July 19, 1932. L. W. BALCH ET AL 1,868,303

PNEUMATIC SOCKET FOR ARTIFICIAL LIMBS

Filed Sept. 19, 1929

Fig. 3

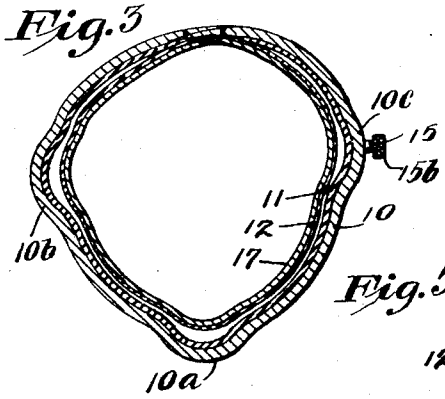


Fig. 5

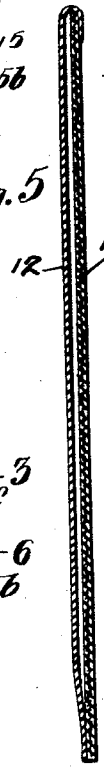


Fig. 6

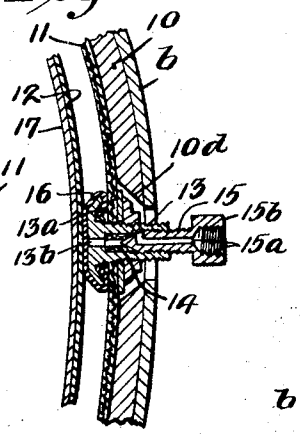


Fig. 1

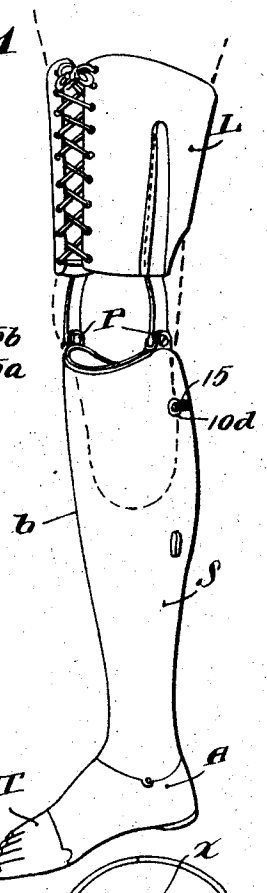


Fig. 2

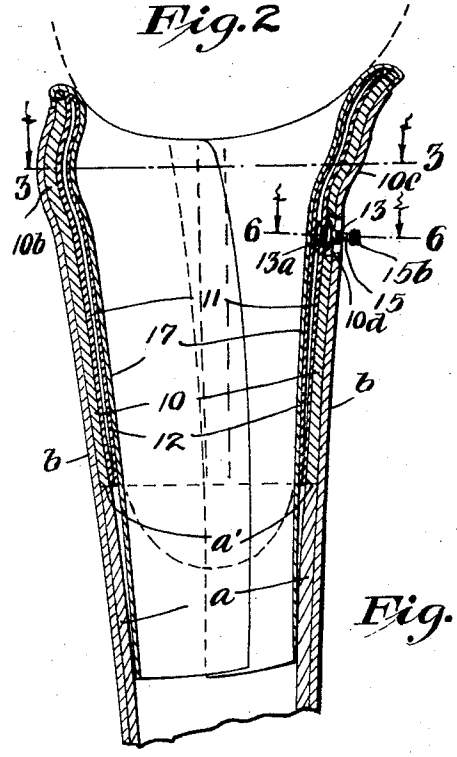


Fig. 8

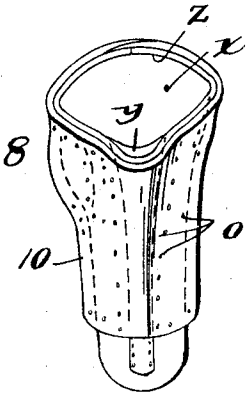


Fig. 7

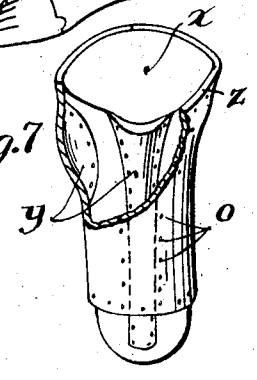
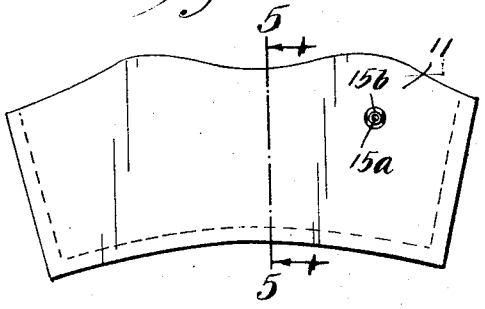


Fig. 4



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UNITED STATES PATENT OFFICE

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PNEUMATIC SOCKET FOR ARTIFICIAL LIMBS

Application filed September 19, 1929. Serial No. 393,707.

This invention relates to artificial limbs and especially to the socket construction thereof, which is adapted to receive and form the bearing for the stump of the limb.

It is an object of our invention to provide an efficient pneumatic socket structure for artificial limbs, which will supply the maximum amount of comfort to the wearer, which will effectively cushion the stump, making special provision for the prominent bones thereof, and which is adjustable by inflation to compensate for the shrinkage of the stump and to meet different requirements on the part of the wearer.

A further object of our invention is to provide in artificial limb structure, a pneumatic socket for efficiently fitting and cushioning the stump, wherein an inflatable bag or bearing pad is so connected and related with the socket shell that its cushioning effect will be exerted scientifically over a large area of the stump.

We, of course, realize that we are not the first to utilize an inflatable bag in the socket structure of artificial limbs, but in all pneumatic socket constructions known to us at this time the inflatable bags, which are usually annular, are so related and combined with the shell of the socket that they swell or bulge, when inflated, inwardly approaching in cross section a semi-circle and thereby encircling only a relatively small area of the stump. Such inflatable socket structures choke the blood circulation in the stump and usually must be deflated before the artificial limb may be removed from the wearer. The continued usage of devices of this type has proven harmful to the amputated limb.

It is, therefore, a further object of our invention to provide pneumatic socket structure employing a pneumatic pad which is so connected and related with the shell of the socket that it will engage the entire bearing area of the stump, thereby obviating the objectionable features enumerated in the preceding paragraph.

Another object of our invention is to provide pneumatic socket structure for artificial limbs wherein a somewhat greater amount of pneumatic cushioning is supplied for the prominent bones of the stump than the remainder of the area of the stump engaged.

Still another object is to provide a new process for making the socket structures of artificial limbs, which will result in a nearly perfect fitting socket having the advantages previously mentioned.

These and other objects and advantages of the invention will be fully set forth in the following description made in connection with the accompanying drawing wherein like reference characters refer to similar parts throughout the several views and in which,

Fig. 1 is a perspective view of an artificial limb for a limb amputated below the knee having an embodiment of our invention therein;

Fig. 2 is a vertical section taken through the stump portion of the artificial limb shown in Fig. 1;

Fig. 3 is a cross section of our improved socket structure detached, taken on the line 3—3 of Fig. 2;

Fig. 4 is a plan view of our inflatable bag detached and laid out flat;

Fig. 5 is a cross section taken on the line 5—5 of Fig. 4;

Fig. 6 is an enlarged detail cross section taken on the line 6—6 of Fig. 2, showing our valve construction;

Fig. 7 is a perspective view of a cast model of a stump illustrating several steps in our novel method for making the pneumatic socket structure, some portions of the bearing forming material being broken away; and

Fig. 8 is a perspective view of the stump model illustrating some of the other steps in our method.

In Fig. 1 of the drawing, an artificial limb for a below-the-knee amputation is shown having the usual shank or casing S, and the corset or lacing portion L, said portions being swivelly connected at the knee of the wearer by the usual knee pivots P. The shank S usually includes an inner wooden case *a* covered with a layer of raw hide *b*, the raw hide extending upwardly beyond the upper edge of case *a* to receive the socket structure. The upper edge of case *a* con-

stitutes an abutment to support the lower edge of the socket shell. To the lower end of shank S, the usual ankle portion A is swivelly attached having the toe portion T of the limb jointed thereto.

Our invention resides in the provision of a pneumatic socket structure at the stump opening of the shank S. We provide a socket shell 10, preferably constructed of leather or some other suitable material having some flexibility, although adapted to substantially retain its shape. The shell 10 is annular and is constructed, as will hereinafter be described, to perfectly fit a special model of the stump.

Shell 10 is so constructed that the portions thereof wherein the prominent bones of the stump are disposed will be bulged outwardly slightly beyond the actual contour of said bones. We refer to the tibia, and fibula bones of the leg and the lower end of the femur bone of the thigh. In Fig. 3 the tibia receiving bulge of the socket shell is indicated by the numeral 10*a*, the fibula receiving bulge, by the numeral 10*b*, and the femur receiving bulge by the numeral 10*c*. Shell 10 is usually constructed from a single strip of material, the end edges being tapered in cross section and stitched or otherwise secured together at the calf portion of the shell.

We provide a special inflatable pad, which is cemented or adhesively secured to the inner surface of the socket shell 10. Our pad comprises an outer sheet 11 of rubberized fabric or other suitable material, which is relatively non-elastic and an inner sheet 12, of thin elastic material, such as pure gum rubber. Both sheets 11 and 12 at their upper edges are cut along a curved line, which is determined accurately from the plaster model of the stump, later to be described. The upper edges are so curved that they will properly engage the upper portion of the stump to insure comfort. The upper edge of the elastic sheet 12 is folded about the upper edge of sheet 11 and vulcanized or otherwise secured by an air tight joint thereto. The lower and side edges may coincide with the edges of sheet 12 and are suitably vulcanized or secured thereto.

We provide an efficient valve structure by which our bag may be inflated or deflated, although, of course, other suitable valves may be employed. As shown, our inflation valve comprises a tubular stem 13, externally threaded at its outer portion and having rigidly attached to the inner end thereof, a bridge washer 13*a*, which is adapted to engage the inner surface of fabric sheet 11. The inner portion of sleeve 13 has a diminished air port 13*b* outwardly of which is disposed a concave valve seat 14, which may be constructed of leather or other suitable material and which is adapted to be engaged by a valve member 15 of the needle type having an axial bore 15*a* terminating at its inner end in a radially extending outlet, which is adapted to communicate with the port 13*b* when member 15 is loosened. The inner end of member 15 is externally threaded to engage internal threads on valve stem 13 and the outer end of member 15 is provided with an enlarged head 15*b*, which is internally threaded to receive the discharge end of a suitable pump. A strip of elastic material 16, such as rubber, is stretched across the flat inner surface of bridge washer 13*a* normally closing the port 13*b*. Ster[illegible]3 is adapted to project through an aperture 10*d*, formed in the inner side of shell 10 for convenient inflation by the wearer.

The entire outer surface of fabric sheet 11 of our inflatable bag is adhesively secured by rubber, cement or other suitable material to the inner surface of socket shell 10, and is positioned at all points smoothly against said surface and with the upper edge of said bag extending fully to the upper edge of the shell. The ends of the bag are spaced slightly apart across the calf portion of the shell, as clearly shown in Fig. 3, and due to the manner in which the side or end edges of the sheets 11 and 12 are joined, when the bag is inflated, taper nicely in cross section to conform to the calf.

A suitable liner 17, constructed of some soft flexible material, such as elk hide, is folded at its upper edge about the upper edge of the bag and the adjacent upper edge of shell 10 and covers the interior of the bag, having a depending skirt which usually extends below the socket. The liner 17 is preferably made from a single sheet of material with the end edges overlapping at the calf portion of the artificial limb.

In constructing our improved pneumatic socket, a plaster cast X is first made from an actual plaster mold of the stump. The tibia, fibula and sometimes the inner portion of the plaster casting are then partially covered with suitably formed pieces of leather Y or other material to slightly exaggerate the contour of the prominent bones of the stump and these pieces may be tacked or otherwise secured to casting X. Suitable material, such as heavy leather is then soaked in water until it is properly saturated to render it flexible and to some extent stretchable. The soaked material is then tightly stretched about the prepared casting and secured thereto to form a covering Z, as clearly shown in Fig. 7. Usually, the covering Z, is secured by a multiplicity of tacks O disposed at such points as are necessary to cause the material to properly conform to the shape of the prepared casting. This covering, with the prepared casting, forms the actual model for the shell 10 of our socket. The leather covering Z is of such thickness as to properly compensate for the thickness of the material from

which the inflatable pad is made as well as the leather lining 17.

Another sheet of leather or other suitable material is soaked in water and tightly stretched about the described model, and is tacked to the model as shown in Fig. 8, its overlapping edges being tapered to afford a smooth joint. When the leather for shell 10 is dry, it will be almost a perfect replica of the model from which it is made and will have sufficient rigidity to retain its shape although having some flexibility and resiliency.

Our inflatable pad is cemented to the inner surface of shell 10 in the manner previously described and the leather liner 17 is stitched or otherwise secured to the upper edge of shell 10 completing the socket structure.

Due to the exaggerated outwardly bulged portions of the shell 10, wherein the tibia, fibula and lower end of the femur bones are disposed, a slightly greater cushioning effect, as clearly shown in Fig. 3 will be present at those sensitive portions. That is: the air cushion between the sheets 11 and 12 of the pad at the bone receiving portions of the socket will be greater in thickness than the air cushion at the other portions of the socket. When inflated, the elastic wall 12 of the bag will be distended substantially parallel with the cemented non-elastic wall 11, thereby causing practically the entire area of the stump to be engaged and cushioned. The bag will not bulge inwardly and circumferentially at its mean height in the manner of inflatable bags utilized at this time. Only a small amount of air is inserted in the bag. It will be noticed that due to the construction of the bag at its upper edge the air cushion formed extends to the extreme upper edge of the socket shell 10, thereby preventing the edges of the shell from cutting or chafing the stump.

In Figs. 1 and 2, the position of the stump in the artificial limb is indicated in dotted lines. When the weight of the body is thrown upon our pneumatic socket, it will be obvious that the prominent bones and sensitive portions will be adequately cushioned by the bag in combination with the slightly exaggerated outwardly bulged portions of the socket shell. The upper and lower edges of the bag cannot draw or creep, since the entire surface of the non-elastic fabric 11 is cemented to the shell, and in actual practice we have found that a greater degree of comfort will be obtained from our socket structure than with any other construction known to us at this time.

From the foregoing description it will be apparent that we have provided a novel, comparatively simple and highly efficient socket structure for artificial limbs adapted for application either to below-the-knee or above-the-knee amputations. The device is readily adjustable for shrinkage of the stump by varying the amount of inflation and is self-adjustable under certain conditions. Thus, if the wearer is walking a considerable distance where excess of cushioning is needed, the increased body heat of the stump increases slightly the air pressure in the bag, providing the increased cushioning effect. The lower portion of the stump can never be choked by our socket structure. The artificial limb, when inflated, may be readily applied or removed without varying the contents of air in the bag.

It will, of course, be understood that various changes may be made in the form, details, arrangement and proportions of the parts without departing from the scope of applicants' invention.

What is claimed is:

1. In artificial limb construction, a pneumatic socket having in combination a generally annular casing of relatively non-elastic material, and an inflatable cushioning bag comprising a sheet of non-elastic material which is adhesively secured throughout its exterior surface to the inner surface of said casing, and an inner sheet of elastic material secured to said outer sheet.

2. In artificial limb construction, a pneumatic socket comprising an annular casing constructed of relatively stiff non-stretchable material and a very shallow inflatable cushioning bag extending at least partially around the interior of said casing, said bag comprising inner and outer parallel plies of material, the outer ply being constructed of relatively thick stiffened non-elastic material and the inner ply being constructed of relatively thin elastic material, the outer surface of the outer ply being adhesively secured to the inner surface of said casing to prevent drawing and bulging of the bag when inflated.

3. In artificial limb construction, a pneumatic socket having in combination, a generally tubular casing of somewhat flexible non-stretchable material, a shallow inflatable cushioning bag comprising an outer sheet of relatively non-elastic material smoothly secured to the inner surface of said casing and an inner sheet of elastic material secured at its marginal edges to said outer sheet, said bag being arranged circumferentially within the peripheral wall of said casing.

In testimony whereof we affix our signatures.

LUKE W. BALCH.
EDWARD DE WAGENAERE.