

March 19, 1968

J. T. HILL ETAL

3,373,741

PLASTIC SPLINT

Filed March 19, 1965

2 Sheets-Sheet 1

FIG. 3

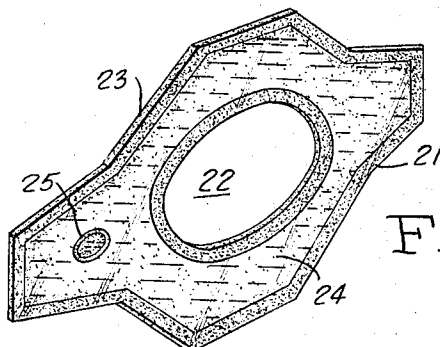
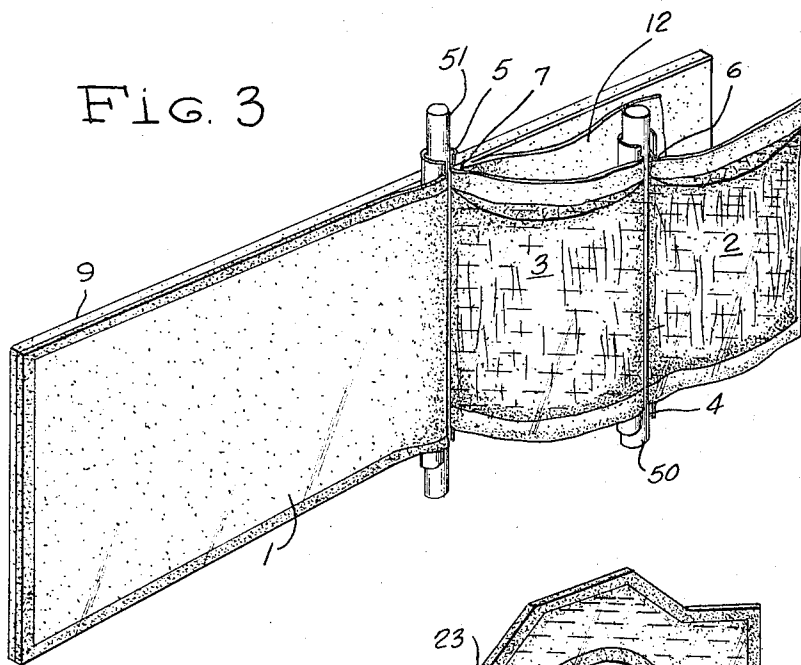
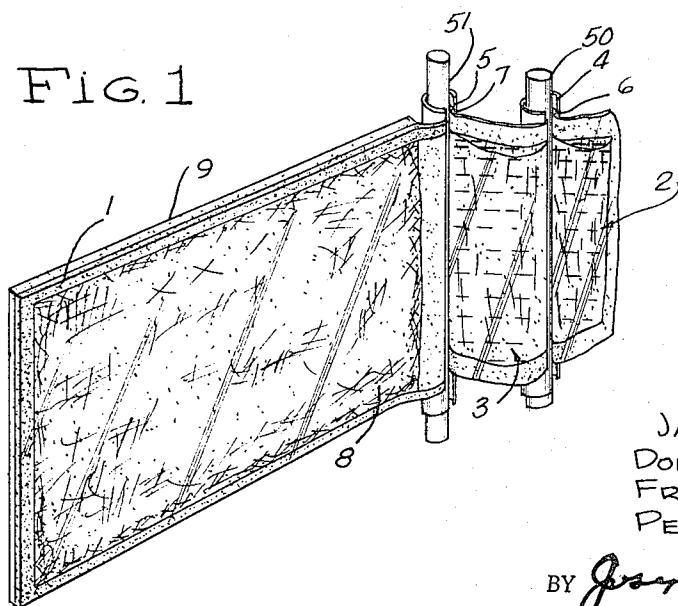


FIG. 4

FIG. 1



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2 Sheets-Sheet 2

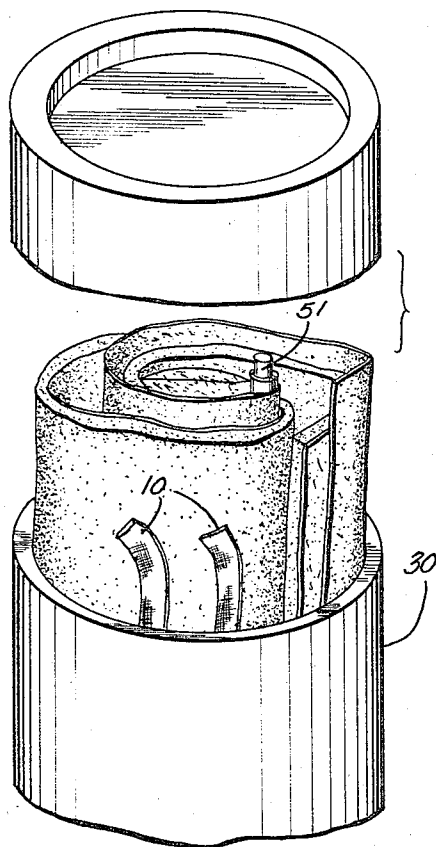


FIG. 5

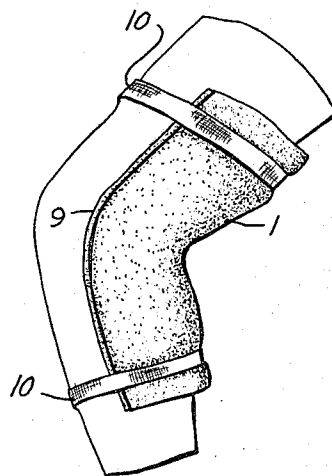


FIG. 2

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PLASTIC SPLINT

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8 Claims. (Cl. 128—90)

ABSTRACT OF THE DISCLOSURE

This disclosure relates to a new splint and more particularly to a novel, light-weight, load bearing splint. The splint comprises a padded envelope containing at least two separate and distinct materials maintained separately, the materials when mixed being capable of forming a cured plastic resin composition.

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

In the emergency treatment of broken bones, dislocations and sprains, splints are required to render the injured member immobile while the patient is being transferred to a hospital or other place for the necessary medical treatment. Splints also are used in the treatment of injuries such as sprains and dislocations in which a permanent cast is not required. In the particular instance of battle wounds and injuries sustained in inaccessible places, such as those sustained in skiing, hunting or mountain climbing accidents, it is desirable that the splint be light weight and compact. It is also desirable that the splint be applicable under adverse conditions of light and weather. In addition, especially in the case of battle wounds, the splint should be capable of bearing a load so that the injured party may, after having the splint applied, leave the scene of the injury under his own power.

The emergency splints presently used by the Army are generally either basswood splints or wire ladder splints. Both of these splints are bulky and must be heavily padded before use. As opposed thereto, the splint of this invention, before application, is a unitary, flexible structure capable of being folded or rolled into a compact package and weighs approximately 0.9 pound.

It is accordingly an object of this invention to provide a unitary self-contained splint package.

It is another object of this invention to provide a light-weight compact splint.

It is further an object of this invention to provide a light weight load bearing splint.

These and other objects of the invention will be obvious from the following description of the invention with reference to the accompanying drawings wherein:

FIG. 1 is a perspective view of one embodiment of the invention;

FIG. 2 is a perspective view of the splint of the invention used in the treatment of a knee injury;

FIG. 3 is a perspective view of an embodiment of the invention employing a foam forming resin;

FIG. 4 is a perspective view of a splint for use on an injured jaw; and

FIG. 5 is a perspective view, partly cut away, of a packaged splint.

Broadly the objects of this invention are accomplished when the splint comprises a closed envelope containing at least two separate and distinct materials maintained separately, the materials when mixed being capable of forming a cured plastic resin composition. As will be described more fully below, blowing agents and reinforcing

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means may also be incorporated in the envelope when needed.

The essential characteristic to be considered in choosing the material used for the envelope is that it be insoluble in, non-reactive with and non-permeable to the materials used to form the cured resin. Suitable materials consist of most of the commercially available packaging films. Polystyrene and Pliofilm, however, which tend to be soluble in urethane systems containing tolylene diisocyanate therefore should not be used with such systems. The films can be heat sealable or capable of adhesive bonding and may either be single layers or laminated. Films which can be used either alone or in lamination are cellophane, cellulose acetate, polyvinylidene chloride, polyvinyl chloride, polypropylene, polyethylene and polyesters. A particularly good laminate consists of oriented polyester-polyvinylidene chloride-polyethylene since the individual layers provide distinct advantages in the film. The polyester supplies toughness to resist tearing when the envelope is kneaded; the polyvinylidene chloride provides a water vapor barrier to protect water-sensitive isocyanate components and the polyethylene permits heat sealing. Aluminum foil also can be incorporated in a laminate to reduce water vapor permeability.

The resin systems usable in the invention are quite varied. The essential criteria in their choice being that they cure to form a hardened solid upon the mixture of the separate components of the system without the application of heat. Foam systems that do not require the application of heat from an external source to accomplish blowing are usable in certain embodiments of the invention. Broadly, polyester, epoxy and polyurethane resin systems have been found to be particularly effective in this invention.

According to the invention, the precursors of the cured resin are maintained physically separated in individual compartments in the splint envelope until the splint is to be formed at which time they are mixed, formed to shape and allowed to cure.

The precursors, depending upon the resin system used, may comprise the basic materials from which the cured resins are formed or they may be prepolymer or partial prepolymer systems.

For example, when a polyester resin system is used one compartment contains the uncured resin and a promoter, if necessary, and the other compartment could contain the catalyst. With epoxy resins one compartment contains the uncured resin and the other compartment the curing agent. With polyurethane foam systems one compartment contains a polyisocyanate and the other compartment contains a polyol resin, a blowing agent, a surfactant and catalyst.

A prepolymer system is one in which the polyisocyanate and polyol are permitted to react in advance, with the polyisocyanate being present in excess in the product. This product is in the first compartment and the second compartment contains blowing agent, surfactant and catalyst. In such a system, the amount of material in the second compartment is very small, being in the order of 1-10 parts of the mixture to 100 parts prepolymer and permits the second compartment to be in the form of a capsule within the prepolymer compartment.

A quasi or partial prepolymer system is similar to the prepolymer system except that only part of the polyol is reacted with the polyisocyanate to form the product in the first compartment and the second compartment contains polyol resin in addition to the materials of the prepolymer system.

Polyester resins usable in this invention are those unsaturated polyester resins generally based on dibasic acids or anhydrides and dihydric alcohols which are capable

of crosslinking with vinylic monomers to form thermoset materials. Examples of suitable dibasic acids and anhydrides include maleic anhydride, phthalic anhydride, adipic acid, succinic acid and fumaric acid. Typical dihydric alcohols include ethylene, propylene, diethylene and dipropylene glycols. Polyhydroxyl alcohols such as glycerol and pentaerythritol can be used to introduce branching in the polyester chains. Monomers added to the resins which serve to reduce their viscosities and which are reactants in crosslinking of the resin include styrene, methyl methacrylate, diallyl phthalate and triallyl cyanurate. The type of resins defined above form the first component of a polyester system.

Catalysts or initiators are used to actuate the crosslinking process through a free radical mechanism which involves the opening of the double bonds of the polyester chain and/or the monomer. Typical catalysts include peroxides such as benzoyl and lauroyl peroxide and hydroperoxides such as cumene and tertbutyl hydroperoxide and methylethylketone peroxide.

Accelerators are used to promote release of free radicals and include metallic salts such as cobalt and manganese naphthenate, anilines such as diethyl and methyl aniline and mercaptans such as dodecyl mercaptan and mercaptoethanol.

The common epoxy resins are produced by the reaction of epoxy compounds with dihydro phenols, for example reacting epichlorohydrin with bisphenol A. In this invention only liquid resins can be used, commercial examples of which are Epon 815 and 828 available from Shell Chemical Corporation and ERL 2795 available from Union Carbide. These resins are contained in one compartment and the curing agent or catalyst which may be amines, anhydrides or acids is in the second compartment. In this invention catalysts, such as the polyfunctional aliphatic amines which cause rapid reaction, are required: examples of which are diethylene triamine and diethylamino propylamine.

With respect to the polyurethane foam systems described above, polyisocyanates useful in this application include 2,4-tolylene diisocyanate, 2,6-tolylene diisocyanate and mixtures of these isomers; p,p'-diphenylmethane diisocyanate; m-phenylene diisocyanate; 1,5-naphthalene diisocyanate; hexamethylene diisocyanate; dianisidine diisocyanate; polymethylene polyphenyl isocyanate; and diphenylmethane 4,4'-diisocyanate.

Polyol or polyhydroxy compounds usable in the above systems include ethylene and propylene oxide adducts of polyfunctional active hydrogen compounds such as glycerine, sorbitol, trimethylolpropane, ethylene diamine, sucrose, etc., and generally referred to as polyethers. Another class of polyhydroxy compounds usable in the above systems are the hydroxyl terminated polyesters made by the esterification of polybasic acids with polyhydric alcohols.

Blowing agents useful in this invention include water, which reacts with the isocyanate producing carbon dioxide, and other materials which generate a gas when mixed.

Catalysts useful in these reactions include amines, particularly tertiary amines, e.g., N-methyl morpholine, triethyl amine, triethyl diamine (1,4-diazobicyclo-(2,2,2)-octane); organometallic compounds are likewise useful as catalysts, e.g., stannous octoate, dibutyltin dilaurate, lead naphthenate, cobalt naphthenate, tributyl in methacrylate. Certain synergistic combinations of catalysts are known to the urethane foam industry and can be usefully employed in this application, e.g., organotin and tertiary amine combinations. Concentrations of these catalysts ranging between .1 and 5 percent can be used, and this concentration may be varied to vary the reaction time.

Useful surfactants include organo silicon compounds such as dimethyl polysiloxane and polyalkylene ether copolymers. Commercial products used include Union Carbide Corporation's L-520, L-531, General Electric Corporation's XF-1066 and SF-1034 and Dow Corning's 113.

These materials function to promote fine, uniform cell formation within the foam.

Polyurethane foam materials can be formed using these processes in a wide range of foam densities. Foam densities useful in this invention range from 4 to 40 pounds per cubic foot.

In all of the above systems the material should be chosen so that the resin cures within a time suitable for the condition under which the splint is to be used. For use in battle wounds or emergency accident treatment, a rapid cure is essential and polyester or polyurethane systems that cure within 10 minutes are desirable. When used in hospitals or places where time of cure is not of the essence, epoxy systems, which have cure times in the order of hours, are suitable.

Referring now to FIG. 1, one embodiment of the invention consists of a closed flexible envelope 1, formed from a laminate of 3 mil polyethylene and 1 mil mylar heat sealed around the edge having two compartments 2 and 3 formed at one end thereof. The compartments may be formed by a weak heat seal across the width of the envelope or by a weak adhesive bond or by means which pinch off an area across the width of the envelope. The preferred embodiment employs split resilient cylinder separators 4 and 5 which engage folds 6 and 7 of the envelope formed around cylinders 50 and 51. Each compartment contains a precursor of a cured polyester resin system or of a cured epoxy resin system.

The other portion of the envelope contains, coextensive therewith, a reinforcing mat 8. The mat is preferably made of 4 layers of woven fiberglass but other woven, knitted or matted textiles such as nylon, Dacron, cotton or Orlon may be used. The lower portion of the envelope has secured thereto thick flexible pad 9 which serves as padding to prevent irritation of the patient and also serves as insulation to protect the patient from the heat liberated during the curing process. Pad 9 can, for example, be made from 1/4" flexible polyurethane foam adhesively bonded to the envelope by an adhesive on the foam.

In use, the separation between compartments 2 and 3 is removed by breaking the bond forming the separation or by removing separator 4 and the precursors in the two compartments are mixed thoroughly. After mixing is completed, the remaining separator 5 is removed and the contents worked uniformly into the remaining section of envelope 1 to impregnate mat 8 with the mixture. After the mat 8 has been impregnated with the resin, the split is placed in contact with the injured member, with the pad 9 contacting the body, and formed to the desired shape. The splint is then fastened in place by means of straps 10 as shown in FIG. 2.

Suitable precursor compositions for a polyester resin system are set forth below:

Example 1

Compartment 2:	
Laminac 4110	g-- 200
Vibrin Promotor #3	ml-- 5
Compartment 3:	
Benzoyl peroxide paste (50% in tricresyl phosphate)	gm-- 4

Laminac 4110 is a styrene containing polyester resin with a viscosity of 450 centipoise available from American Cyanamid. The Vibrin promotor is available from Naugatuk Chemical Corporation.

The above splint was rigid and weight bearing 7 minutes after mixing the components and impregnating the mat 8.

A suitable precursor composition for an epoxy resin system is set forth in the following example:

Example 2

Compartment 2:	
Epon 815	g-- 200

Compartment 3:

Epon curing agent T-1 -----g-- 50

Both components are available from Shell Chemical Corporation, Epon 815 being a liquid epoxy resin with a viscosity of about 700 centipoise and an epoxide equivalent of 175-195 and the T-1 curing agent being an aliphatic polyamine. Cure was sufficient to yield a weight bearing splint after 4 hours.

The splint package used when a foam resin system is employed differs from that already described basically in that the mat 8 is not incorporated into the envelope.

As shown in FIG. 3, the envelope 1 has two compartments 2 and 3 formed at one end thereof by separators 4 and 5, each compartment containing a precursor of the foamed resin. The pad 9 is secured to envelope 1 up to the edge of compartment 3. The pad is equal in length to the whole envelope and that portion coextensive with compartments 2 and 3 has a strippable sheet 12 adhered thereto. In use, the precursors are mixed as described above until the mixture takes on a whitish appearance and there is a noticeable evolution of heat. The other separator is then removed and the foaming resin worked uniformly through the envelope 1. The backing 12 is removed and pad 9 is adhered to the portion of the envelope that previously formed compartments 2 and 3. The splint is now ready for application and is placed in contact with the injured member, shaped and fastened as described above.

Suitable precursor compositions, a polyurethane foam system, are as follows:

Example 3

Compartment 2:	
Isofoam 15-A -----gm--	150
Compartment 3:	
Isofoam 15-W -----gm--	113
Stannous octoate -----mg--	9
Triethylene diamine -----mg--	9

The Isofoam materials were obtained from the Iso-cyanate Products Co. and the above mixture yielded a weight bearing splint with a foam density of 18 pound/ft.³ six minutes after mixing of the precursors.

The above examples have been described with respect to a splint for a limb injury and the envelopes for such application are about 26" long and 8" wide. However, the splint of this invention can be made in different configurations for various uses. Referring now to FIG. 4 a splint package for a jaw injury is illustrated.

In this embodiment, the envelope 21 is formed into the shape shown with the central opening 22 heat sealed around the edges. A foam pad 23 of the same configuration as envelope 21 is adhered to one surface of the envelope 21. The envelope 21 contains a liquid prepolymer 24 having an excess of isocyanate and a blowing agent, catalyst, surfactant mixture is contained within rupturable capsule 25. The capsule can be formed of the same material as envelope 1. In use the capsule 25 is ruptured, the contents mixed with the prepolymer 24 until the mixture turns white and heat is evolved. The mixture is distributed evenly throughout the envelope and then applied with the subject's jaw in the central opening 22, formed to shape and then held in place with adhesive tape or tied by straps.

In the above splint approximately 50 grams of a liquid prepolymer containing excess polyisocyanate is contained in the envelope and the capsule contains 2 gms. of water, 2 gms. of triethylene diamine and 9 mg. of stannous octoate.

Before curing the splint, envelopes can be rolled into a compact cylinder and packaged in a tubular container 30 together with the adhesive or other type of straps 11 used to fasten the splints as shown in FIG. 5.

While this invention has been disclosed with respect to several embodiments thereof, the invention is not limited thereto and includes all modifications thereof within the scope of the following claims.

We claim:

1. A splint package comprising a flexible sealed envelope having a flexible pad attached to one face thereof substantially coextensive therewith, the interior of said envelope being divided into at least two compartments by removable separating means, a first compartment containing a first material and a second compartment containing a second material, said first and second materials being precursors of a cured resin system and which, when mixed, will cure without the application of external heat.

2. The splint package of claim 1 wherein the interior of said envelope is divided into three compartments, the third compartment containing, coextensive therewith, flexible reinforcing means and wherein said first and second materials are precursors of cured resin systems selected from the group consisting of polyester resins and epoxy resins.

3. The splint package of claim 2 wherein said reinforcing means is a woven fiberglass mat.

4. The splint package of claim 1 wherein said first and second materials are precursors of a foamed resin system and one of said materials contains a blowing agent.

5. The splint package of claim 1 wherein at least one of said removable separating means comprises a resilient member in clamping engagement with a fold across the width of said envelope.

6. The splint package of claim 1 wherein at least one of said separators comprises a rupturable capsule contained within one of said compartments.

7. The splint package of claim 1 wherein the interior of said envelope is divided into three compartments, said third compartment being substantially longer than the combined lengths of said first and second compartments and said flexible pad is attached to the face of said envelope coextensive with said third compartment.

8. The splint package of claim 7 wherein the flexible pad extends along the length of said first and second compartments and the portion of said pad coextensive therewith has an adhesive surface covered by a removable sheet.

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