March 13, 1951 R. R. HYDORN 2,545,146

ARTIFICIAL LIMB

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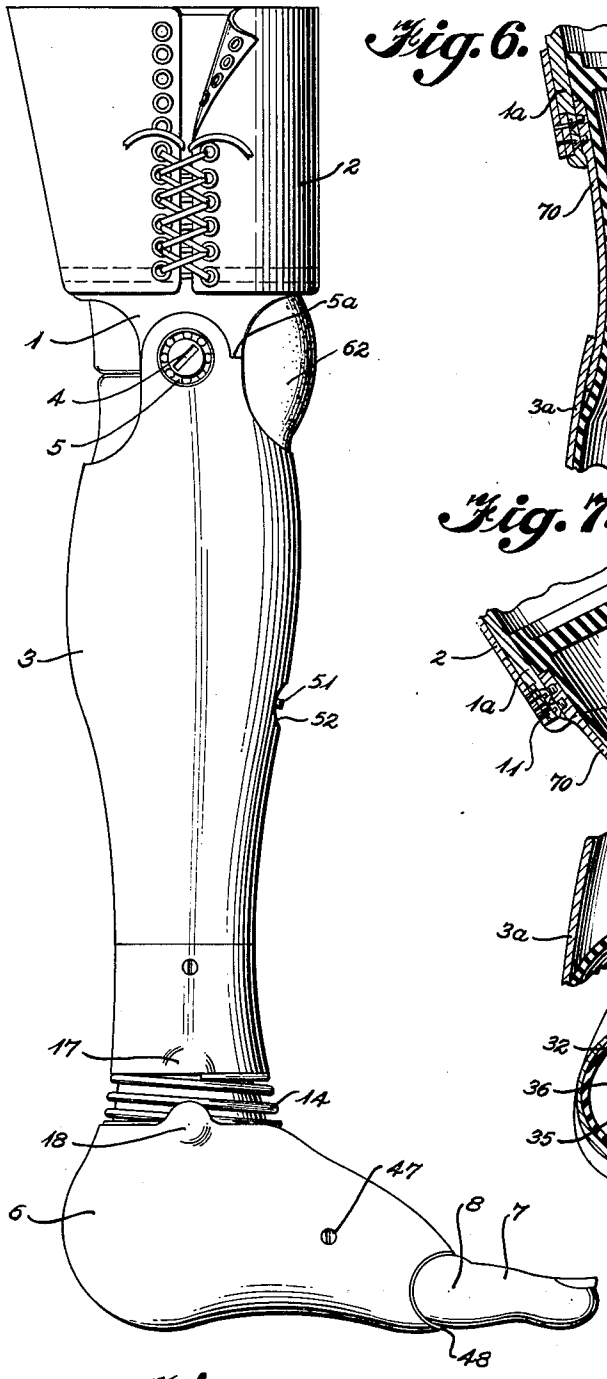


Fig. 1.

Fig. 6.

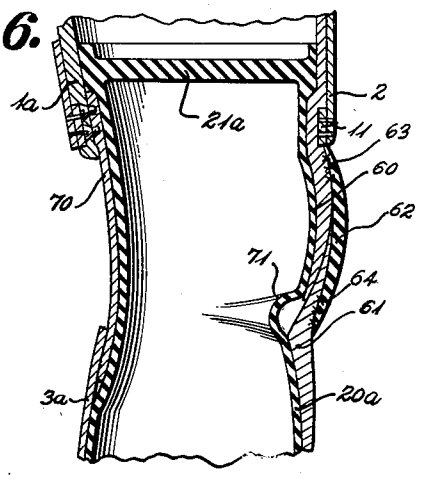
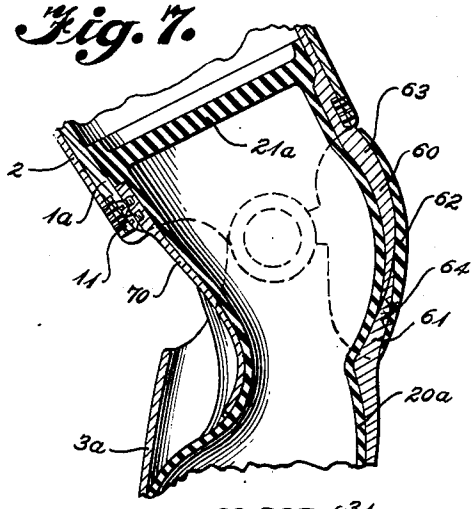


Fig. 7.



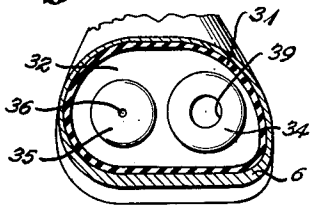


Fig. 5.

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Fig. 2.

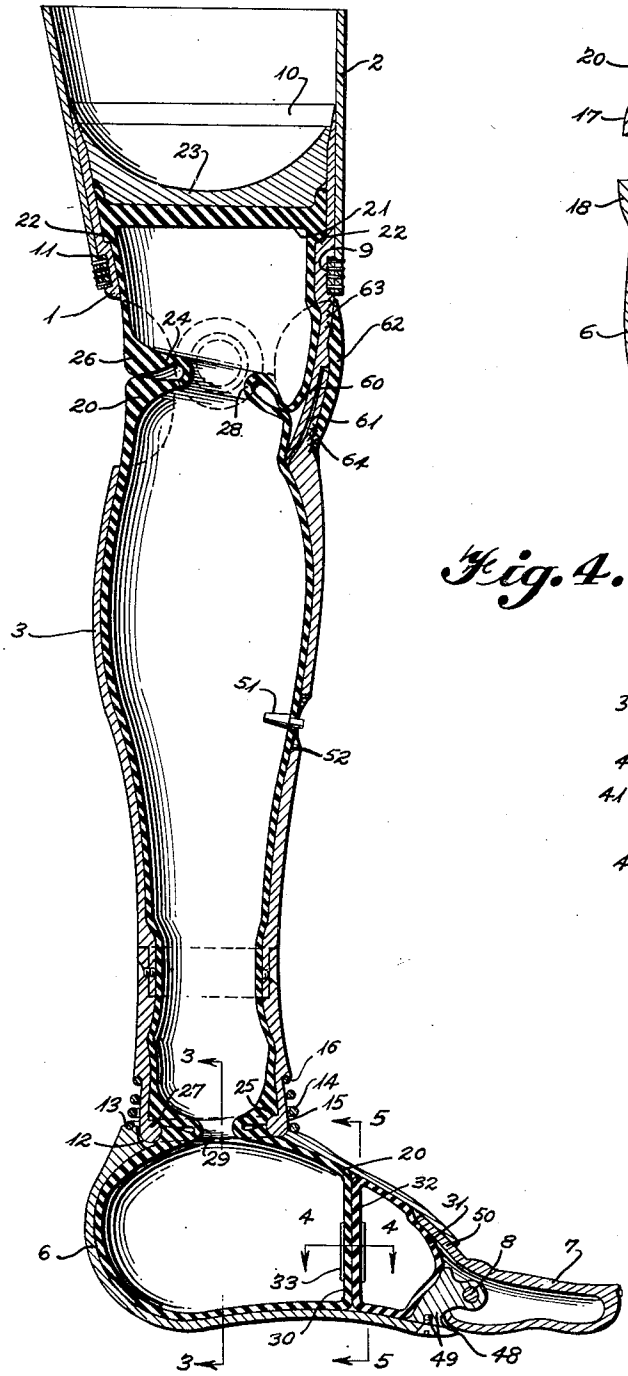


Fig. 3.

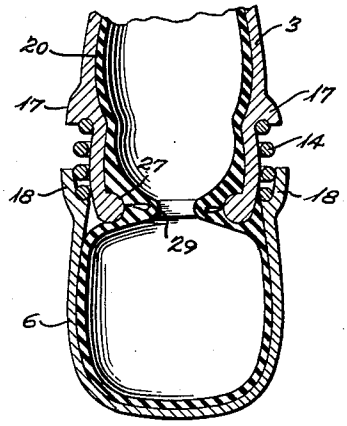
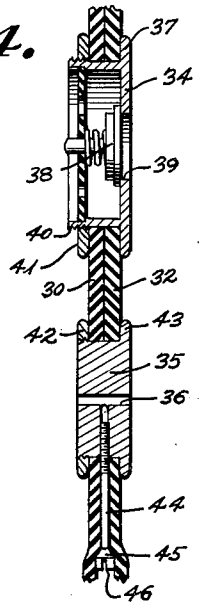


Fig. 4.



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ARTIFICIAL LIMB

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Application February 25, 1949, Serial No. 78,309

12 Claims. (Cl. 3—2)

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This invention relates to artificial limbs and particularly to such limbs constructed of light-weight materials and employing inflatable means to assist in supporting the weight of a wearer.

In general the invention contemplates an artificial limb comprising limb sections in the form of hollow shells appropriately hinged together at the joints. An inflatable bag is formed to occupy the interior of the entire limb structure, extending across the joints, to assist in supporting the weight of the wearer and performing the additional function of returning the pivoted sections to a normal predetermined position after flexure.

It is an object of this invention to provide an artificial limb of extremely light-weight construction yet having sufficient strength and rigidity for its intended purpose.

It is another object of this invention to provide an artificial limb including pivoted joints wherein an inflatable member assists in supporting the weight of a wearer and in addition acts to return parts to a predetermined normal relative relationship.

It is a still further object of this invention to provide an artificial limb having relatively hinged portions capable of being quite freely pivoted in one direction, during walking or the like, and including means to retard the return of those parts to normal position.

Further objects and advantages will become apparent as the description proceeds in connection with the accompanying drawings wherein:

Fig. 1 is a side elevational view of an artificial limb embodying the principles of the present invention.

Fig. 2 is a vertical sectional view through the embodiment illustrated in Fig. 1.

Fig. 3 is a fragmentary vertical sectional view taken substantially along the line 3—3 of Fig. 2.

Fig. 4 is a fragmentary sectional view taken substantialy along the line 4—4 of Fig. 2.

Fig. 5 is a sectional view through the foot section substantially along the line 5—5 of Fig. 2.

Fig. 6 is a fragmentary, vertical, sectional view, similar to Fig. 2 but illustrating a modified form of knee joint, and,

Fig. 7 is a view similar to Fig. 6, illustrating the parts in different relative positions.

Referring now to Fig. 1, numeral 1 indicates an upper leg section having a leather boot 2 fixed thereto in a manner to be described. A lower leg section 3 is pivoted to the upper section 1, as at 4, by means of an anti-friction ball bearing joint 5 provided in opposed ears extending from the sections 1 and 3. The ears referred to are further

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provided with inter-engageable abutments, at 5a, to limit pivotal movement in one direction. A foot section 6 has pivoted thereto a toe section 7 on a transverse axis 8 and the foot section is, in turn, universally mounted relative to the lower leg section 3 in a manner to be described.

Referring now to Fig. 2 the upper leg section 1, the lower leg section 3 and the foot section 6 are of hollow, shell-like construction and are preferably made of relatively light-weight materials such as aluminum or magnesium but may, if desired, be made of steel or any other suitable material.

The upper leg section 1 is provided with a circumferential groove 9 adjacent its lower end and its upper edge 10 is preferably bevelled or "feathered" to avoid the presentation of an abrupt shoulder at that point. The leather boot 2, previously referred to, has a ring or band of leather 11 sewed or otherwise affixed thereto at its innermost lower end and positioned in the circumferential groove 9. Upon lacing the boot to the upper leg section, as indicated in Fig. 1, the ring or band 11 acts as a key or locking means to retain the boot in fixed position on the upper leg section 1.

The foot section 6 is provided with a generally circular opening 12 at its uppermost portion and the opening 12 is surrounded by a generally horizontal abutment or shoulder 13 which may be provided with an annular channel-like seat to receive the lower end of a helical compression spring 14. The lowermost portion of the lower leg section 3 is provided with a generally spherical outer surface 15 of a diameter somewhat less than that of the opening 12 in the foot section. The leg section 3 is further provided with a downwardly facing shoulder or channel 16 forming a seat or abutment for the upper end of the spring 14. The lower terminus of the leg section 3 extends downwardly into the opening 12 and the clearances therebetween are sufficient to permit the upper leg section to swing in any vertical plane relative to the foot section. The spring 14 will prevent the leg section 3 from dropping through the opening 12 and wedging itself therein and is of sufficient strength to support a substantial portion of the weight of the wearer. Adjacent the shoulder 16 and on opposite sides of the leg section 3, the limb is provided with abutments 17 (Figs. 1 and 3) extending outwardly beyond the outer edges of the spring 14. The abutments 17 are positioned directly above upwardly and outwardly extending ear portions 18 on the foot section 6. The ears or rockers 18

are provided with upper surfaces curved in a fore and aft direction. It will be apparent from Fig. 1, that if the weight applied to the limb is excessive or if shock loads are applied, the engagement of the abutments 17 with the ears 18 will prevent further telescoping of the leg section 3 into the foot section and provide a stop means at that point. In addition to acting as a limiting stop, inter-engagement between the portions 17 and 18 will permit the leg section 3 to rock or "roll" on the curved surfaces of the ears 18 in a fore and aft direction, thus permitting the user to walk in a normal manner, even with the section 3 in its lowermost position. In addition, the ears 18 at all times limit the lateral swinging of leg section 3 to an amount less than its permissible fore-and-aft pivotal movement.

A hollow, inflatable bag member 20 is molded or otherwise formed to have a normal shape substantially complementary to the space inside the assembled limb, including at least a portion of the foot section. This inflatable bag may be made entirely of rubber or may be formed from fabric or other reinforcing material, treated in a suitable manner to render it impervious to air. The upper end of the bag 20 is provided with a reinforced, relatively thick and generally flat portion 21 having shoulders 22 resting upon suitable abutments provided in the upper leg section 1. A pad or cushion of sponge rubber or other suitable material 23 is positioned within the upper leg section 1 and rests upon the reinforced upper end 21 of the bag 20. In use the bag 20 is inflated and the boot 2 may be laced to the wearer with the stump of the wearer's natural limb resting upon the cushion or pad 23. By this arrangement it will be apparent that the inflatable bag 20 provides a resilient support for a substantial portion of the wearer's weight.

The bag 20 extends across the joints between the leg sections 1 and 3 and across the "ankle" joint between the sections 3 and the foot section 6. In the general vicinity of the knee and ankle joints the bag 20 is formed with inwardly turned portions 24 and 25. These inwardly turned portions define restricted necks or passageways between sections of the limb. The inturned portions at the rear of the knee joint are thickened considerably, as at 26, and provided with suitable reinforcing means (not shown) to render them substantially rigid and inflexible adjacent the outer surfaces of the bag 20. The inturned portions at 25 are likewise provided with suitable reinforcing means rendering them substantially rigid and are so formed and shaped that when fully inflated they snugly engage the inner lowermost portion of the leg section 3 in gripping engagement with a bead or ring 27 formed at the lower terminus of the section 3 and engage the bottom thereof whereby the section 3 is also supported by the portion of bag 20 in the foot section. The reinforcing means referred to may be in the form of metal inserts or successive layers of cloth imbedded in the material of the bag or such stiffening may be provided by any other suitable means.

As clearly shown in Fig. 2 the thickened portions of the bag 20 at the joints are of such configuration that when the limb is in its normal position adjacent thickened portions are in direct contact with each other. The innermost portions 28 and 29 of the inturned constrictions of the bag 20 have relatively thin wall sections and are positioned substantially symmetrically of the pivotal axes at the respective joints whereby flexure of the bag may be performed with relative ease.

As also shown in Fig. 2 the inflatable bag 20 does not completely fill the hollow foot section but terminates short of the toe section in a generally vertical end wall or partition 30. The remaining space within the foot section is occupied by an inflatable bag 31 so shaped as to be snugly received within the remaining space. The small bag 31 has an end wall 32 abutting against the end wall 30 of the bag 20. The walls 30 and 32 are each provided with a pair of openings and the openings in the wall 30 are aligned with the openings in the wall 32. In one pair of aligned openings a one-way or check valve 34 is positioned and in the other openings a member 35, having a restricted passageway 36 therethrough, is positioned. The check valve 34 comprises a valve body having an outwardly extending flange 37 and a spring-pressed valve element 38 urged toward an opening 39 in the said valve body. The end of the valve body opposite the flange 37 is preferably threaded as at 40 to receive a clamping ring 41 to position the valve in the composite partition wall in fixed and air-tight relation thereto. It will be apparent that the one-way valve described provides for rapid and easy passage of air through said valve in one direction and blocking of the return of said air in the opposite direction through said valve. The one-way valve structure described is merely illustrative and may be replaced by any suitable arrangement to permit air to be readily passed in one direction only from the interior of the small bag 31 to the interior of the large inflatable bag 20.

In the other pair of aligned openings previously referred to the member or plug 35 is held in fixed position by means of a threaded clamping ring 42 clamping the periphery of the openings against an opposed flange 43 in an obvious manner and in the manner described in connection with the valve 34. As stated, the member 35 is provided with a restricted opening 36 therein, which opening provides a small passageway between the interiors of the bags 20 and 31. The effective size of the opening 36 may be varied by adjustment of a control member 44 threaded through the element 35 and having a head 45 provided with a screwdriver slot 46. The control element 44 extends outwardly between the walls 30 and 32 and the head 45 thereof lies inwardly of an opening 47 (see Fig. 1) provided in a side wall of the outer shell of foot section 6. The inner end of the element 44 may be extended into or withdrawn from the opening 36. The control member 44 described is merely illustrative and any other suitable means may be employed to control the effective size of the passageway 36. Preferably such control means will be accessible to and manipulable from the outside of the foot section.

The forward portion of the foot section 6 is open, as at 48, and a bracket 49 is fixed to the interior of the foot shell. The bracket 49 provides a bearing support upon which the toe section 7 may be pivotally mounted on the transverse axis 8. The toe section 7 is further provided with an inwardly extending tongue 50 which extends inwardly of the foot section beyond the axis 8 and into contact with the outer surface of the small bag 31.

A valve 51, of any suitable type of construction, is provided in the inflatable bag 20 and is positioned inwardly of opening 52 in the leg section

3 whereby the valve is readily accessible for the inflation of the bag 20 or for the regulation of air pressure within said bag. The valve 51 will preferably be formed to extend inwardly of the bag 20 to avoid outwardly projecting parts.

In use, the wearer may swing the artificial limb forwardly to an advanced position and upon transferring his weight thereto the knee joint and the toe section will pivot under his or her weight in a manner simulating the action of a natural limb as the body moves forwardly. As the wearer's body moves forwardly of the artificial limb, which then extends toward the rear, the knee and toe joints will bend further but such bending will be opposed by the pressures within the inflatable bags. It will be apparent from Fig. 2 that upon swinging the leg section 1 rearwardly about the joint 4 the reinforced portions 26 at the rear of the knee will cause compression of the bag 20 in a manner to resist bending at the knee joint. In like manner bending of the toe section 7 upwardly will cause the tongue 50 to be pressed inwardly of the bag 31 and will be resisted by the pressure within the inflatable bag. Pressure within the bag 31, however, will cause some of the air therein to be transferred to the bag 20 through valve 34 and upon release of the weight from the limb in question, in walking, and swinging of the limb forwardly, the toe section will be allowed to return to normal position under the influence of the pressure of air returning to the bag 31 through opening 36. Such return to normal position, will, however, be delayed since expansion of the bag 31 is limited by the restricted opening 36 so that the toe section 7 does not return to extended position before the limb has been swung forwardly, thus obviating the danger of the wearer stumbling or "stubbing" the toe section during the forward swinging movement of the limb. In like manner the limb is straightened to normal position at the knee joint, while being swung forwardly, due to the tendency of the bag 20 to resume its normal shape adjacent the reinforcements 26.

The upper leg section 1 is further provided with a depending, transversely curved, plate-like portion 60 slidably received behind an upwardly extending similar portion 61 on the lower leg section 3. During flexure of the knee joint the portions 60 and 61 may slide relative to each other to provide a continuously closed forward knee surface. A resilient and flexible stretchable pad 62 is cemented or otherwise attached, as at 63 and 64, to the upper and lower leg sections respectively. The attachment of the pad 62 to the upper and lower leg sections will preferably be limited to relatively small areas at the top and bottom of the pad whereby as the knee is bent the pad may stretch or contract in simulation of a natural knee.

Figs. 6 and 7 illustrate a modified form of knee joint for an artifical limb of this general type. In this modified construction an inflatable bag 20*a* extends across the knee joint, as in the previous embodiment, but the bag is not provided with the restricted neck portions described in connection with the earlier embodiment. The upper leg section 1*a* is provided with a downwardly extending spring element 70, attached at its upper end to the upper leg section and extending downwardly into the lower leg section 3*a* and in contact with the outer surface of the bag 20*a* therein. The member 70 may be in the form of a ribbon of spring steel or the like. Upon flexure of the joint to the position shown in Fig. 7, the spring member 70 will act to compress the bag 20*a* and distort it to the shape shown in Fig. 7, thereby conditioning the bag to urge the sections 1*a* and 3*a* back to the normal position shown in Fig. 6. Preferably the bag 20*a* will be provided, in the normal position of the sections, with an inwardly turned portion 71 in its forward wall at the knee joint, to permit the bag to assume the position shown in Fig. 7 without a tendency to stretch its forward wall.

Although a limited number of embodiments have been illustrated herein, it is to be understood that the specific forms of the invention shown and described do not limit the scope of the invention, which is to be limited only by the scope of the appended claims.

I claim:

1. In an artifical limb, a pair of members, means providing for relative pivotal movement between said members, one of said members comprising a hollow shell, an inflatable bag in said hollow shell, said bag comprising at least two cells separated by an impervious partition, the other of said members having a portion engaging one of said cells to compress the same upon relative pivotal movement between said members, a check valve in said partition to permit inflating fluid to flow freely from said one cell to the other cell, and a restricted passage between said cells to permit inflating fluid to flow at a low rate from said other cell to said one cell.

2. In an artificial limb, a pair of members, joint means providing for relative pivotal movement between said members, each of said members comprising a hollow shell, an inflatable bag in said hollow shells and extending across said joint, and means actuated by relative pivotal movement of said members to compress a portion of said bag, said means being fixedly carried by one member and extending across said joint to engage said bag in the other of said members whereby to urge said members in relative pivotal movement opposite to that effecting compression of said bag by return of said bag to uncompressed condition.

3. In an artificial limb, a pair of members, means providing for relative pivotal movement between said members at a limb joint, each of said members comprising a hollow shell, and an inflatable bag within said hollow shells and extending across said joint.

4. In an artificial limb, a pair of members, means providing for relative pivotal movement between said members at a limb joint, each of said members comprising a hollow shell, and an inflatable bag within said hollow shells and extending across said joint, said bag having a restricted flexible neck portion at said joint.

5. In an artificial limb, a pair of members, means providing for relative pivotal movement between said members at a limb joint, each of said members comprising a hollow shell, and an inflatable bag within said hollow shells and extending across said joint, said bag having a restricted flexible neck portion at said joint, portions of said bag adjacent to and on opposite sides of said neck portion being relatively inflexible and normally in contact with each other.

6. In an artificial limb, a foot section and a leg section, said sections comprising hollow shells, an opening in said foot section at the ankle thereof, said leg section having a terminal portion at the bottom thereof within the said opening, an inflatable bag within said shells and extending across said ankle joint, said leg sec-

tion resting upon and being at least partially supported by a portion of said inflatable bag in said foot section.

7. An artificial limb as defined in claim 6 and further including a helical spring loosely surrounding the lower portion of said leg section, said spring bearing upon an upper surface of said foot section and engaging said leg section to at least partially support said leg section.

8. An artificial limb as defined in claim 6 wherein said leg section is provided with an abutment normally spaced above said foot section but engageable therewith to limit downward movement of said leg section relative to said foot section.

9. An artificial limb as defined in claim 6 wherein said leg section is provided with an abutment normally spaced above said foot section but engageable therewith to limit downward movement of said leg section relative to said foot section, said abutment being positioned at the side of said leg section, and said foot section having a curved surface engageable with said abutment whereby said leg section may rock in a fore and aft direction relative to said foot section while in its lowermost position.

10. In an artificial limb, an upper section, a lower section, said sections being pivotally

joined on a transverse axis to provide a joint, said sections further having relatively slidable overlapping portions on one side of said axis, and a pad of resilient material overlying said overlapping portion.

11. An artificial limb as defined in claim 10 wherein said pad is fixed to at least one of said sections adjacent said overlapping portions.

12. In an artificial limb, a pair of members, joint means providing for relative pivotal movement between said members, said members each comprising a hollow shell, an inflatable bag in said hollow shell and extending across said joint, one of said members having a portion engaging said inflatable bag to compress the same upon relative pivotal movement between said members.

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