

United States Patent

Larson

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[54] BI-VALVED CAST

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[52] U.S. Cl. **128/82.1, 128/89 R, 128/93**

[51] Int. Cl. **A61n**

[58] Field of Search **128/87-89, 93, 128/82.1, DIG. 20**

[56] References Cited

UNITED STATES PATENTS

3,032,033	4/1970	Ramirez	128/89
3,351,055	11/1967	Gottfried	128/87

3,477,427 11/1969 Lapidus 128/82.1

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[57] ABSTRACT

A bi-valved cast for immobilizing broken limbs in which complementary rigid shells, each having an inflatable liner, are releasably secured together about the limb or other body portion to be immobilized, so that upon pressurizing the liners, the limb or other body portion will be immobilized. A significant feature of the disclosed invention resides in the provision of air entry passages through which ventilating air reaches the interface between the immobilized limb and the inner surfaces of the inflatable liners.

7 Claims, 10 Drawing Figures

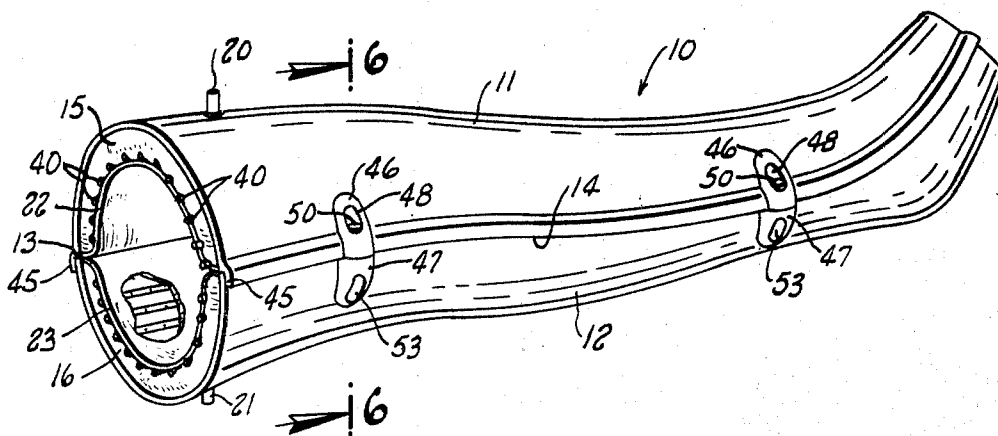


Fig. 1.

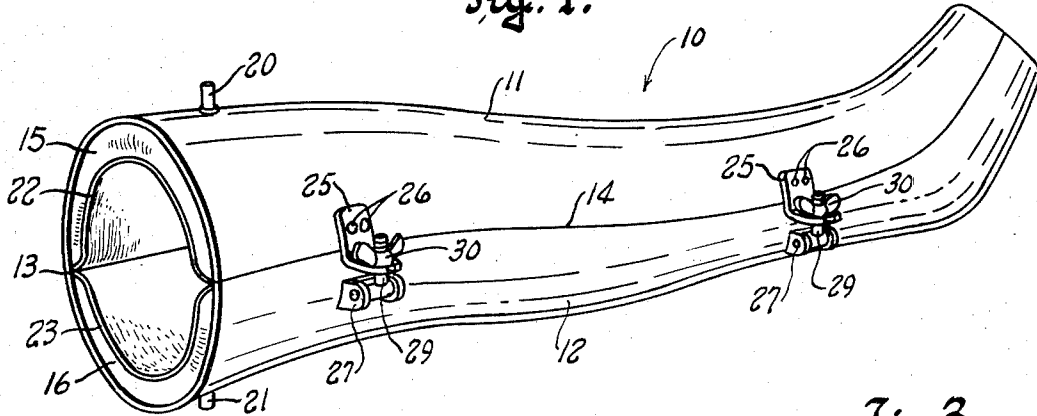


Fig. 2.

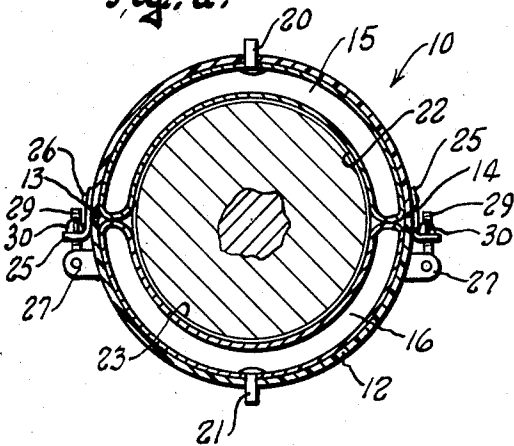


Fig. 3.

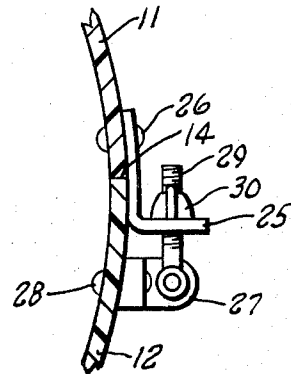
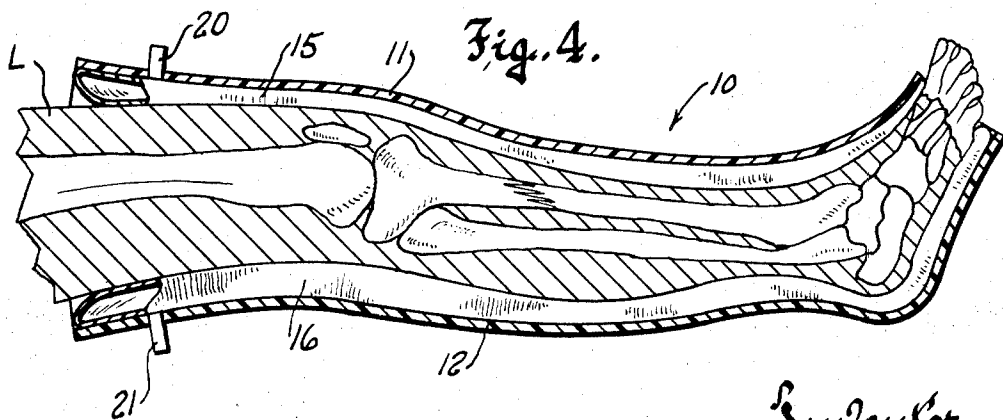


Fig. 4.



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Fig. 5.

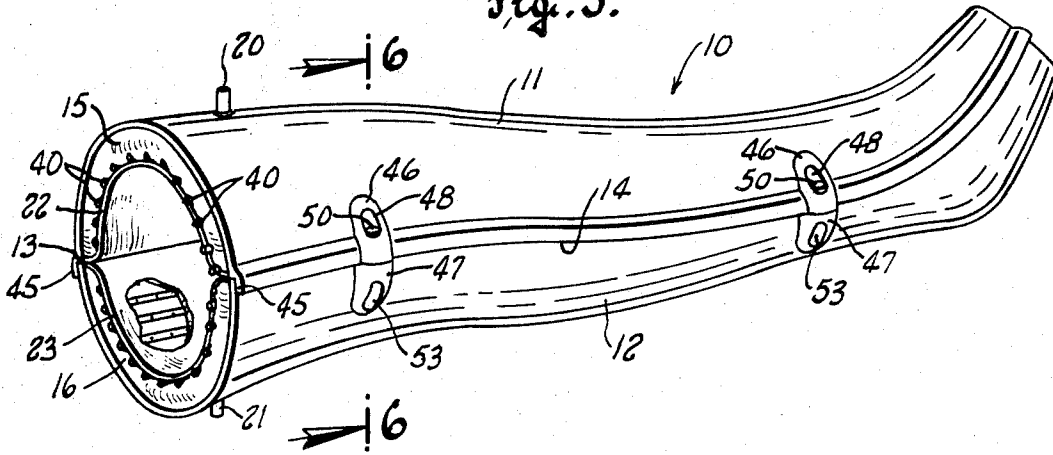


Fig. 6.

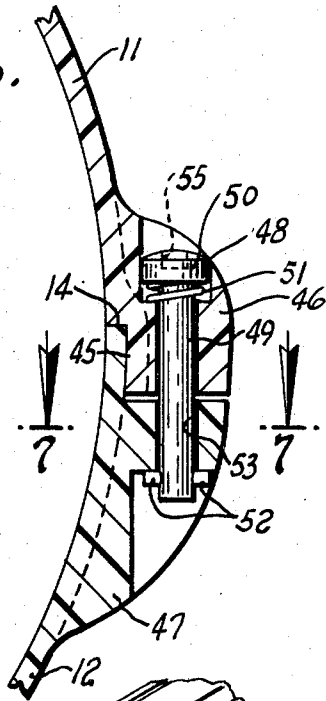


Fig. 7.

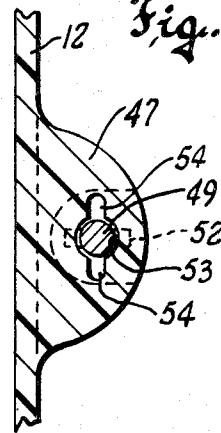
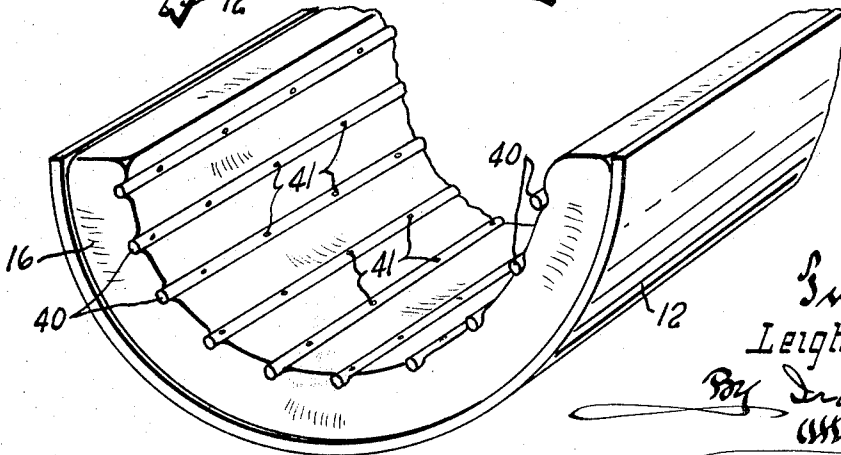


Fig. 8.



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BI-VALVED CAST

BACKGROUND OF THE INVENTION

The invention relates to the field of immobilizing broken limbs and other body parts through the use of a cast or splint. In the past, this was customarily done by a plaster-of-paris cast formed in situ about the body part to be immobilized. Since a plaster-of-paris cast can not be opened or removed without destroying it, such a cast could not be re-used, nor did it permit visual inspection of the limb, and of course adjustment of the cast to compensate for swelling and contraction of the immobilized limb was out of the question.

There have been a number of efforts to depart from the traditional plaster-of-paris cast in favor of a lighter, reuseable and adjustable cast. There have also been efforts to make casts which may be opened for visual inspection of the limb, and reclosed when the inspection is completed. None of these prior art devices, however, offer the advantages of the present invention.

The Ramirez U.S. Pat. No. 3,032,033, for example, discloses a resin-impregnated fiberglass shell which includes two halves that are secured together to form a cast that conforms to the shape of the limb to be immobilized. The Ramirez cast, however, does not include any means for adjusting or compensating for the difference in configuration between the limb and the shell of the cast. In other words, the rigid shell portion must be formed with extreme care to insure that it conforms accurately to the shape of the limb which is to be immobilized. By contrast, the present invention provides for substantial adjustment to insure that the immobilized limb will be tightly held even though there may be differences in shape and size between the cast and the limb. Moreover, the present invention allows for continued adjustment to compensate for swelling or a decrease in size of the immobilized limb.

The Gottfried U.S. Pat. No. 3,153,413 discloses an inflatable pressure bandage-splint which provides adjustability to compensate for swelling or decrease in size, but it does not include a rigid outer protective shell. In addition, the Gottfried bandage-splint provides for visual access and reclosing of the device. There is, however, a lack in uniformity in the thickness of the inflatable liner from a maximum thickness opposite the closure means to a complete lack of thickness at the closure means. The lack in liner thickness at the closure means along with the lack of a protective rigid outer shell limits the value of the Gottfried design to temporary or first-aid type applications.

Casts have also been made of plastic foam, as disclosed in the Gibbons U.S. Pat. No. 3,403,676. While initially there is excellent conformance between the plastic foam cast and the immobilized limb, there is no way of adjusting the inside cavity of the cast as the immobilized limb swells or decreases in size.

SUMMARY

The present invention is an improvement over that of the copending application, Ser. No. 780,335, filed Dec. 2, 1968, now U.S. Pat. No. 3,580,248. As disclosed and claimed in said U.S. Pat. No. 3,580,248, the device of the instant invention comprises two rigid complementary shells releasably secured together to form a rigid cast which conforms in shape to the limb or other body portion to be immobilized, and which may

be opened to afford access to the immobilized body portion. An inflatable liner disposed in each of the rigid shells extends over substantially its entire inner surface, and valved air introduction means on the outside of the rigid shells provide for inflating each of the liners. A layer of absorbent material is preferably placed between the liners and the immobilized body portion.

In addition to the provision of convenient access without destruction of the cast, the present invention, like that of the aforesaid U.S. Pat. No. 3,580,248 makes adjustment of the cast a simple matter. More particularly, as the limb swells or contracts, the pressure in the inflatable liners may be varied to compensate for the swelling or contraction and thereby maintain a constant pressure on the limb. Moreover, pressure may be varied, within the limits necessary to immobilize the limb, to provide for individual patient comfort.

The bi-valved cast of the present invention also need not conform accurately to the shape of the body portion which is to be immobilized, since the inflatable liners can compensate for such difference as might be encountered. And, finally, as in the patent, the cast of the present invention is substantially lighter than most casts, particularly the plaster-of-paris cast, yet provides equivalent protective and immobilization strength.

One of the objects of this invention is the provision of means for ventilating the interface between the immobilized limb and the layer of absorbent material in which it is wrapped.

It is also an object of the present invention to provide a walking-type cast embodying the advantages of the bi-valved formation of the aforesaid patent.

Still another object of the instant invention is to provide improved locking means for securing together the complementary sections or half shells of the bi-valved cast, by which the securement is more readily effected and unauthorized opening of the cast — as by the patient himself — is precluded.

With these observations and objectives in mind, the manner in which the invention achieves its purpose will be appreciated from the following description and the accompanying drawings, which exemplify the invention, it being understood that changes may be made in the specific structure disclosed herein without departing from the essentials of the invention set forth in the appended claims.

The accompanying drawings illustrate several complete examples of the embodiments of the invention constructed according to the best modes so far devised for the practical application of the principles thereof, and which:

FIG. 1 is a perspective view of the bi-valved cast of the present invention, in its closed position, but without association with the limb — in this case the lower leg — for which it is intended;

FIG. 2 is a cross sectional view of the cast shown in FIG. 1, applied to the limb to be immobilized;

FIG. 3 is an enlarged sectional view of the means for releasably securing the two complementary shells together, as employed in that embodiment of the invention illustrated in FIGS. 1 and 2;

FIG. 4 is a longitudinal sectional view of the cast showing the relationship between the cast, the inflatable liners, the absorbent padding material and the immobilized limb;

FIG. 5 is a perspective view similar to FIG. 1, illustrating an improved embodiment of the bi-valved cast of this invention;

FIG. 6 is a cross sectional view through FIG. 5 on the plane of the line 6—6;

FIG. 7 is a cross sectional view through FIG. 6 on the plane of the line 7—7;

FIG. 8 is a perspective view of the upper end portion of the lower shell of the cast shown in FIG. 5, and illustrating one way of providing ventilating air circulation to the immobilized limb;

FIG. 9 is a longitudinal sectional view showing another way of achieving the desired ventilating air circulation; and

FIG. 10 is a vertical section view of a walking type cast embodying the principles of this invention.

Referring now more particularly to the accompanying drawings, and initially to FIG. 1, it will be seen that the bi-valved cast 10 in accordance with the present invention, includes an upper rigid shell 11 and a lower rigid shell 12. The shells 11 and 12 are complementary and coact to provide a rigid enclosure conforming to the general shape of the limb or body portion which is to be immobilized — which, in the case illustrated, is a leg. Each of the shells has a generally channel-shaped cross section, the two edges of which mate, as at 13 and 14, with the edges of the other shell.

Each of the shells is provided with an inflatable liner. Liner 15 is nested in the rigid shell 11 and liner 16 is nested in rigid shell 12. These liners extend over substantially the entire inner surface of rigid shells 11 and 12, respectively.

A valve 20 protrudes from the rigid shell 11 through which the liner 15 may be inflated, and a similar valve 21 protrudes from the lower rigid shell 12 to provide for inflating the liner 16.

Layers of absorbent material, such as sheet wadding 22 and 23, line the inner walls of the inflatable liners 15 and 16, respectively, to make direct contact with and enwrap the immobilized limb.

The means for releasably securing the rigid shells 11 and 12 in mating relationship, as shown in FIG. 1, comprises a bracket 25 secured to the upper rigid shell 11, as by rivets 26, and a lower bracket 27 secured to lower shell 12, as by rivets 28. A screw eye 29 is pivoted to each lower bracket 27 and passes through a slot in its companion bracket 25 so that, by tightening a wing nut 30, which is threaded onto the screw eye, the two shells can be held tightly together. The brackets 25 project beyond the adjacent edge of the shell 11 to engage the edge portion of the shell 12 and thereby hold the shells against lateral displacement when the bi-valved cast is in its closed condition. The pivotal connection between the screw eyes and the lower brackets 27 enables the bi-valved cast to be opened with a hinge action upon loosening of the wing nuts along one of the two mating edges.

While the specific embodiment shown is for immobilization of the lower leg from a point above the knee to a point below the heel, the bi-valved cast which comprises the present invention may be used for a wide variety of other applications. More particularly, it may be formed with a rigid shell conforming in shape to other parts of the body, so that it may be used for fractures of the calcaneus, metatarsals, fibulas, tibias, femur, fractures of the body of vertebra, fractures of

vertebral bodies, clavicular fractures, metacarpal fractures, etc. It is therefore contemplated that the present invention may be used as an upper leg cast, lower leg cast, an upper arm cast, a lower arm cast, a body spica, a foot cast, a neck cast, and a hand cast.

As shown in FIG. 10, the invention is especially well adapted to a walking type cast. In this case, the lower rigid shell 12' defines the heel portion of the cast and the upper shell 11' supplies the front part of the cast. A significant feature of this embodiment of the invention resides in the fact that the inflatable liner 16' of the lower shell is divided into two separate chambers or compartments 33 and 34 by a transverse seal 35. This seal can be formed in any suitable way as long as it is air tight and is so located that one of the two resulting chambers or compartments — in this case, the one designated by the numeral 33 — underlies the sole of the foot and the other embraces the back of the heel and lower portion of the leg. These two chambers or compartments have their own air admission valves, indicated at 36 and 37.

As will no doubt be obvious, the separation of the inflatable liner 16' into a sole compartment and a leg compartment enables maintenance of the desired pressure within the cast, despite the added pressure resulting from the weight placed on the sole during walking. It should also be apparent that the two compartments could be provided by two separate appropriately shaped liners, each individually placed in the shell 12'.

The lower shell 12' is preferably increased in thickness at the bottom of its shell portion, as at 38, to facilitate attachment thereto of a rubber heel 39.

An especially valuable attribute of the present invention is the provision for ventilating the interface between the encased limb or body portion and the directly adjacent absorbent material. Two different ways of achieving this objective are illustrated. In one of these, most clearly shown in FIGS. 5 and 8, the inner wall of each inflatable liner, i.e. the wall that is adjacent to the absorbent material, has a plurality of tubes 40 fixed thereto. These tubes have open ends contiguous to the opposite extremities of the cast, but so placed that they will not be closed when the liners are inflated, and perforations 41 along the length thereof opening to the absorbent material.

In the other embodiment of the ventilating feature, illustrated in FIG. 9, the inner and outer walls of the inflatable liners are adhered together at spaced localized areas, as at 42, and these adhered areas have holes 43 which align with holes 44 in the rigid shells.

Another improvement upon the embodiment of the invention illustrated, disclosed and claimed in the aforesaid U.S. Pat. No. 3,580,248 concerns the manner in which the complementary shells are secured together. As shown in FIGS. 5, 6 and 7, the mating edges of the shells are rabbetted all along the length thereof, as at 45, to hold the shells against relative transverse displacement. At spaced intervals, the edges of the shells have integral lugs or enlargements 46 and 47 in line with one another. The lugs 46, which are on the upper shell 11, have a counterbored hole 48 in which a rotatable pin 49 is located. The pin has a head 50 which is received in the counterbore of the hole, with a compression spring 51 between its underside and the bottom of the counterbore. The pin projects from

the bottom of the lug 46 where it has diametrically opposite projections 52 to engage the underside of the adjacent lug 47 when the pin is inserted through a hole 53 in the lug 47. As shown in FIG. 7, the hole 53 has diametrically opposite grooves 54 to accommodate the projections 52, providing the pin is in proper rotational orientation with the hole 53. Hence, upon entry of the pin into the hole 53 and the application of downward pressure on the pin to compress the spring 51, the pin can be rotated to disengage its projections 52 from the grooves 54 and engage them under the bottom of the lug 47.

The operation of depressing the pin 49 and rotating it is best done with a special wrench, such as an Allen head wrench, shaped to fit a specially shaped socket 55 in the head of the pin. By this expedient, unauthorized opening of the bi-valved cast is precluded.

The complementary shells of the bi-valved cast may be formed of a wide variety of materials, the primary requirements being radiolucense and adequate rigidity without excessive weight. Aluminum, resin-impregnated fiberglass and plastics are examples of materials that meet these requirements.

The inflatable liners may be formed of rubber, plastic or other pliable air impervious material.

The layers of absorbent material which cover the inner walls of the inflatable liners, may be formed of gauze or sheet wadding, or a sponge material.

In addition to the means specifically disclosed for releasably securing the two rigid shells together, a wide variety of conventional fasteners may be employed, including the non-metallic fastener sold under the trademark "VELCRO", a product available commercially, which consists of mating hooked pile fabric.

Although sufficient adhesion normally exists between the inflatable liners and the rigid shells to preclude relative shifting therebetween, where it is deemed necessary a suitable adhesive may be used to assure against such relative shifting.

The pressure in the inflatable liners should be 75 to 95 percent of diastolic pressure for best results. Such a pressure range provides substantial immobilization of the encased body portion and yet does not inhibit or prevent circulation of blood in the arteries and veins.

Although the operation of the invention is no doubt readily understood from the foregoing description and the drawings, for sake of completeness, in applying the cast to a limb, the limb L is placed in the lower shell 12-12' and then the upper shell 11-11' is closed upon the limb. After the shells are secured in mating relationship, air is introduced into inflatable liners through the inlet valves 20 and 21. A conventional pressure device may be readily employed to measure the pressure in the liners. The inflated liners provide a uniform pressure on the immobilized limb and automatically compensate for any variation in distance between the shells and the limb. As the limb swells or contracts, the volume of air in the liners may be varied to maintain the limb under a constant pressure.

The bi-valved cast may be reused by simple removing and replacing the layers of absorbent material, following washing of the cast, if needed.

Those skilled in the art will appreciate that the invention can be embodied in forms other than as herein disclosed for purposes of illustration.

The invention is defined by the following claims:

1. In a bi-valved cast for immobilizing a body portion, wherein the cast comprises complementary separate rigid shells, which when joined together form a rigid cast conforming in contour to the body portion to be immobilized, wherein means are provided to releasably secure the shells in joined relation, and wherein each shell has an inflatable liner extending over substantially the entire inner surface thereof so that the introduction of air under pressure into the liners after the shells are secured in joined relation immobilizes the body portion in the cast, the improvement which resides in:

means for introducing air from the exterior of the cast to the inner surface of the liners so that the interface between an immobilized body portion and the liners is ventilated.

2. The bi-valved cast of claim 1, wherein said means for introducing air to the inner surface of the liners comprises perforated tube means on the inner surface of the liners, said perforated tube means having open ends opening to the exterior of the cast.

3. The bi-valved cast of claim 2, wherein said tube means comprises open ended perforated tubes affixed to the inner surface of the liners, with at least one open end thereof projecting beyond an extremity of the liner so as not to be closed when the liner is pressurized.

4. The bi-valved cast of claim 1, wherein said means for introducing air to the inner surface of the liners comprises means sealing the inner and outer walls of the liners to one another at spaced apart localized areas, openings through said localized areas, and openings through the walls of the shells.

5. In the bi-valved cast of claim 1, the further improvement which resides in the means for releasably securing the rigid shells in joined relation and which comprises:

A. a locking pin rotatably mounted on an edge portion of one shell and protruding therefrom for entry into a hole in the adjacent edge portion of the other shell;

B. interengageable means on the locking pin and said adjacent edge portion of said other shell to secure the locking pin against withdrawal from said hole when the locking pin is turned; and

C. means on the locking pin by which the same may be turned, said last named means requiring the use of a special tool.

6. A bi-valved walking type cast for immobilizing a foot, comprising:

A. complementary separate rigid shells which, when joined together, form a rigid cast conforming in contour to the foot to be immobilized, said shells being generally channel shaped in cross section and having edges which mate when the shells are joined, one of said shells being shaped to embrace the heel of the foot and the other shell being shaped to overlie the front of the foot;

B. retaining means on the shells for releasably securing the same in joined relation;

C. inflatable liner means in each shell extending over substantially the entire inner surface thereof, the liner means in said shell which embraces the heel of the foot being divided into two separate compartments, one of which underlies the sole

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of the foot and the other of which embraces the back of the lower leg; and
 D. air introduction means on said liner means including one for each of said separate compartments of the liner means in the shell which embraces the heel, through which said inflatable liner means

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may be pressurized to immobilize the foot in the cast.
 7. The bi-valved cast of claim 6, further characterized by a heel secured to the underside of the shell which is shaped to embrace the heel of the foot.
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