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E. L. GUSTUS ET AL

2,781,287

DIMENSIONALLY STABLE SHEET MATERIAL FOR REPRODUCTION PURPOSES

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FIG 1

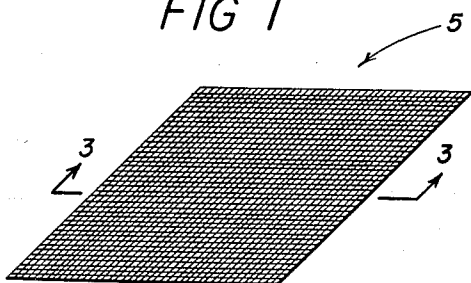


FIG 2

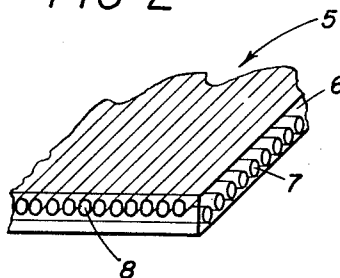
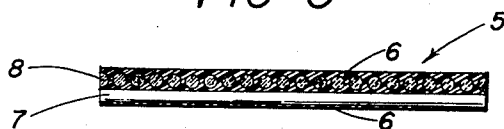


FIG 3



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DIMENSIONALLY STABLE SHEET MATERIAL FOR REPRODUCTION PURPOSES

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4 Claims. (Cl. 154—46)

This invention relates to a thermally and hygroscopically dimensionally stable sheet material suitable for use as a base in the graphic arts and more particularly to such a material comprising glass monofilaments.

The subject matter of this patent may be used by or for the Government for governmental purposes without the payment of any royalties.

Graphic art and particularly cartographic base materials have been made of synthetic resin reinforced with glass fabric. The property of dimensional stability is most particularly desired in cartographic bases and in bases for photographic reproduction of master drawings of engineering plans and cartographic base materials and other such materials have heretofore been unsatisfactory because of dimensional instability when subjected to conditions of high humidity or of extremely high or low temperatures. Therefore a translucent sheet material (which may almost be transparent in appearance) which is unaffected dimensionally or is substantially unaffected by varying moisture conditions, including being soaked in water for 24 hours, and which is resistant to temperature change by reason of having a low thermal coefficient of expansion is highly desirable.

Glass, because of its low thermal expansion coefficient and insignificant moisture absorption, is an ideal reinforcement for such a base made of synthetic resin which itself has substantially no moisture absorption.

Heretofore cartographic base materials have been produced by impregnating glass cloth with synthetic resin such as a polyester resin, but such materials have been undesirably affected by variations in temperature and further have the disadvantage that the thermal expansion is different in the machine direction from that in the cross direction and expansion in each direction has been excessive. We have discovered that this is because of the crimp or waviness in the strands of yarn which permits elongation when under stress.

It is therefore an object of this invention to provide a translucent sheet material for reproduction purposes which has great dimensional stability under varying conditions of temperature and moisture.

Another object is to provide such a material comprising a synthetic resin reinforced with substantially parallel layers of substantially parallel glass monofilaments.

Further objects will become apparent from the drawings and the following detailed description, in which like reference numerals refer to like parts and in which it is our intention to illustrate the invention without intending to limit its scope and in which:

Figure 1 is a perspective view of a sheet of cartographic base material according to the invention;

Figure 2 is an enlarged perspective view of one corner of the sheet of Figure 1;

Figure 3 is a cross-sectional view along lines 3—3 of the sheet of Figure 1.

Referring now to Figures 1, 2 and 3 there is shown

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a sheet of translucent graphic base material indicated generally as 5 which consists of synthetic resin 6 having imbedded therein a layer of substantially parallel glass monofilaments 7 and another superposed adjacent layer of substantially parallel glass monofilaments 8. The layers may be parallel or substantially parallel and the monofilaments in the two layers may be at about 90° to each other as shown or may cross each other at some lesser angle. It is a characteristic of the invention that because the reinforcing glass strands are not wavy or crinkled they cannot be readily stretched or compressed and they therefore provide great dimensional stability for the sheet material. Dimensional stability is provided in the longitudinal direction of the strands in each layer and therefore is provided in both the cross direction and the machine direction of the material.

Resin 2 may be a polyester or styrenated polyester or may be such a thermosetting resin as melamine formaldehyde, phenol formaldehyde or urea formaldehyde resin, or it may be a thermoplastic such as a vinyl halide, vinyl ester, polyethylene or a halogenated hydrocarbon such as polychlorotrifluoroethylene or polytetrafluoroethylene. A flexible transparent thermosetting synthetic resin is preferred and a polyester or modified polyester resin has been found most preferable.

In order to provide a material which is at least translucent and which may be more or less transparent in order to facilitate its use in tracing engineering drawings, maps, and like matter and in order to facilitate its use for reproducing such graphic material in a photosensitive coating applied to one of its surfaces, the indices of refraction of the glass monofilaments and the synthetic resin used are preferably at least nearly the same. The index of refraction of glass monofilaments tends to vary rather widely since only very slight differences in the proportions of the ingredients used in making the glass from which the glass monofilaments are drawn produce marked variations in refractive index in the glass in the resulting monofilaments. Thus it may be necessary to prepare a composition of polymerizable material which has the desired flexibility and also which has an index of refraction matched to the index of refraction of the glass monofilaments prepared from a particular batch of glass. It has been found that it is not necessary to have the indices of refraction of the glass and the synthetic resin after polymerization matched exactly and that quite satisfactory material for tracing or photo-reproduction purposes can be prepared with an appreciable difference between the index of refraction of the glass and the index of refraction of the synthetic resin, except that it is necessary that the indices of refraction be sufficiently well matched that the glass monofilaments are not noticeable on a photo-reproduction when a camera is operated at the exposure normally used to reproduce graphic material appearing on a surface of the material and it is necessary that the sheet of course be preferably translucent for this purpose. It is of course desirable that the sheet be sufficiently translucent that tracing may be easily accomplished by laying the sheet over a sheet of paper or other material having thereon a map, engineering drawing, or other graphic matter and that the monofilaments not be sufficiently differentiated from the synthetic resin in appearance as to obstruct the view of such material as it is being traced. Such a degree of translucency may be accomplished in most instances by preparing a polymerizable composition having an index of refraction sufficiently close to the average of most batches of glass used to make yarn composed of monofilaments which may be used with most batches of glass yarn without change in composition. In some instances however it may be necessary to vary the resin composition to obtain the de-

sired hiding of the filaments. The index of refraction of the glass in glass monofilaments as normally prepared commercially is believed to be in the neighborhood of from $n_D^{20}=1.474$ to $n_D^{20}=1.546$ but may be higher or lower and several commercially available polyester polymerizable substances, which polymerize to form a flexible transparent thermosetting synthetic resin, are suitable as materials for major components of polymerizable compositions with which this object may be accomplished. For example, resins having $n_D^{20}=1.5441$ or 1.5405 have been found suitable.

The translucent sheet material indicated generally as 1 may be provided with any suitable coating to facilitate its use in the graphic arts. For example, it may have applied to it an adherent coating adapted to provide a surface which will easily retain graphite or ink or paint and thus facilitate the use of the base material in tracing directly with pen or pencil or painting thereupon with oil or water paint. It may have applied to a surface a photosensitive coating of any one of the numerous types known to the art which may serve to facilitate making a photographic image of a map, picture, engineering drawing or other graphic material on the highly dimensionally stable base of the invention.

It is generally preferable that the sheet of the invention be provided with substantially smooth, non-wavy surfaces to facilitate its use for the purposes and in the manners described above. Such surfaces may be provided on a sheet by accomplishing the polymerization of the synthetic resin while pressure is maintained against the surfaces of the sheet and such pressure is preferably applied by smooth, or even glossy, non-wavy metal-like surfaces. These surfaces may be applied either as rolls or as platens of a press, or by other suitable means, and may be either metal or any suitable material such as for example glass. Such metal-like surfaces need not be applied directly against the polymerizing synthetic resin of the sheet but may be applied through interposed sheets of a material such as regenerated cellulose (cellophane) or other sheet material which itself is non-adherent to the synthetic resin of the base material and which serves the purpose of preventing the synthetic resin of the base material from becoming adhered to the metal or glass surface during its polymerization.

As shown in the figures, the axes of the monofilaments in each of said layers are preferably disposed in a plane and parallel to each other or are at least generally substantially parallel to one another. Furthermore the planes defined by the axes of the monofilaments are preferably substantially parallel to both surfaces of the sheet of base material formed as described above.

The base material of the invention may be made by any suitable process and several methods are adaptable to the continuous production of base material according to the invention. A method which is suitable for the mass production of sheets according to the invention is the following:

A rectangular plate which may be glass, wood, or metal and which may have rounded edges is provided with shafts or axles attached thereto by clamps disposed on one of the axes of said plate in the plane of said plate. Journal or other bearings are provided for said shafts to support the plate rotatably and a crank may be provided on the end of one of said shafts which projects thru one of said bearings. Glass monofilament may then be wound onto said plate in the form of either a single monofilament or in the form of roving consisting of a group of monofilaments only slightly twisted. The first turn may be wound on substantially parallel to an edge of said plate and subsequent turns may be wound on parallel to the monofilament or monofilaments previously wound on, said winding being accomplished by turning said crank. The glass plate is thus provided with a layer of parallel or substantially parallel glass monofilaments on each of its sides and on two edges. The shafts may then be removed and

then relocated on the other axis of said plate. Glass monofilaments may then be wound onto the plate again thus forming a second layer of parallel or substantially parallel glass monofilaments disposed on each side of said glass plate, the monofilaments in the second layers being substantially at 90° to those in the first layers. Two sheets of base material may then be provided by impregnating the two layers on each side of said glass plate with synthetic resin and pressing in a laminating press or by other suitable means known to the art. Each resulting sheet of base material thus contains two layers of parallel or substantially parallel glass monofilaments, the monofilaments in each of said layers being substantially in a single plane and the planes being substantially parallel to the two surfaces of the sheets thus produced.

It is generally preferable to provide a substantial amount of tension in all of the glass monofilaments during the carrying out of the polymerization. Such tension increases the dimensional stability of the resultant sheet material and it has been found to be generally true that the stability of the sheet material is to some extent proportional to the amount of tension maintained in the glass monofilaments during the process of polymerization. Tension may be produced and maintained in the glass strands by any suitable means. For example, it has been found suitable to wind the glass monofilaments around a wooden plate and then, by internal screw means, to force one section of the plate away from another section. It has been found somewhat more suitable to use a plate of metal or glass, and to allow the glass monofilament or roving to pass through a tensioner of a type well known to the art adapted to maintain a constant tension in the monofilament as it is wound on to the plate. The monofilaments after being wound on the plate of course continue to retain the tensional stress imposed upon them during the winding operation. It has been found suitable to maintain just a little more tension than that necessary to keep the monofilaments stretched sufficiently to avoid kinks, but it has been found preferable to maintain a greater degree of tension and sheets of the greatest dimensional stability have been produced with the tension being maintained at a stress as near to the breaking point as practicable with the tensioners and winding means used.

It has been found desirable to utilize glass monofilaments which have been provided with vinyl groups attached to their surfaces prior to being imbedded in polymerizable material. It has generally been found desirable to provide such vinyl groups attached to glass monofilament surfaces through silicon atoms not originally part of the silica structure of the glass. Monofilaments provided with vinyl groups on their surfaces in this manner become attached to the synthetic resin during the polymerization of the resin through carbon atoms which were part of the vinyl groups prior to carrying out the polymerization step.

Vinyl groups attached to the monofilament surfaces in this manner may be provided by treating the monofilaments with vinyltrichlorosilane and then hydrolyzing the vinyl trichlorosilane to form vinylsiloxane. Vinyl groups attached to the glass monofilaments in this manner may also be provided by treating the glass monofilaments with polyvinyl silanol or with vinyl siloxane partially polymerized in the form of lactone rings. Vinyl groups on glass monofilaments may also be suitably provided with vinyl siloxanates, vinyl starch, vinyl amines, and the like. Allyl groups may suitably be provided in a similar manner and may suitably serve the purpose of the vinyl groups.

The invention is further illustrated by the following examples.

Example 1

Glass yarn comprising 8 monofilaments, only slightly twisted (sold commercially by Owens-Corning as ECG 150 1/0 E), sized with vinyl siloxane partially polymerized in the form of lactone rings, was wound in both

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directions around a 19" x 19" aluminum plate with approximately .140" spacing between strands. A layer of polymerizable material consisting of 15% of rigid polyester (such as that sold commercially as Laminac 4128) and 85% flexible polyester (such as that sold commercially as Laminac 4134) was applied to the strands. A sheet of regenerated cellulose (cellophane) was applied to each side of the sheet to prevent adherence of the synthetic resin to platens of the laminating press, and the assembly was then placed between platens of a press and polymerization carried out for ½ hour at 130° C. at a pressure of about 10 pounds per square inch.

The assembly was then removed from the press; the cellophane sheets were removed and the sheets of material thus produced were removed from the plate by cutting the glass strands at the edges of the plate.

The sheets thus prepared had a tensile strength of approximately 200 pounds per lineal inch. Dimensional change when the material was subjected to an increase in humidity from 30% R. H. to 90% R. H. was no more than .0045% and temperature coefficient of expansion was approximately .0086%.

Example 2

Sheets of material were prepared according to the method of Example 1, utilizing similar glass yarn provided with a starch-oil size and a spacing between strands of approximately .125 inch. Similar results were obtained except that the dimensional stability of the material was not as great as the material prepared in accordance with Example 1.

Example 3

The glass yarn of Example 2 was provided with vinyl groups attached to the surface of the glass monofilaments by first heat-treating the yarn to remove the starch-oil size and then treating with vinyl trichlorosilane and then with water to hydrolyze the vinyl trichlorosilane to form vinyl siloxane. Such yarn was utilized to prepare sheets of material 6" x 12" and 15" x 15", using aluminum plates as in Example 1 and also using glass plates in place of aluminum plates. Sheets prepared in this manner were translucent or even almost transparent and had dimensional stability characteristics equal to or better than sheets prepared in accordance with Example 1.

As shown in the drawings and discussed in the above description, the invention relates to a sheet comprising glass monofilaments imbedded in synthetic resin wherein at least substantially each of said monofilaments extends from an edge of the sheet to another edge of said sheet. It is not necessary that each monofilament be exactly parallel to every other monofilament in a layer but it is generally sufficient if every monofilament in each layer is at least within about 3° of the mean axis of all monofilaments in the layer.

Such material is also disclosed in co-pending application Serial No. 317,072, filed October 27, 1952, by Luther L. Yaeger.

It is clear that certain variations and modifications may be made within the scope and essence of the invention and it is our intention to cover such equivalent structures and articles

Having thus disclosed our invention, we claim:

1. A translucent sheet for reproduction purposes comprising synthetic resin having imbedded therein two planar layers of glass monofilaments, said monofilaments being substantially parallel to one another, the axes of monofilaments in one of said layers being disposed at an angle to the axes of said monofilaments in the other of said layers, substantially each of said monofilaments extending substantially from an edge of said sheet to another edge of said sheet, said synthetic resin having been polymerized while said monofilaments were maintained under tension further characterized by said synthetic resin being a flexible thermosetting synthetic resin and by the index of refraction of the glass in said monofilaments

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being at least approximately equal to the index of refraction of said synthetic resin.

2. A translucent sheet comprising synthetic resin having imbedded therein two planar layers of glass monofilaments said monofilaments being substantially parallel to one another, the monofilaments in each layer substantially having their axes in the same plane, the axes of monofilaments in one of said layers being disposed at an angle to the axes of said monofilaments in the other of said layers, substantially each of said monofilaments extending substantially from an edge of said sheet to another edge of said sheet, characterized by said synthetic resin having been polymerized while said monofilaments were maintained under tension and by being adapted to be a base for graphic reproduction and further characterized by the indices of refraction of said glass and said synthetic resin being so nearly the same that said monofilaments cannot be identified by a camera operated at an exposure normally used in reproducing graphic material appearing on a surface of said sheet and also by the polymerization of said synthetic resin in the presence of vinyl-silicon radicals attached to the surface of said monofilaments.

3. A translucent sheet for reproduction purposes comprising synthetic resin having imbedded therein glass monofilaments, two planar layers of said monofilaments, said monofilaments being substantially parallel to one another, the monofilaments in each layer substantially having their axes in the same plane, the axes of monofilaments in one of said layers being disposed at an angle to the axes of said monofilaments in the other of said layers, substantially each of said monofilaments extending substantially from an edge of said sheet to another edge of said sheet, characterized by said synthetic resin having been polymerized while said monofilaments were maintained under tension and by being adapted to be a base for graphic reproduction and further characterized by smooth non-wavy surfaces of said sheet and by said synthetic resin being a flexible thermosetting synthetic resin and by the index of refraction of the glass in said monofilaments being at least approximately equal to the index of refraction of said synthetic resin and by possessing the characteristics of such a sheet in which said synthetic resin is chemically attached to said glass monofilaments through an addition bond provided by a vinyl-silicon radical attached to the surface of said glass monofilaments.

4. A translucent sheet of material characterized by being adapted to serve as a cartographic base, comprising a transparent synthetic resin having imbedded therein glass monofilaments, two planar layers of said monofilaments, said monofilaments being substantially parallel to one another, the monofilaments in each of said layers having their axes in the same plane, each of said planes being parallel to surfaces of said sheet, the axes of the monofilaments in one of said layers being disposed at an angle to the axes of the said monofilaments in the other of said layers, substantially each of said monofilaments extending from an edge of said sheet to another edge of said sheet, characterized by said synthetic resin having been polymerized while said monofilaments were maintained under tension and further characterized by the indices of refraction of said glass and said synthetic resin being so nearly the same that said monofilaments cannot be identified by a camera operated at an exposure normally used in reproducing graphic material appearing on a surface of said sheet.

References Cited in the file of this patent

UNITED STATES PATENTS

2,015,006	Ekisler	Sept. 17, 1935
2,131,024	Cordts	Sept. 27, 1938
2,311,613	Slayter	Feb. 16, 1943

(Other references on following page)

UNITED STATES PATENTS

2,322,771	Palm et al. -----	June 29, 1943
2,354,110	Ford et al. -----	July 18, 1944
2,420,912	Hurd -----	May 20, 1947
2,428,654	Collins -----	Oct. 7, 1947
2,563,288	Steinman -----	Aug. 7, 1951
2,574,221	Modigliani -----	Nov. 6, 1951
2,631,957	Francis -----	Mar. 17, 1953

OTHER REFERENCES

"Glass Fibre Laminates in Cartography" by E. W. Jackson, published in British Plastics, June 1950, pages 272-280.

"Vinyl Silane Size for Glass Fabric" by J. Bjorksten and L. L. Yeager, Modern Plastics, vol. 29, July 1952, pp. 124 and 188.