

[72] Inventor **James T. Hill**
Bowie, Md.
 [21] Appl. No. **747,316**
 [22] Filed **July 24, 1968**
 [45] Patented **June 29, 1971**
 [73] Assignee **The United States of America as**
represented by the Secretary of the Army

FOREIGN PATENTS

7,721	3/1912	Great Britain	128/80
121,322	12/1918	Great Britain	128/80

OTHER REFERENCES

"Strength of Glass" by Games Slayter, AMERICAN CERAMIC SOCIETY BULLETIN, Vol. 31, No. 8, August 15, 1952. Copy in Group 170.

Primary Examiner—Richard A. Gaudet

Assistant Examiner—J. Yasko

Attorneys—Alva H. Bandy, William G. Gapcynski and
 Lawrence A. Neureither

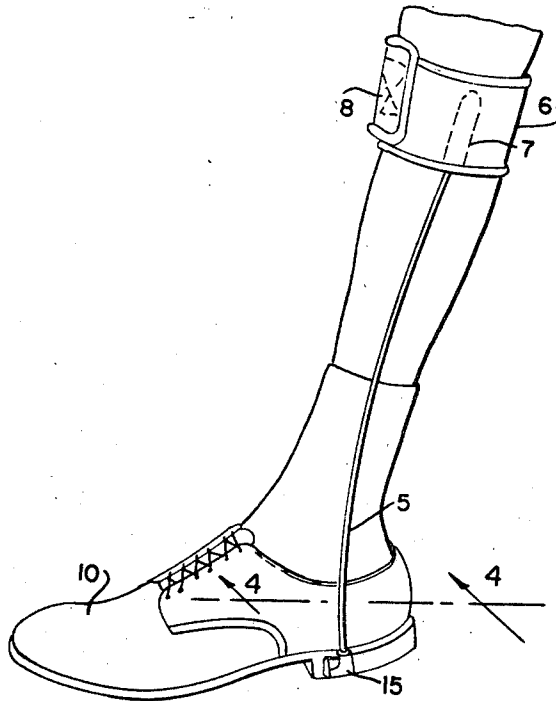
[54] UNIDIRECTIONAL FIBERGLASS COMPOSITE DROP-FOOT BRACE 2 Claims, 6 Drawing Figs.

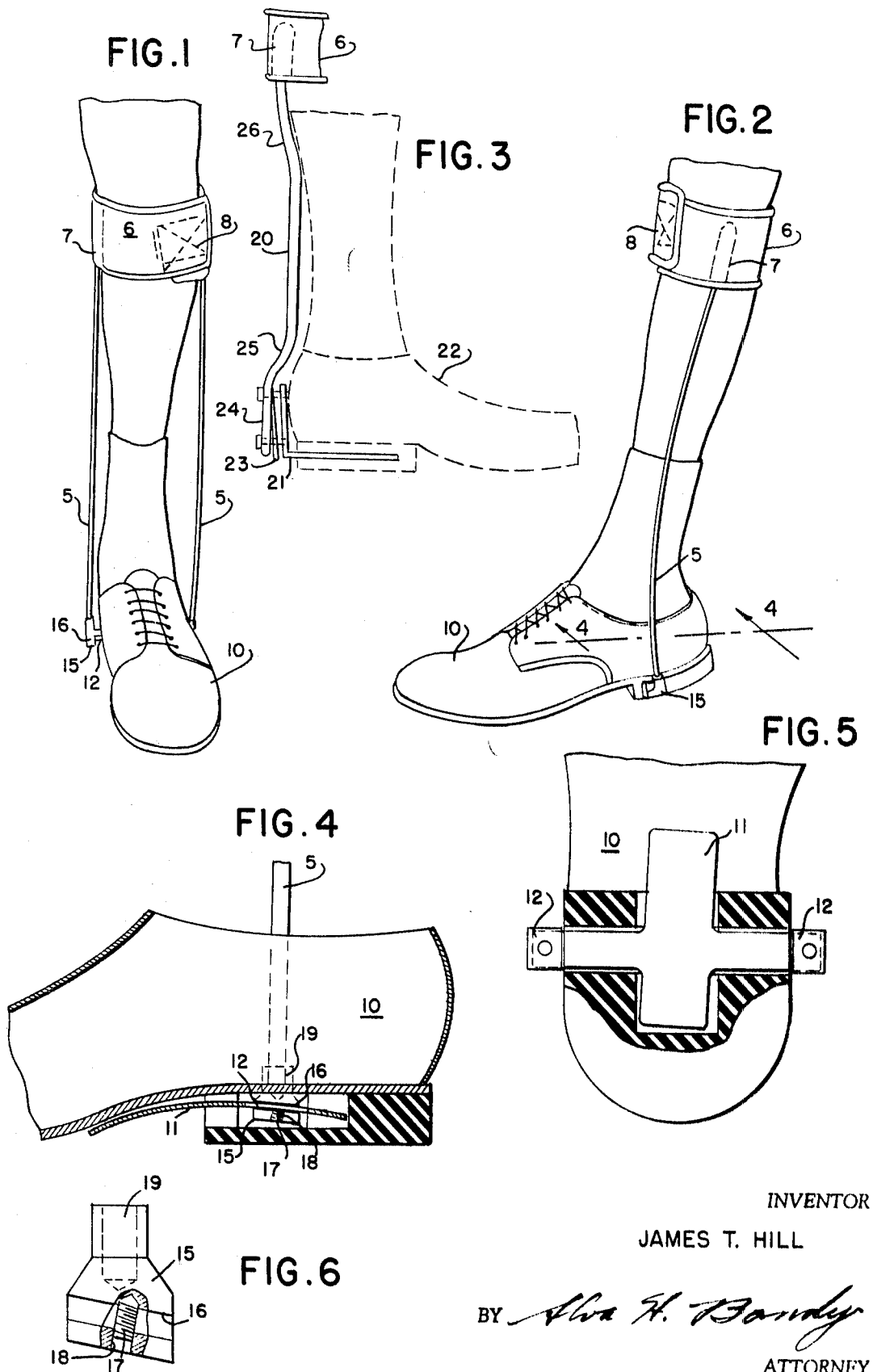
[52]	U.S. Cl.	128/80
[51]	Int. Cl.	A61f 3/00
[50]	Field of Search	128/80, 87, 89, 90; 135/49, 50, 51

[56] References Cited UNITED STATES PATENTS

2,567,195	9/1951	Ellery	128/80
2,571,717	10/1951	Howald et al.	43/18
2,573,698	11/1951	Ellery	128/80

ABSTRACT: This invention relates to a novel foot brace constructed of unidirectional fiberglass reinforced with epoxy resin. The brace is designed of light flexible plastic and includes two embodiments. The first is a bilateral drop-foot brace consisting of two fiberglass-epoxy rods disposed on each side of the wearer's leg, and extending from a calf band to shoe adapters. The second is a fiberglass-epoxy resin posterior, unibar, drop-foot brace having a contoured brace rod extending from a calf band to a single shoe connection.





UNIDIRECTIONAL FIBERGLASS COMPOSITE DROP-FOOT BRACE

The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment to me of any royalty thereon.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention includes the use of fiberglass reinforced epoxy resin brace rod in a novel design to correct a drop-foot abnormality while leaving the other muscles free to act normally.

2. Description of the Prior Art

Prior art appliances have heretofore been constructed out of metal. The use of metal in braces is only partially successful because of the weight of the appliance and the shortened fatigue life due to high notch sensitivity.

Conventional plastic laminates have not been successful in this type of application due to low fatigue life.

Wire spring braces, metal braces with no ankle joint, have an average patient life of around 6 weeks. Both the spring and metal rod braces, in addition to being heavy, have a tendency to take a permanent set when bent too far. This could happen in every day usage. These braces also tend to tear the wearer's clothing and snag objects, or when two braces are worn, interlock with each other, tripping the wearer.

It has been discovered that unidirectional, fiberglass reinforced epoxy resin rods may be easily and cheaply constructed from commercially available impregnated tape. These rods are extremely light, strong, and flexible, and may be tapered or contoured for flexibility.

Accordingly, it is an object of this invention to provide a light, flexible foot brace constructed of unidirectional, fiberglass reinforced epoxy resin rods.

It is another object to provide a foot brace which will correct only a particular abnormality while allowing the wearer's other muscles to function normally.

It is a further object to provide a bilateral drop-foot brace having flexible brace rods which will not snag or tear adjacent articles of clothing.

It is yet another object to provide a unibar, posterior, drop-foot brace having a contoured, flexible, brace rod, said flexible rod eliminating the necessity for a metal spring connecting the brace to a shoe adapter.

These and other objects will become apparent with reference to the drawings and following discussion.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front view of the bilateral drop-foot brace of this invention.

FIG. 2 is a side view of the brace of FIG. 1.

FIG. 3 is a side view of the unibar posterior drop-foot brace of this invention.

FIG. 4 is a vertical section of the shoe attachment for the brace of FIG. 2 taken along line 4-4.

FIG. 5 is a bottom view of the shoe lift plate of FIG. 2.

FIG. 6 is a partial sectional view of the adapter of FIG. 4.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fiberglass-epoxy composites offer great flexibility of design due to their extremely high strength-to-weight ratio. The specific compressive strength of these composites is 2.8 times that of steel and 3.7 times that of aluminum. From a practical standpoint, this allows a brace designer a wide latitude of application. For example, in a brace where strength is a prime consideration, a brace could be constructed with almost three times the strength of steel of the same weight, or a brace could be constructed as strong as aluminum which weighs only one-fourth as much.

The fatigue strength of unidirectional fiberglass-epoxy composites is 36,000 p.s.i. at 10^7 cycles, while spring steel and alu-

minum are 33,000 p.s.i. and 27,000 p.s.i., respectively at 10^7 cycles. The specific fatigue of the fiberglass-epoxy composite is almost five times that of steel, and over twice that of aluminum.

Another important property in spring applications is the physical energy that is stored when it is deformed from zero stress up to its fatigue limit. The relatively low modulus of the oriented, nonwoven, reinforced fiberglass-epoxy composite, coupled with its high ultimate strength, provides it with nine times greater capacity for stored energy than spring steel.

Notch sensitivity is also important in fatigue application because nicks and scratches from every day use lead to premature failures. Reinforced plastics are far less sensitive to notches than most metals. Aluminum retains only 37 percent of its original fatigue strength, steel 43-47 percent of its original strength, while the fiberglass-epoxy composite retains 80-90 percent of its original fatigue strength.

In the bilateral brace of FIGS. 1 and 2 fiberglass-epoxy rods, 5, are connected at their upper ends to cuff band, 6, by insertion into sewn pockets, 7. Cuff band, 6, may be constructed of leather and joined, releasably, by any suitable fastening means, 8. If a rigid cuff band is desired, it may be constructed from a form corresponding to the wearer's leg. The rods and the rigid band may be made from the same material and cured to form an integral piece as will be described.

The wearer's shoes, 10, may have a conventional flat channel (not shown) attached to the shoe plate, 11, of FIG. 5. The plate, 11, is of metal and may be riveted to the shoe, 10, or cemented in place or embedded using conventional procedures. It is to be understood that shoe 10 is used as a generic term to include all coverings for the human foot.

Plate, 11, has lateral extensions, 12, which extend beyond the heel of the shoe. Shoe adapters, 15, are then attached to extensions, 12. Adapters, 15, are designed to have an angled extension receiving groove, 16. This angle may be varied depending on the wearer, but the basic principle is to provide a lift from the horizontal transmitted from the flexible, vertical rods, 5, to the toe of the shoe, 10, through the angled groove, 16, in adapter, 15, and plate, 11.

Adapters, 15, are attached to plate, 11, by setscrews, 17, at holes, 18, in the said plate. After rods, 5, have been cut to the length appropriate to the particular wearer, the ends thereof are inserted in holes, 19, of adapters, 15, and glued in place with any conventional epoxy glue.

The alternate embodiment of FIG. 3, a unibar, posterior drop-foot brace utilizes a contoured, fiberglass reinforced epoxy resin brace rod, 20. The construction of rod, 20, will be described in a subsequent discussion.

Rod, 20, is constructed in a reinforced contour to conform to the posterior of the wearer's leg. The upper portion of the rod, 20, may be sewn in a cuff as described for the bilateral rods of FIGS. 1 and 2 or molded into a rigid band as will be described. Shoe connector, 21, is an L-shaped member which may be riveted or cemented to the wearer's shoe or inserted in a precut channel for rigid attachment to shoe, 22. The particular means utilized will be obvious to one skilled in the art. The lift for the toe of shoe, 22, is provided by rubber wedge, 23, which is inserted between rod, 20, and connector, 21.

Rods, 5, are constructed from commercially available, unidirectional fiberglass tape preimpregnated with epoxy resin. The tape is cut in strips having glass fibers disposed longitudinally within the said strips. The flat strip is then rolled longitudinally as tightly as possible to eliminate a visible hollow core. Additional strips are rolled in the same manner around the rod until the desired diameter is reached. The rod is then spirally wrapped with a commercially available release film applying slight tension to the rod.

It was found that Scotchply Reinforced Plastic, Type 1008, was suitable for the longitudinal roll, and Tedlar, polyvinyl alcohol, and Scotchply XP-242 release films were suitable for the spiral roll.

After the rods are rolled the ends are sealed with, for example, transparent adhesive tape, and the rods are cured for 2

hours at $160^{\circ}\pm 5^{\circ}$ C. For maximum physical properties, an 18 hour postcure at 140° C. is necessary.

In the case where a rigid calf band is necessary the band may be made of 40—70 durometer silicone sheeting, which is wrapped around a suitable form of the patient's leg. The sheet is then wrapped with a release film. To build successive layers the preimpregnated tape is cut and disposed about the band with the fibers of each successive layer disposed at 90° to the previous layer. The layers are then covered with a release film, and with a $1/32$ inch, 70 durometer silicone sheet. This band is cured for 2 hours at $160^{\circ}\pm 5^{\circ}$ C. under 25—30 inches of mercury vacuum.

Rods may be attached to the rigid band in the same manner by looping short strips of preimpregnated tape, a release film, and a silicone sheet around an end of the rod. The ends of the strip buildup are disposed against the band prior to curing, and the composite is cured as described above.

To construct the unibar posterior rod, 20, flat strips of preimpregnated tape are laid up over a suitable form that duplicates the contour of the profile of the patient's leg. These strips are laid up and cured in the same manner as for the rigid calf band described above.

It will be obvious to one skilled in the art that the sloping contours of rod, 20, result from a selective buildup of preimpregnated pieces at the ankle area, 25, and in the area, 24, of the shoe connection. This is a selective buildup and does not extend into the calf area, 26, where only unidirectional fibers are used.

Rod, 20, may be inserted in a leather cuff or laminated to a rigid band depending on the needs of the wearer as described in relation to the bilateral rods, 5.

The race rods of this invention may be constructed according to laminating processes well known to those skilled in the art and the rods may be secured to the calf bands by a variety of methods. The methods of construction, therefore, are important from the standpoint of constructing brace rods having

unidirectional fibers, but they may be varied by lamination procedures obvious to those skilled in art within the scope of this invention.

I claim:

1. A drop-foot brace comprising:

- a. dual flexible brace rods, said rods constructed from fiberglass reinforced, epoxy resin;
- b. a calf band attached to the upper ends of said brace rods, and adapted to be releasably secured around the calf of a wearer;
- c. a shoe connector disposed at the heel of a brace shoe including a flat plate having a rear portion connected to the heel of the shoe, a forward portion aligned with the sole of the shoe, and lateral extensions; and
- d. shoe adapter means for attaching said brace rods to said shoe connector and further including a wedging portion having inclined sections above and below said lateral extensions of said plate and a setscrew which enables the connector plate to be adjusted to set the desired angle between the longitudinal axes of said brace shoe and said brace rods.

2. A drop-foot brace comprising:

- a. dual flexible brace rods, said rods constructed from fiberglass reinforced, epoxy resin;
- b. a calf band attached to the upper ends of said brace rods, and adapted to be releasably secured around the calf of a wearer;
- c. a shoe connector having a flat plate said connector being disposed at the heel of a brace shoe; and
- d. shoe adapter means for attaching said brace rods to said shoe connector, said adapter means including a wedging portion having inclined sections above and below said connector plate and further including means to adjust said connector plate to set the desired angle between the longitudinal axes of the brace shoe and said brace rods.

40

45

50

55

60

65

70

75