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PHOSTHETIC FOOT

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FIG. 1

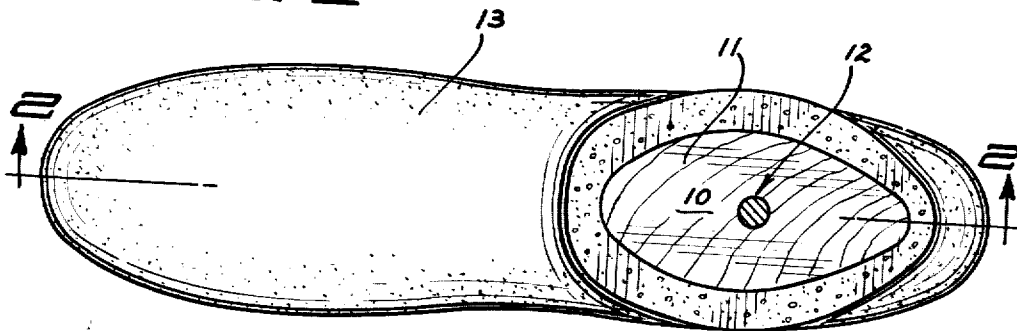
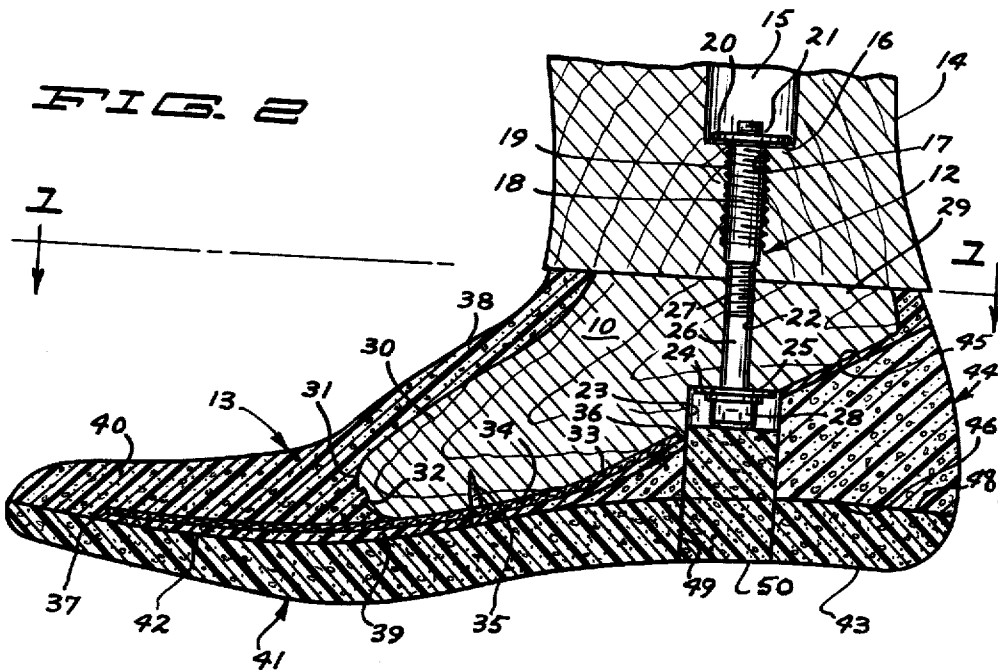


FIG. 2



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## PROSTHETIC FOOT

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4 Claims. (Cl. 3—7)

This invention relates to a prosthetic foot and more particularly to the type of artificial foot known as SACH (Solid-Ankle-Cushion Heel).

In recent years the SACH type foot has become used widely as a replacement for the articulated type of foot having a hinged or pivoted ankle joint. The SACH type foot is directly attached to a prosthetic shank and foot action during walking is achieved entirely through the elasticity of the heel and toe portions.

In general the absence of the simulated ankle joint action eliminates completely problems such as wear or moving parts, instability, characteristic noises created by articulation and pressures placed upon the foot and unreliability in the action at the joint due to variations in frictional contact within the moving parts. Also, the SACH type foot has a cushioned heel which simulates plantar flexion in a natural ankle. The heel provides shock absorption and is compressed at the beginning of each step. After compression of the heel, the foot begins to simulate ankle dorsiflexion. With continued rocking of the shank over the foot, the heel cushion expands and the weight of the user shifts to the ball of the foot. The internal keel provides a fulcrum which assists in sharing weight placed upon the foot and upon continued rocking of the shank, transfers full weight to the keel and causes the toe portion to flex. When the leg is lifted, the toe springs back to its original position. The resilient action of the heel and toe portions assist the user in walking and, in addition to simulating the natural gait, also makes it possible for the user to walk for longer distances before becoming tired.

Because of the reliance upon resilience of the heel and toe portions of the SACH type foot, the parts tend to separate and delaminate more easily. Furthermore, the steps of affixing the parts together render the prior solid ankle-cushion heel prosthetic foot more costly. Still further, adjusting the natural resilience of the cushioning material is done at the sacrifice of resistance to abrasion. Despite these disadvantages, the SACH type foot has gained wide appeal and is rapidly being adopted throughout the world.

It is within the contemplation of the present invention and a general object thereof to provide an economical and efficient prosthetic foot of the SACH type which will have improved simulated walking characteristics.

It is another object of the invention to provide a stable prosthetic foot made up of a rigid keel surrounded by mounted resilient sections so related as to give different degrees of cushioning effect and at the same time to exhibit wear resistance where it is most needed.

A further object of the invention is to provide a prosthetic foot which utilizes rigid and flexible members joined in continuously secured relation, the area of juncture under the greatest strain being keyed in a novel manner to relieve compression and to prevent rupture or delamination of the parts.

These and other objects and advantages of my invention will more fully appear from the following description, made in connection with the accompanying drawings, wherein like reference characters refer to the same or similar parts throughout the several views and in which:

FIGURE 1 is a top plan view of the artificial foot

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taken below the ankle segment in horizontal section along the line 1—1 of FIGURE 2; and

FIGURE 2 is a vertical section thereof taken on the line 2—2 of FIGURE 1.

With continued reference to the drawing, FIGURE 1 shows my solid ankle-cushion heel prosthetic foot, the keel 10 being constructed of a rigid material such as wood and presenting an upper face 11 from which projects a fastener element 12. The keel 10 is covered for the greater portion of its area, with a resilient and tough material constituting an upper foot portion 13. I conveniently employ a polyurethane foam, the density and flexibility of which can be controlled in a manner already known to the art.

Referring now to FIGURE 2, the foot is there shown as secured to an ankle segment 14, which may be constructed of material such as wood, which enables the foot to be attached to the prosthetic shank. The ankle segment 14 has a vertical opening 15 which is shouldered at 16 and terminates downwardly in a reduced bore 17 as shown. The fastener element 12 includes a threaded steel sleeve or adapter collar 18 having an external threaded portion 19 which is screwed into the reduced bore 17 until the head 20 is firmly abutted against the shouldered area 16. The adapter collar 18 also has an internally threaded bore 21 which extends through the entire length thereof. Keel 10 has a bore 22 with an enlarged portion 23 at the bottom thereof forming a shouldered area 24 and is aligned with bore 17 as shown in FIGURE 2. A washer element 25 abuts against shoulder 24 and bolt 26 which also forms a part of fastener element 12, has a threaded portion 27 adapted to be screwed into the threaded bore 21 of adapter collar 18 until head 28 abuts against the washer 25 and is securely drawn thereagainst.

The keel 10 has a portion 29 which extends rearwardly of the bolt 26 of fastener 12. The keel 10 also has a forwardly and downwardly extending portion 30 which has a rounded terminus 31 at its forwardmost position. The terminus 31 in turn is provided with a recess or keyway 32, the function of which will be described in greater detail later in this specification.

The keel 10 has secured to its bottom surface 33 a belting reinforcement 34 which may be glued and/or secured by screw means 35 to the keel so as to have its rearward terminus 36 adjacent the enlarged bore 23 and the forward terminus 37 extending well beyond the forward terminus 31 of keel 10.

The foot upper 13 is molded in one piece so as to cover the greater portion of the surface area of keel 10. A layer 38 of upper 13 extends over the top and sides of the forward keel portion 30 and may also form a thin bottom wall 39 covering the belting reinforcement 34 and the rearward keel portion 29 as shown. A thicker toe portion 40 of the foot upper 13 extends forwardly of both the keel terminus 31 and the forward terminus 37 of belting reinforcement 34.

A sole 41 underlies the undersurface 42 of the forward toe portion 40 of resilient upper 13 and is adhered thereto as shown. The rearward portion 43 of the sole 41 diverges from, and is not adhered to, the upper 13.

At the heel portion of the foot, a resilient segment 44 is shaped in the form of a wedge having an upper surface 45 and a lower surface 46 which are designed to precisely contact the corresponding bottom surface 42 at the rear portion of the upper 13 and the corresponding top surface 48 of sole 41 and to be adhered or sealed thereto to complete a solid unitary structure with the upper 13, sole 41, and keel 10. A hole 49 may be formed through the sole 41 and heel segment 44 so as to be aligned with the bore enlargement 23 in keel 10 as shown in FIGURE 2. A resilient plug 50 may be removably secured within the

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hole 49 to gain access to the bolt head 28 of the fastener assemblage 12.

An important feature of the invention resides in the comparative density and resilience of the upper 13, sole 41 and heel segment 44. I have found that where polyurethane is molded in several densities, I can obtain a comparative effect which will lend an improved resilience and, at the same time, achieve a good resistance to wear and abrasion. To achieve this end, I employ a high density material for the upper 13 which gives a stiffness and good abrasion resistance, particularly at the toe 40. The sole 41 has an intermediate density which will give lateral stability and good abrasion resistance, yet will be sufficiently flexible to present a natural cushioning effect and to permit proper flexion. The heel segment 44 is of lowest density and has the highest compressibility of the resilient foot portions. The cushioning effect of the heel makes possible a natural walking gait without articulating the prosthetic foot at the ankle joint.

It will be further noted that the sole 41 provides wear resistance below the heel segment 44 and hence, the softer material of the heel segment is not called upon to resist surface wear and abrasion.

The arrangement of the resilient portions is such that surface adhesives can resist delamination in the surface junctures. The most critical point of strain is that where the keel terminus 31 joins with the upper toe 40, since this constitutes a fulcrum point during use of the prosthetic foot. The recess or keyway 32 provides additional securing of the resilient upper 13 to the keel 10 since the upper material extends into and is adhered to the walls of the recess.

The herein disclosed prosthetic foot has been flexed in simulated walking gait for over 3,000,000 times without losing its resilient character or causing any delamination. Furthermore, the foot remained secured by its special fastening assemblage and did not exhibit undue wear at the undersurface of the sole.

It may thus be seen that I have devised a solid ankle-cushion heel prosthetic foot with improved attaching means and having improved function and wearing characteristics through selected resilience of solidly assembled molded portions.

What is claimed is:

1. A solid ankle-cushion heel prosthetic foot comprising, a keel having a portion thereof extending forwardly and downwardly to provide a bottom surface sloping generally forwardly and downwardly from an elevated rear terminus, attaching means extending upwardly from said keel at a position rearwardly of the forward and downward portion and adapted to secure said foot to a pros-

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thetic ankle segment, an upper foot portion constructed of a tough but resilient material and overlying the forward portion and sides of said keel and extending forwardly of the forwardmost terminus of said keel, said upper portion also underlying the bottom of said keel to thereby completely cover said forward portion, said sides and bottom of the keel with at least the section of said upper foot portion that underlies the rear portion of said keel bottom being in direct contact therewith, a generally horizontal sole portion constructed of resilient material having a density less than that of the upper and secured to the bottom of said upper between the forward terminus thereof and the forward terminus of said keel, and a unitary wedge-shaped keel segment of resilient material having a density less than that of said sole portion and secured at the rear of the foot between said underlying upper portion and said sole, said heel segment having its greatest thickness underlying said rear terminus of the keel and overlying the rear terminus of said sole, whereby said foot will have improved walking characteristics with good resistance to wear and abrasion.

2. A prosthetic foot in accordance with claim 1 including a flexible belting reinforcement secured to the bottom of said keel at the forward portion thereof and extending forwardly beyond said keel, the forward section of said upper portion that underlies the bottom of said keel being in direct contact with the underside of said belting reinforcement to form an uninterrupted continuation of the rear section of said upper portion which is in direct contact with the bottom of said keel.

3. A prosthetic foot in accordance with claim 1 in which said keel has a recessed keyway at said forwardmost terminus and receiving an integral projection of said upper foot portion, whereby, when the upper foot portion is bent forwardly of said keel, said keyway will prevent delamination and rupture of said resilient material at the juncture of the forward terminus of said keel with the upper forward extension of said resilient material.

4. A solid ankle-cushion heel prosthetic foot in accordance with claim 1 in which said upper foot portion completely encircles the upper portion of said keel.

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