ABSTRACT

A leg prosthesis comprises a stiff upright leather casing, a sleeve freely suspended from the upper rim thereof and extending into the casing with free elastic play in all directions, and a foot affixed to the lower end of the casing. The foot includes a sole and a separate ankle part, a leaf spring extending through the foot in a horizontally inclined plane and connecting the foot parts, and a rubber cushion mounting the ends of the leaf spring.

9 Claims, 2 Drawing Figures
LEG PROSTHESIS WITH RESILIENTLY MOUNTED STUMP SOCKET

The present invention relates to improvements in leg prostheses. It is designed specifically to eliminate the two weakest points in conventional prostheses.

Considerable problems have been encountered in suitably buffering the stump of an amputee against a leg prosthesis and to provide proper functioning of the joints. It has not been possible to buffer the stump so as to avoid undue friction and corresponding painful irritations of the stump. Also, the joints have not functioned properly and have had to be repaired repeatedly. Furthermore, amputees have complained that available prostheses are not good enough to enable them to engage in sports.

Experience has shown that buffering the stump against the stiff upright prosthesis leather casing, be it by rubber cushions, felt or other material, is unbearable because the cushion does not keep the stump in the same position. All known cushions have pressed against blood vessels, causing considerable pain.

If no cushion is used between the stump and the stiff prosthesis casing, this difficulty is avoided but the frictional irritation between stump and casing is correspondingly increased. Since the casing wall must be stiff enough to support the weight of the amputee whose stump extends into the casing, it cannot follow the movements of the stump in the casing. This causes continuing irritations.

It has been proposed to use a springy sleeve in the casing. However, this has only relieved frictional pressures at the stump during walking and has been designed only for very short stumps to prevent them from sliding out of the casing during the load-free phase of walking. In the load phase, the stump is pressed again into the casing and the springy sleeve then operates just like the stiff casing.

Furthermore, the known prostheses do not permit the foot joint to function properly. Essentially, all known artificial feet are more or less centrally fixed to the shaft of the prosthesis and, when the foot is under load, the connecting parts rub against each other. This rubbing causes considerable wear. As soon as this wear between the relatively moving parts permits a play between the parts, the entire foot connection becomes progressively looser.

The relatively best solution to the problem has been provided by a rubber block connection between the sole part and the ankle part of the prosthesis. This, too, however, has serious shortcomings, as have various other devices used in known leg prostheses.

It is the primary object of this invention to provide a novel leg prosthesis which overcomes the various disadvantages of the conventional artificial limbs and provides an improved bearing for the stump of the amputee as well as a better foot joint function.

The above and other objects are accomplished in accordance with the invention with a stiff upright prosthesis leather casing having an upper rim and a lower end, a sleeve extending into the casing and so suspended from the upper rim thereof as to have free elastic play in all directions in relation thereto without making contact with the casing, and a prosthesis foot affixed to the lower end of the casing. The foot includes a sole part having a forward toe portion, an ankle part separate from the sole part, a leaf spring extending along the entire foot to the forward toe portion in a horizontally inclined plane, the leaf spring connecting the sole and ankle parts, and an elastic rubber cushion mounting at least one end of the leaf spring. The sleeve preferably also consists of leather and it is preferred to mount both ends of the leaf spring on elastic cushions.

This combination provides a leg prosthesis of very good properties which not only permits even double amputees easier walking but also makes it possible to engage in such sports as skiing, tennis, mountain climbing, running, broad jump, etc.

The above and other objects, advantages and features of the present invention will become more apparent from the following detailed description of a preferred embodiment thereof, taken in conjunction with the accompanying drawing wherein

FIG. 1 is an elevational side view, partly in section, of a leg prosthesis according to this invention; and

FIG. 2 is an enlarged section of the prosthesis foot.

Referring now to the drawing, the leg prosthesis is shown to comprise a leg portion I including a stiff upright leather prosthesis casing 1a having an upper rim and a lower end. A sleeve 2 extends into the casing and is so suspended from the upper rim of casing 1a as to have free elastic play in all directions in relation to the casing without making contact therewith. This suspension is accomplished by an outwardly bent upper edge of the sleeve defining a groove of U-shaped cross section for suspending the sleeve from the upper rim of the casing. An annular rubber insert 4 is positioned in the groove and bonded to the sleeve so as to produce an elastic bearing for the sleeve on the casing rim, the insert 4 having a strip portion 5 spacing the sleeve from the casing about 2 or 3 cm. for permitting contactless free play. The rubber bearing will generally hold the sleeve stable in the casing so that its motions in the casing are minimal, the bearing being of hard rubber.

As shown in broken lines, the stump of the amputee is received in the sleeve. The minimal free play of the sleeve in a horizontal direction suffices fully for elastic absorption of the lateral impacts caused by movement of the stump during the constantly uneven load on the prosthesis, combined with the vertical impact absorption in the annular space 3 between casing 1a and sleeve 2. Due to the limited elastic movement of the sleeve with the stump, which extends therein, while the prosthesis is under load, there is no friction or pressure against the stump, thus avoiding irritations.

In fact, this elastic suspension of a stump receiving sleeve within the stiff casing constitutes a prosthesis within a prosthesis, the sleeve being made of a yielding or elastic material, such as soft leather, and being movable freely with the stump while the casing is stiff and load-bearing to provide a support for the sleeve. The elastic sleeve can be shaped according to the shape of the stump since its material is flexible. The sleeve may be accurately shaped by making a plaster cast of the stump and using the cast to shape the sleeve. This sleeve is then freely suspended in the stiff casing so that it has free play therein without ever contacting the casing wall. The hard rubber bearing 4 dampens the free play of the sleeve in the casing and the elastic sleeve material aids in the movement of the sleeve to conform fully to that of the stump. The rubber bearing permits movement in a lateral as well as a vertical direction, operating as a hard shock absorber in all directions when a load is applied there against. The load is evenly distributed over the entire prosthesis due to the
shock absorber as well as the elastically conforming shape of the sleeve to the stump.

The gauge of the sleeve wall is relatively thin to provide for good conformity to the stump and even distribution of the weight thereover but it is thick enough to provide a good support for the stump. In this manner, the weight remains evenly distributed in all angular positions, which is particularly important for the amputee in walking steps, climbing mountains, and like up or down movements, as well as in running, jumping, bicycling, etc. During all such movements, the impacts of the stump are elastically absorbed by the universal elastic motion of the freely suspended sleeve.

These and other advantages of the freely suspended stump carrying sleeve of the prosthesis are combined according to the invention with a novel artificial foot whose improved joint movement brings out the full advantage of the novel stump support. The prosthesis foot is affixed to the lower end of the casing and includes a sole part 10 having a forward toe portion, and an ankle part 20 separate from the sole part. A leaf spring 13 extends along the entire foot to the forward toe portion in a horizontally inclined plane and connects the sole and ankle parts.

The leaf spring is preferably made of a glass fiber reinforced plastic, for instance Scotch-Ply, having a thickness of 6 mm. In the illustrated embodiment, a pair of threaded bolts 15, 15 and 16, 16 respectively connect the leaf spring to the rear portion of the ankle part 20 and the ball portion of the sole part 10. A flat plate 15a with threaded bores receives the outer threaded ends of the pair of bolts 15, 15 at the rear portion for tightening the bolts, and a pair of nuts 17, 17 receive the outer threaded ends of the pair of bolts 16, 16 at the ball portion for tightening these bolts. The ball portion of the sole part 10 has recesses receiving the nuts 17, 17, and washers are interposed between the nuts and the recesses.

In assembling the artificial foot, the rear end of the leaf spring is first attached to the ankle portion, the plates 15a being inserted into a slot in the ankle part to receive the ends of bolts 15, 15 and the bolts then being tightened. The sole part 10 is then mounted on the bolts 16, 16 and the nuts 17, 17 are tightened to fasten the sole part to the leaf spring and thus to connect the two foot parts.

The sole and ankle parts define a space therebetween in the assembled condition, the spring leaf 13 extending diagonally therebetween through this space 14. The front portion of the leaf spring rests on the front toe portion of the sole part and an elastic rubber cushion 18 is mounted over the leaf spring and engages the ankle part 20. Similarly, an elastic rubber cushion 19 is mounted between the rear end of the leaf spring and the sole portion so that the ends of the leaf spring are elastically cushioned in respect of the foot parts in opposite directions. The elastic cushioning not only improves the mobility of the foot but also increases the life of the prosthesis. It is particularly advantageous for maximum effect if the cushion 18 adjacent the forward toe portion is smaller and less elastic, i.e., of harder rubber, than the rear cushion 19.

The front and rear portions of the foot carry protective caps 11 and 12, respectively. A particularly useful material for the leaf spring 13 is a glass fiber sheet having a fatigue strength or resistance to bending of 10,000 kg/sq.cm. Such a material is commercially available under the trademark "Scotch-Ply" and remains useful for many years. A leaf spring of this material makes the foot wearable almost indefinitely and securely unites the two foot parts.

This connection effectively assures an elastic joint movement of the foot, assuring not only comfortable walking but also stability and enduring elasticity. The relatively hard elasticity of the leaf spring, combined with its cushioned mounting, can be readily conformed to the individual needs of all types of amputees to transform the impact energy of the weight of the wearer into rotational and angular energy needed for comfortable foot and leg movement. The two rubber cushions assist in this movement and limit the free springiness of the leaf spring so as to produce maximum comfort. Furthermore, the leaf spring may be readily replaced if it ever wears out or if a different elasticity is desired by the amputee.

The leg prosthesis of the present invention is not only very hardy in use, low in cost, light in weight and insensitive to atmospheric conditions, such as humidity, but also is smoother in function than any known leg prosthesis, operates without noise, involves no need for adjustments and gives ideal freedom of movement in lateral directions.

If the gage of the leaf spring is increased from 6 to 12 mm. and the front cushion for the leaf spring is removed, the artificial foot is ideally suited for skiing.

I claim:

1. A lower leg prosthesis comprising
   a. a stiff tubular casing, upright in the normal operating position of the prosthesis, said casing having an upper rim and a lower end,
   b. a sleeve extending into said casing and having an upper edge portion bent outwardly and downwardly so as to define a groove of downwardly open, U-shaped cross section, said upper rim being received in said groove,
   c. resilient insert means interposed in said groove between said rim and said edge portion for suspending said sleeve from said casing while permitting movement of said sleeve relative to said casing, and
   d. a prosthetic foot including
      a. an ankle part affixed to said lower end,
      b. a sole part vertically spaced from said ankle part, said parts vertically bounding a free space therebetween, said sole part having a forward toe portion,
      c. an elongated leaf spring having two longitudinal ends respectively fastened to said ankle part and to said sole part and freely extending through said space, and
      d. an elastic cushion, one of said longitudinal ends being fastened to one of said parts, and said cushion being vertically interposed between said one longitudinal end and the other one of said parts.

2. The leg prosthesis of claim 1, wherein said resilient insert means includes an annular rubber member vertically interposed between said rim and said edge portion, a strip portion of said rubber member being horizontally interposed between said casing and said sleeve.

3. The leg prosthesis of claim 2, wherein the casing and the sleeve consist of leather.

4. The leg prosthesis of claim 2, further comprising a pair of threaded bolts respectively connecting the leaf spring to the rear portion of the ankle part and the ball portion of the sole part, a flat plate with threaded bores.
receiving the outer threaded ends of the pair of bolts at the rear portion of the ankle part for tightening the bolts, and a pair of nuts receiving the outer threaded ends of the pair of bolts at the ball portion for tightening the bolts.

5. The leg prosthesis of claim 4, wherein the ball portion of the sole part has recesses receiving the pair of nuts, and washers are interposed between the nuts and the recesses.

6. The prosthesis of claim 2, wherein said foot further includes another elastic cushion vertically interposed between the other longitudinal end of said leaf spring and said one part.

7. The leg prosthesis of claim 6, wherein said leaf spring has a longitudinal portion intermediate said ends, said intermediate portion extending diagonally through said free space in spaced relationship to said ankle part and said sole part, said leaf spring constituting the sole effective connection between said parts.

8. The leg prosthesis of claim 6, wherein the first-mentioned cushion is adjacent the forward toe portion and is smaller and less elastic than the other cushion.

9. The leg prosthesis of claim 1, further comprising a front and a rear protective cap mounted on the foot.