Nov. 10, 1942. S. P. LOVELL 2,301,426

SPLINT-FORMING MATERIAL

Filed April 3, 1939

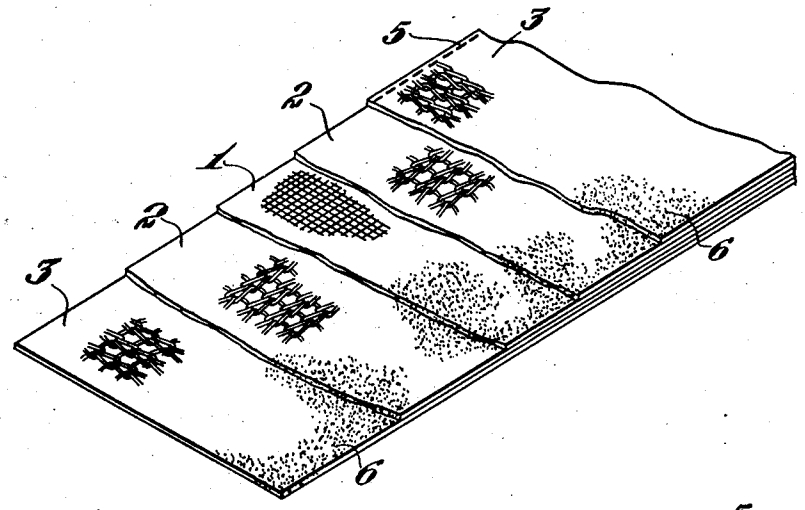


Fig. 2

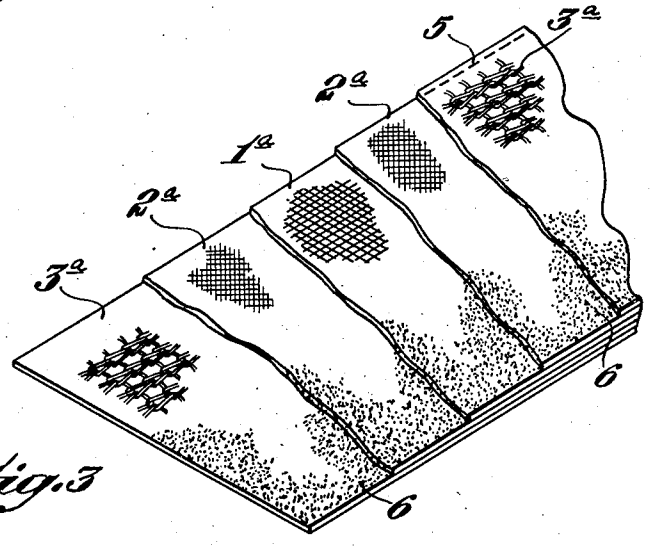
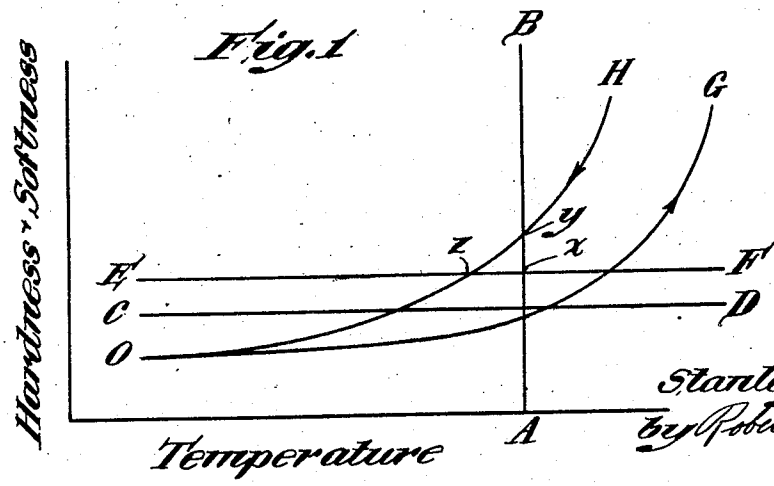


Fig. 3

Fig. 1



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Patented Nov. 10, 1942

2,301,426

UNITED STATES PATENT OFFICE

2,301,426

SPLINT-FORMING MATERIAL

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Application April 3, 1939, Serial No. 265,673

1 Claim. (Cl. 128—90)

This invention relates to splints, shores and the like structures used in the treatment of sprains and fractures.

In treating sprains and fractures it is the usual practice to form a cast, splint or the like about the site of the injury so as to render immobile the injured bone, muscles, etc., adjacent thereto, the usual technique consisting essentially in the application of the so-called "plaster of Paris" (dehydrated calcium sulphate) bandage in conjunction with slabs of wood, metal braces or the like reinforcing elements. Although this practice has been in vogue for years, it has several disadvantages which have been recognized by the medical profession and also the patient. For example, the weight of the plaster cast frequently causes the bones to knit in maladjusted relation, and, due to the opacity of the plaster of Paris, the use of Roentgen ray photography to detect defective setting is rendered practically impossible.

Moreover in splints of the non-tubular type it is invariably necessary to employ reinforcing strips of a nature which do not readily conform to body contours and as such reinforcing strips tend to span the gaps or reentrant portions of irregular surfaces to which they are applied, they do not afford adequate support and hence it is usually necessary to apply additional plaster, thus greatly increasing the bulk and weight of the cast.

The principal objects of the present invention are to overcome the aforementioned objections and to provide a material which may be readily formed into an accurately fitting cast or splint by the direct application of the conditioned material which when applied is in moldable condition and which is inherently capable of setting or hardening at temperatures endurable by the human body so as to provide a rigid structure which is of relatively light weight and permeable to X-rays.

Other objects of the invention are to provide a strong and rigid splint-forming material entirely conformable to the area treated and having an immobilizing time not exceeding five minutes after application to the treated area, and to provide a splint-forming material which after hardening in situ may be overlaid and/or incorporated into a solvent-softened type of cast material or alternatively in a plaster of Paris type of cast.

Further objects and advantages will be apparent from a consideration of the following description and the accompanying drawing wherein

Fig. 1 is a chart illustrating the characteristics of a thermoplastic composition useful in the present invention;

Fig. 2 is a fragmentary perspective view illustrating one type of splint-forming material; and

Fig. 3 is a view similar to Fig. 1, but illustrating another type of splint-forming material.

I have observed that when thermoplastic resinoids, which are normally hard at ordinary temperatures, are heated to their flow point and subsequently cooled to temperatures at which they again become hard, the temperature at which they regain their hardness on cooling is not the same as the temperature at which they lose their initial hardness on heating. In other words, such compositions possess a hysteresis characteristic which varies with the particular resinoid or mixture of resinoids.

I have found that it is possible to modify the hysteresis characteristic of normally hard thermoplastic resinoids and the like compositions so that upon heating they retain their hardness up to a certain prescribed point or range, after which they become soft and readily moldable, and upon cooling they retain their moldability down to a certain prescribed point or range, after which they become relatively hard and resistant to flow. The point or range at which the resinoid becomes soft and moldable on heating is herein referred to as the "primary softening point," and the point of range at which the resinoid on cooling loses its softness and moldability is referred to herein as the "secondary softening point," the difference between the two being an index of the hysteresis characteristic.

Although I am not prepared to explain the cause of the hysteresis phenomenon, it is quite possible, if not probable, that such thermoplastic compositions possess to a greater or lesser extent the character of supercooled melts in which the constituents function to reduce the crystallization velocity. However, I do not wish to limit myself to this explanation.

In accordance with the present invention, I provide a splint-forming material which is preferably in sheet form, comprising a fibrous base impregnated with a water-insoluble or water-resistant thermoplastic composition which is normally hard and resistant to flow, having an initial softening point above the maximum temperatures endurable by the human body, and a second softening point at or below the maximum temperatures endurable by the human body, thereby per-

mitting the material, when in moldable condition, to be applied to the site of a fracture or injury to provide an accurately fitting splint of light weight and permeable to X-rays.

The fibrous base may consist of one or more layers or plies of a bibulous fabric such as felt, wadding, batting etc., a woven fabric such as osnaburg, scrim, terry cloth, etc.; a nap fabric such as flannel; or a knitted fabric, all of which are capable of holding an adequate amount of a thermoplastic impregnant to form a unified splint-forming material of the desired strength and rigidity. In order to insure adequate extensibility I preferably employ a laminated fabric base having a cross-grained fabric construction, such as one or more inner layers of relatively coarse fabric interposed between one or more outer layers of knitted fabric, the wales and courses of the contiguous layers of the outer plies preferably extending in different directions.

The thermoplastic impregnant may comprise natural or synthetic water-insoluble resins which may be modified by or blended with plasticizers or any other ingredients capable of producing a composition having the characteristics indicated in Fig. 1, wherein the line AB represents the maximum temperature endurable by the human body (approximately 120° F.), the line CD representing the minimum hardness capable of effecting substantial immobilization and the line EF representing minimum softness permitting moldability. The intersection (*x*) of the lines AB and EF represents the minimum softness and maximum temperature at which the thermoplastic composition is moldable and yet capable of being applied to a patient without injury to the tissue. The curve OG represents the hardness/softness factor or characteristic when being heated, and the curve OH represents the hardness/softness factor or characteristic of the same composition when being cooled from a temperature at or above its melting point (ring and ball). It will be observed that the curve OG intersects the line CD beyond the line AB, and hence at temperatures endurable by the human body the thermoplastic composition possesses sufficient rigidity or hardness to insure substantial immobilization. The intersection of the curve OG and the line EF indicates the temperature at which the composition becomes sufficiently soft to permit molding, it being observed that the temperature indicated by the latter point is greater than the maximum temperature endurable by the human body. The curve OH represents the hardness characteristic of the composition when being cooled, and it will be noted that due to hysteresis the curve OH intersects the line AB at a point (*y*) which is above the line EF, thus showing that at the maximum temperature endurable by the human body the composition is readily moldable and retains its moldability down to a temperature indicated by the point *z*, the intersection of curve OH and line EF, which is considerably lower than the maximum temperature endurable by the human body. On further cooling the composition regains substantially its original hardness, as indicated by the merging of the curves OG and OH.

A thermoplastic composition having the characteristics indicated in Fig. 1, may comprise such natural resinoids as the bitumens, certain vegetable, mineral and animal waxes or mixtures thereof which may be modified by or blended with other materials capable of imparting the desired characteristics, or such synthetic resinoids as the cumaron-indene resins, the cellulose esters, vinyl resins or the like polymers, or mixtures of natural and synthetic resinoids, with or without fillers, modifiers and plasticizers. In any case, the resulting composition should be normally hard and sufficiently resistant to flow at temperatures endurable by the human body so that a splint made therefrom furnishes substantial immobilization of the part at which it is applied, and in addition its secondary softening point should be such as to permit application of the splint without danger of injuring the patient.

Where, as is preferred, the fibrous base comprises a plurality of plies, the number and weight of such plies, as well as the proportion of thermoplastic impregnant may be varied throughout a wide range, depending upon the required strength and rigidity of the splint to be made therefrom and such other factors as the inherent strength of the impregnating composition, the characteristics of the individual plies, etc. As a general rule a satisfactory splint-forming material may be made from a fabric base and a water-insoluble thermoplastic composition of the character above specified when the proportion of these constituents falls within the following range:

	Parts by weight
Fibrous base (dry bases)	1–2
Thermoplastic composition	2–3

Referring to Fig. 2, the particular splint-forming material there shown comprises a relatively coarse central ply 1 of woven fabric such as burlap having a weight of approximately 7½ oz. per 50" yard, and on each side of the central ply 1 are intermediate plies 2 and outer plies 3 of knitted fabric preferably having a weight of approximately 2 oz. per square yard. The wales of the intermediate plies may extend longitudinally and the courses transversely and the several plies may be secured together by suitable stitching 5, thus producing a laminated fibrous base having a cross-grain construction which permits greater extensibility than would otherwise be possible.

In Fig. 3 I have shown a modified form of fabric base which comprises a central ply 1^a of relatively coarse woven material, intermediate plies 2^a of bias cut woven fabric of finer weave than the central ply 1^a, and outer plies 3^a of knitted material, the several plies being united by a row of stitching 5.

The laminated fibrous base prepared as above set forth may be immersed or run through a molten bath of thermoplastic material of the character above described and impregnated to the extent previously indicated, after which it may be cut up into suitable sizes and shapes for convenient application. A specific example of what is now considered a preferred thermoplastic composition for splints adapted for general use is as follows:

	Parts by weight
Carnauba wax	60
Candelilla wax	30
Ground vulcanized rubber	30

The three ingredients are thoroughly mixed, the rubber preferably being added to the molten mixture of candelilla and carnauba wax, and if desired, coloring materials, preferably of aluminum or like metallic compounds, organic colors or the like, which are relatively permeable to X-rays may be added to the molten mixture to produce a white or flesh color. After having prepared the thermoplastic composition the

fibrous base may be immersed in the molten bath preferably at a temperature of the order of 300° F. After sufficient impregnation has taken place, the fibrous base is withdrawn and passed through suitable calenders, thereby to integrate or unify the impregnated base. Upon cooling, the resulting product becomes hard and rigid and is of light weight and uniform thickness. Due to the temperature employed in the impregnating treatment the splint-forming material is sterile and without further treatment may be maintained in condition for immediate use since the thermoplastic composition employed does not favor the growth of pathogenic organisms.

A splint-forming material comprising a fibrous base having the construction illustrated in Fig. 2 and impregnated with the specific thermoplastic composition above set forth possesses the following characteristics:

Weight of central ply 1 oz. per sq. yd.	5.4
Weight of outer plies 2 and 3 oz. per sq. yd.	2.0
Total weight of fibrous base oz. per sq. yd.	7.4
Weight of thermoplastic composition oz. per sq. yd.	56.0
Gross weight of splint-forming material oz. per sq. yd.	63.4
Thickness of splint-forming material (approximate) inch	0.115
Primary softening point (approximate) °F.	136
Secondary softening point (approximate) °F.	110

In applying the splint made in accordance with the present invention it is merely necessary to subject it to a temperature sufficient thoroughly to soften the thermoplastic material so that it becomes readily moldable and to this end the splint-forming material may be placed above a radiator or in an oven heated to a temperature of the order of 150° F. When thoroughly softened the material may be cooled to a temperature endurable by the patient and directly applied to the site of the injury or fracture which, of course, may be wrapped in a stockinette or the like protective covering. After application it takes but a short time, less than five minutes, before the splint cools to a point at which the thermoplastic composition substantially regains its original hardness and rigidity or becomes sufficiently rigid to immobilize the part to which it is applied.

I claim:

Splint-forming material comprising a fibrous base impregnated with a normally hard thermoplastic composition comprising approximately six parts carnauba wax, three parts candelilla wax and one part vulcanized rubber, said composition being sufficiently resistant to flow and deformation at temperatures endurable by the human body to effect substantial immobilization of the part to which the material is applied, said composition having a primary softening point greater than the maximum temperature endurable by the human body and a secondary softening point not exceeding the maximum temperature endurable by the human body.

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