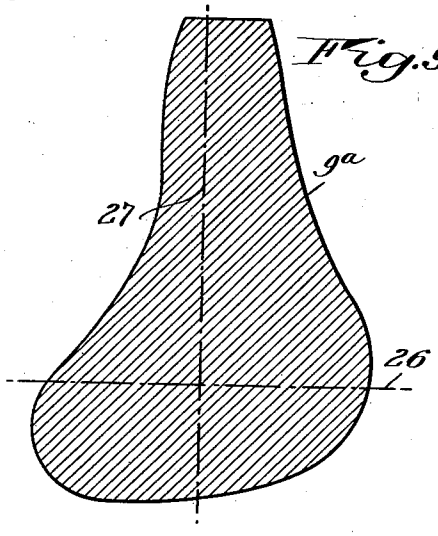


Fig. 11

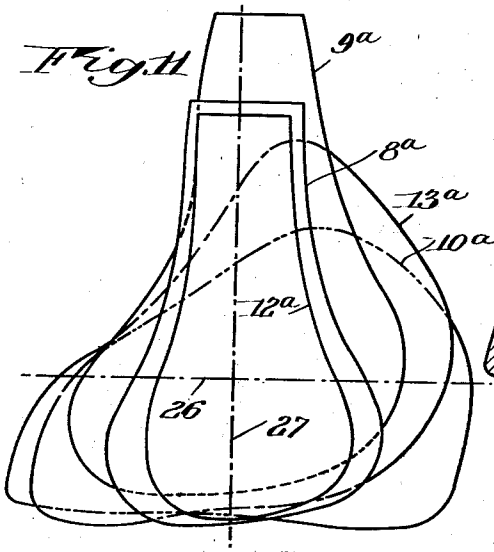
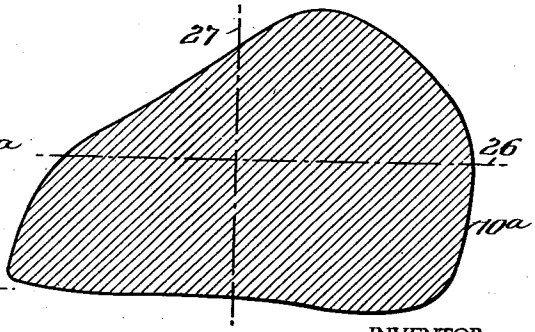


Fig. 10



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Patented June 6, 1939 2,160,991

UNITED STATES PATENT OFFICE

2,160,991

SHOE CONSTRUCTION AND LAST

Russell Plato Schwartz, Rochester, N. Y.

Application May 12, 1937, Serial No. 142,215

4 Claims. (Cl. 36—8.5)

This invention relates to shoes and shoe construction, and lasts for making the same, one object being the provision of a shoe having a construction adapted to meet, in a simple, practicable, and effective way, the requirements disclosed by an accurate and thorough study of the structure and functions of the bones, joints, ligaments, tendons, and muscles of the leg and foot, both in the stationary support and the propulsion in motion of the weight of the body.

Another object is to provide a shoe formed and constructed to compensate for the natural malalinement in axes and shape of the bones of the leg and foot, and to thereby produce and maintain a condition of equilibrium in the weight bearing functions of the foot, to maintain a strong posture and prevent the pronation or lowering of the medial longitudinal arch with the ills attendant thereon, as well as to preserve the natural propelling functions of proper portions of the forefoot, so as to reduce fatigue and promote natural and easy functions in stance and gait.

A further object is to provide a last adapted to produce a shoe construction of the foregoing character.

To these and other ends the invention resides in certain improvements and combinations of parts, all as will be hereinafter more fully described, the novel features being pointed out in the claims at the end of the specification.

In the drawings:

Fig. 1 is a side elevation of a shoe for the left foot embodying the invention;

Fig. 2 is a rear elevation of the same;

Fig. 3 is a top plan view of the same;

Fig. 4 is a vertical transverse section on the line 4*a*—4*a* in Fig. 1;

Fig. 5 is a rear elevation partly in section of portions of the bones of the leg and foot to illustrate in a general way their natural malalinement in weight bearing function;

Fig. 6 is a portion of a diagram representing the indications of a mechanical analysis of the functions of the foot in motion;

Fig. 7 is an inside elevation of a last for a left shoe embodying the invention;

Figs. 8, 9, and 10 are sectional views on correspondingly numbered lines in Fig. 7, and

Fig. 11 is a composite or assembly of the outline contours of Figs. 8, 9, and 10, and of similar additional contours of the last on lines 12*a*—12*a* and 13*a*—13*a* in Fig. 7.

The same reference numerals throughout the several views indicate the same parts.

Solution of the problem of providing proper shoe construction naturally begins with a consideration of the structure and functions of the bones, joints, ligaments, tendons, and muscles of the leg and foot in regard to both stationary support and propulsion in motion of the weight of the body.

The foot may be regarded, for example, as generally divided into three parts, namely, the heel, the outer lateral midfoot portion and the forefoot portion, as indicated by the sections 15, 16, and 17 of the representation of an impression of the foot in the diagram of Fig. 6. The heel is the first to strike the ground in walking, and its chief function is to receive and support the weight, either stationarily or while the body is in motion. The outer lateral midfoot portion assists and stabilizes the function of the heel in supporting the weight which is progressively transmitted to it from the heel in walking. The forefoot portion has as its chief function the propulsion of the weight forwardly in walking.

The heel portion and associated portions of the tarsus are more directly located under the weight bearing structure of the leg, including the tibia, to perform the chief weight bearing function. The outer lateral midfoot, formed by the outer longitudinal arch comprising with the os calcis the cuboid and outer metatarsal bones, is padded along the longitudinal outer side of the foot and adapted to assist in the weight bearing function, not only by stabilizing stationary support on the heel, but by receiving the weight progressively from the heel as the body moves forward. As the weight is shifted forwardly the forefoot portion grips the ground, particularly the inner side of the foot and the great toe, and the tendons of the inner longitudinal arch normally supply, with the ligaments and muscles of the leg, the propelling force for the forward motion of the body. The normal result in walking is that the extreme rear of the heel first strikes the ground, receives the weight, transmits it along the outer longitudinal arch in what is known as the "cuboid stream" to the forefoot portion across which the weight rolls medially inwardly to the region of the great toe "in the scaphoid stream", which latter supplies the forward propulsion. This direction of action is indicated generally by the line of arrows 18 in Fig. 3. These foot portions and the many elements associated in their respective processes must be maintained in normal posture and functional relation in order to prevent unbalance, fatigue and inefficient action in both stance and gait.

There is, however, in the relationship of the os calcis to the tibia, and to some extent in the shape of these bone structures, a normal malalinement of the weight-bearing axes and shapes which, with other pertinent functional and structural characteristics of the foot, make the foot an unstable weight bearing structure in relation to the leg in stance and gait. This is illustrated, for example, in Fig. 5, representing a fragmentary rear elevation of the bones of the left foot. It will be seen from this view that the weight bearing axis 19 of the tibia is offset substantially inwardly from the weight bearing axis 20 of the os calcis. Furthermore, while this axis of the os calcis passes substantially through its lowest point, the lower surface of this bone is inclined upwardly and inwardly at an angle, indicated at 21, varying with different individuals between substantial minimum and maximum limits. The tendency of this malalinement of the bone structures of the leg and foot is to roll the os calcis inwardly so as to bring the weight bearing point of its lower surface more nearly in line with the weight bearing axis of the tibia, producing in the foot the inward turning or pronation commonly termed "flat foot". Such pronation brings in its train the flattening of the longitudinal and other arches of the foot, the stretching of the ligaments and tendons, and maladjustment of the many related elements and their functions, with resulting fatigue, and failure to function in the normal manner indicated above, or even serious injury to the elements themselves. It is a necessary function of the ligaments, tendons, and muscles of the leg and foot to compensate for such normal malalinement of the bone structures by resisting the tendency to pronation and by maintaining the bone structures and associated elements in a normal strong posture and relationship. And a proper shoe construction must be one in the design of which due consideration is given to these factors for the purpose of contributing to these desired functions.

A great number and variety of feet have been examined, including normal and abnormal cases, with particular reference to the provision of suitable shoe construction for both preventing and overcoming foot defects. This study has been facilitated by the development and use of analytical equipment, such as described in my copending patent application, Serial No. 756,710, filed December 8, 1934, for Method and means for recording the gait and muscle functioning of animate bodies. Such equipment includes the provision on the feet of the patient of electrical contact plates corresponding to the three sections 15, 16, and 17 of the foot referred to above, with cooperating contact strips on the floor, and electrical circuit means controlled by such contacts and having indicating mechanism whereby the duration of contact of each such portion of the foot with the ground is indicated, to afford an analysis of the foot action, as disclosed in detail in said application. Such equipment has afforded means for intensive and precise analysis of the effect on such foot action of shoes constructed to aid normal and overcome abnormal functioning of the foot. Such studies have indicated that the medial longitudinal arch is controlled by the position of the os calcis. That is to say, that if the os calcis and heel of the foot is retained in a position which prevents or corrects pronation, the lowering of the medial longitudinal arch is prevented. If the heel, from the time of its first contact with the ground, is positioned to compensate for the normal malalinement of the processes of the foot and the leg of which it is structurally and functionally a part, pronation and its resulting defects, in a great majority of instances is avoided. This is confirmed by the familiar fact that the rear edge of the bottom surface of the heel is usually worn away toward the outer side in most shoes, thus indicating the normal tendency of the foot to assume, in its initial contact with the ground, the outward inclination accomplished by shoes constructed in accordance with this invention.

This control of the os calcis and heel of the foot is accomplished by inclining the heel seat of the shoe outwardly, with a corresponding outward inclination of the midfoot portion or shank of the shoe, these being the primary weight bearing portions of the shoe as pointed out above. However it is important that the forefoot portion of the shoe be substantially horizontal and level and that the forward end of the midfoot or shank portion be gradually merged into such forefoot portion in order that the weight may be transmitted medially across the forefoot portion to its inner side in the region of the great toe for the final propelling action of the foot described above.

Figs. 1 to 4, inclusive, illustrate one type of shoe construction embodying the present invention. It will be seen from Figs. 1, 2, and 4 that the heel seat 22 is inclined outwardly and downwardly at an angle represented at 23 in Figs. 2 and 4. It has been found that this angle will vary in most cases between 10° and 20°, substantially, although particular cases may require more or less inclination. In most instances the heel seat will be at least as high at its rear end as at the breast of the heel, and the moderately high heel here illustrated is also inclined downwardly in a forward direction as shown. The described outward inclination is continued in the midfoot or shank portion which rests at its rear end on and conforms to the heel seat. This outward inclination of the shank portion is decreased progressively toward the forward end of the shank which is merged gradually and smoothly into the rear end of the forefoot portion. The latter, as shown, is substantially horizontal and level so that the weight may be rolled medially inwardly across the forward end of the metatarsal bones to the great toe which supplies the maximum and final weight propelling effort. The shank portion may, if desired, be stiffened by the usual or well known reinforcing strips of metal, fiber, or the like, but I have found that such reinforcements are of lesser importance where the shoe is properly constructed as above described.

The use of the recording means disclosed in my said application Serial No. 756,710, confirms the beneficial action of the foregoing principles of shoe construction. One record made by such means is reproduced in Fig. 6 where, at the left, is shown the foot action of a patient while wearing ordinary shoes. The vertical lines 24*a*, 24*b*, and 24*c* adjacent the impression of each foot indicate the duration of contact of the heel, midfoot and forefoot portions of the left foot and show the relatively flat action of the foot while engaging the ground, as well as the brief period of propulsion by the forefoot after the heel and midfoot have been lifted. The right hand side of Fig. 6 shows the substantially contrasting action of the foot of the same patient provided with my improved shoe construction, the lines

25*a*, 25*b*, and 25*c* showing the shorter, more progressive and rolling contact of the three foot portions with the ground, including the lengthened period of propulsion by the forefoot (line 25*c*) after the heel and midfoot have been lifted.

I have devised and illustrated in Figs. 7 to 11, inclusive, of the drawings, a last adapted for the formation of the above described shoe construction. Figs. 8, 9 and 10 illustrate transverse sectional contours of the last at correspondingly marked lines or points spaced longitudinally from heel to toe. These contours, assembled with additional such contours on the lines 12*a*—12*a*, and 13*a*—13*a*, have been assembled or superposed in Fig. 11 for comparative examination.

This last corresponds with the type of shoe shown in Figs. 1 to 4 of the drawings and it will be seen that the bottom of the last in the heel and midfoot portions is inclined upwardly from the rear end of the heel to the juncture with the forefoot portion and is higher along the outer side to give the desired complementary inclination described above for these portions of the upper surface of the insole in the shoe. In other words, as shown in Figs. 8 to 11, inclusive, the transverse sectional contours at points spaced longitudinally from heel to toe, have bottoms which increase in elevation and are higher along the outer side than along the inner side. This is shown by considering progressively the contours on the lines 12, 8*a*, 9*a*, and 13*a*. Fig. 7 and the contour on line 13*a* show such lateral inclination as gradually decreasing toward the juncture with the forefoot portion where it merges with the substantially horizontal contour of the forefoot taken on the line 10*a*—10*a* and shown in Fig. 10.

It will be understood, of course, that the shape of the last is complementary to the shape of the shoe made on it. For the sake of clarity the shape of the last has been described as a separate body, rather than by reference to the shoe, and so it will be understood, for example, that portions of the bottom of the last described as elevated or high in reference to the last itself, correspond and are complementary to portions of the upper surface of the heel and sole or insole which are described as low, as shown in the drawings.

The upper portions of the last are designed to provide, as shown, shapes and dimensions in the several parts of the shoes which are consistent with the described formation of the last bottom.

I have devised and disclosed in my Letters Patent No. 2,111,815, issued March 22, 1938, for Machine for copying contours, an apparatus for measuring and graphically recording such longitudinally spaced last contours, to facilitate the design and manufacture of lasts embodying the principles of the present invention. By means of such apparatus the last may be designed to develop in the shoe any desired size and shape of its parts, including the described formation of the bottom surface of the last. The horizontal and vertical axes 26 and 27 represent the position of the centers on which the last is rotated in my said machine during the measurement and recording of the contours.

The foregoing principles may be applied in an obvious manner to lasts and shoes of any required heel height. To facilitate the determination of proper heel height, I have devised and disclosed in my Letters Patent No. 2,082,912, issued June 8, 1937, for Foot measuring device, an apparatus for properly measuring such height from the foot of the patient, consistently with the principles of normal equilibrium and propulsion as above described.

The principles of the invention may be readily incorporated in welt, McKay and various other types of shoes without material or objectionable alteration of the superficial appearance to which the public has become accustomed. Such principles have been highly effective in preventing and overcoming pronation and its resulting defects in the foot, obviating foot discomfort and injury and the multiplicity of shoes and contrivances heretofore continuously presented with extravagant claims but without tangible evidence of benefits in use.

I claim:

1. A shoe having an upper heel surface substantially as high at its rear as at its forward end, a forefoot portion and a shank portion extending from the forward end of said heel surface forwardly and downwardly and merging into said forefoot portion, said heel surface and shank portion being inclined from the inner edges thereof downwardly toward the outer edges thereof to compensate for the malalinement of the bones of the leg and angle and support the weight against inward pronation and lowering of the medial longitudinal arch, said forefoot portion of the shoe being substantially horizontal in a transverse direction, whereby the weight of the body is applied progressively forwardly along the outer sides of the heel and midfoot portions of the shoe and then medially across said forefoot portion to the region of the great toe, first in the cuboid and then in the scaphoid stream, to maintain normal functional equilibrium and propulsion of the weight of the body in stance and gait.

2. A shoe having a heel seat at least as high at its rear as at its forward end, a forefoot portion, and a shank portion having its forward end merging into said forefoot portion and its rear end on said heel seat and at least as high as any intermediate part of said shank portion, said heel seat and shank portion being inclined to the horizontal not less than ten nor more than twenty degrees, substantially, from the inner edges thereof downwardly toward the outer edges thereof to compensate for the malalinement of the axes of the bones of the leg and ankle and support the weight against inward pronation and lowering of the medial longitudinal arch, said forefoot portion of the shoe being substantially horizontal in a transverse direction, whereby the weight of the body is applied progressively forwardly along the outer sides of the heel and midfoot portions of the shoe to maintain equilibrium and then medially across said forefoot portion to the region of the great toe to effect propulsion.

3. A shoe last having a convex heel surface at least as low at its rear as at its forward end, a forefoot portion, and a shank portion increasing in height from said heel surface forwardly and merging into said forefoot portion, said heel surface and shank portion being inclined from the outer edges thereof downwardly to the inner edges thereof to form the shoe to compensate for the malalinement of the bones of the leg and ankle and support the weight of the body against inward pronation and lowering of the medial longitudinal arch, said forefoot portion being substantially horizontal in a transverse direction, whereby the shoe is formed to direct the weight of the body progressively forwardly along the outer sides of the heel and midfoot portions of the shoe to main-

tain equilibrium and then medially across its forefoot portion to the region of the great toe to effect propulsion.

4. A shoe last having longitudinally spaced, transverse sectional contours, the bottoms of which, in the heel and midfoot portions, increase in elevation from the rear of the heel forwardly and are inclined downwardly from the outer to the inner side of the last, the contours of the forefoot portion having substantially horizontal bottoms, the said inclination of the bottoms of the contours of said shank portion being progressively decreased at the forward end of said portion to gradually merge with said horizontal bottoms of said forefoot contours, to form the shoe to compensate for the malalinement of the bones of the leg and ankle and support the weight of the body against inward pronation and lowering of the medial longitudinal arch, by concentrating the weight of the body progressively forwardly along the outer sides of the heel and midfoot portions of the shoe to maintain equilibrium, and thence medially across its forefoot portion to the region of the great toe to effect propulsion.

RUSSELL PLATO SCHWARTZ.