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E. H. GROSS ET AL.
FLEXIBLE FIBER COMPOSITION

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Fig. 1.

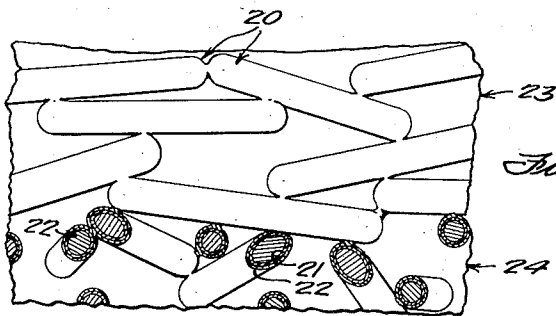
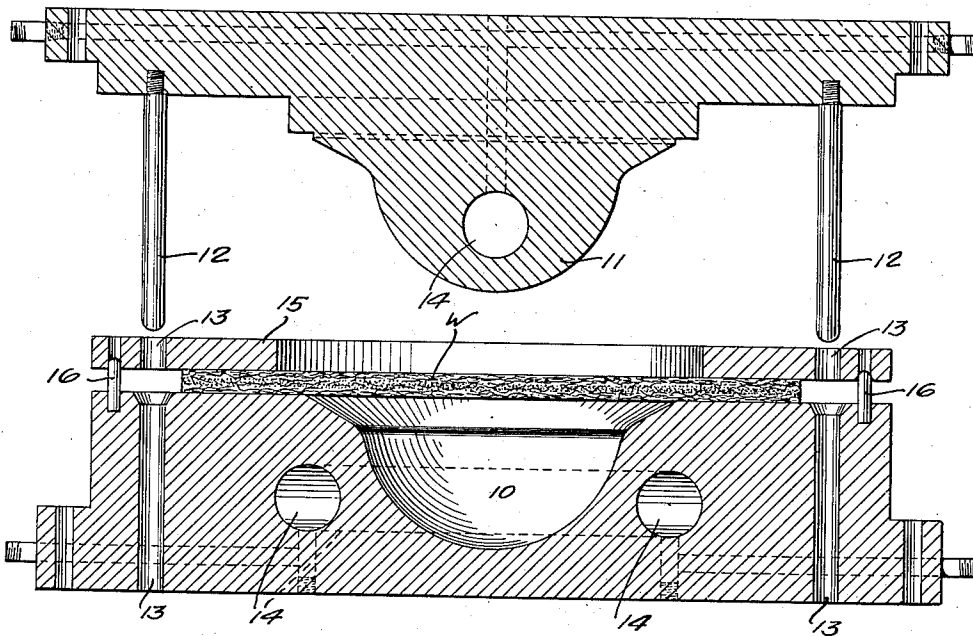
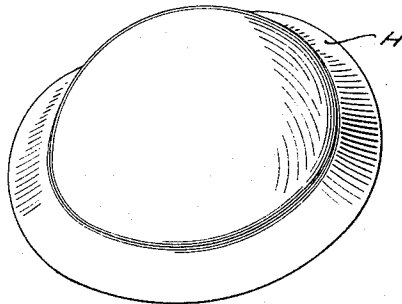


Fig. 3.

Fig. 2.



INVENTORS
EDWARD H. GROSS
BY ALBERT J. HANLEY
Attorney

UNITED STATES PATENT OFFICE

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FLEXIBLE FIBER COMPOSITION

Edward H. Gross, West Hartford, Conn., and Albert J. Hanley, Edgewood, R. I., assignors to Bakelite Corporation, New York, N. Y., a corporation of New Jersey, and Respro Inc., Cranston, R. I., a corporation of Rhode Island

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13 Claims. (Cl. 18—56)

This invention relates to moldable fibrous compositions including resinous binders that are intended for hot-press molding into shapes requiring flow or extensibility of the compositions during molding and to the manufacture of such compositions.

For imparting strength and shock resistance to moldable compositions including resinous binders it is customary to include fibrous materials as fillers. These fall into two distinct types: (1) wood flour or other finely divided materials and (2) continuous water-laid fibrous sheets as paper or woven fabric as duck, canvas, etc. The wood flour compositions are characterized by flow during a molding operation and accordingly are moldable into any configuration or complex shape; but articles molded therefrom have tensile and impact strengths which are insufficient for many uses that molded articles could otherwise satisfy. On the other hand articles made from continuous sheet compositions are generally high in strength and shock resistance; but the compositions have no give or extensibility and therefore can only be molded under simple compression into plates and tubes. Each type accordingly is seriously deficient from the point of view of combining moldability requiring substantial flow with high strength values.

It is known that the high strength values of continuous sheet compositions depend upon the incorporation of long or overlapping fibers whereby the strength of the fibers is transferred to the continuous sheets, and the present invention makes use of this fact by incorporating such fibers. But, unlike paper and woven fabric compositions heretofore used, the compositions of the present invention possess extensibility, i. e. they have the flow requisite for molding under the action of a force or plunger into widely varying shapes other than flat plates or tubes; at the same time the products molded therefrom have a surprisingly unexpected strength and resistance to shock approaching or even superior to compositions made from woven canvas fabric. The invention rests on the discovery that fiber textiles that are of flimsy or of dimensionally unstable character, and preferably so unstable as to necessitate support and some means for preserving the textile formation during the incorporation of a binder, have the property of flow necessary to a molding operation and retain this flow subsequent to the application of the binder.

The textile structure is produced by causing

a series of garnets or cards to severally lay fibrous slivers upon a moving carrier belt. The fiber laps that are fed to the cards can be waste materials of any fibrous nature as cotton, etc., and any mixture thereof; this waste, for example, can be the accumulation of by-products of fiber textile operations such as is obtained from combings, or processed stock produced from shearings, spool ends, and various other normal wastes in woven textile mills. The fibers can be individual, as in the case of comber waste, or they can be fibrous elements as threads from spool ends or rag cuttings. In place of waste fibers there can be used coarse and cheaper base fibers such as hemp, jute or sisal. New cotton can be used, and economies result from the elimination of spinning and of weaving into a fabric. Not only can spinnable fibers be used, but fibers ordinarily considered too short for spinning can be incorporated or blended in producing the sliver for this purpose.

In making the wadding the cards can be placed in such a manner that the traveling apron accumulating the slivers of the series can travel with relation to the cards so as to position the fibers in any predetermined manner, that is, the fibers can be laid with the predominating quantity end to end in the direction of the length of the structure, across the structure, or at any angle between these two extremes. To this end, for example, approximately one-quarter of the fiber can be placed the length of the goods, one-quarter across the goods and one-quarter each in the direction of 45° to the length and breadth of the material.

According to the present invention the textile structure or wadding is preliminarily treated with an adhesive of an elastic and a resilient type so that in a subsequent treatment with a resinous binder a sheet is produced in which the resin is not in physical contact with the fiber itself but is separated by a thin film of the elastic adhesive. This provides a cushioning effect between the fiber and the resin and embrittlement of the fibers by the binder is thereby found to be avoided.

The preliminary treatment of the wadding with the adhesive can be accomplished by passing between two permeable supporting belts through a solution; these belts are maintained under high tension to press the loose fibers and hold them fixed during their immersion and traverse through the solution. When viscous adhesives are used saturation or impregnation

can be obtained by running the wadding through a pair of steel rolls which force the adhesive into the wadding. The impregnated wadding is then dried to remove any solvent or volatile that may be present in the adhesive; if the adhesive has been applied in a fused condition, cooling may be all that is required. The saturated wadding can then be pressed if desired in order to reduce its bulk; this is generally preferred in order to reduce the bulk factor which is very high in a textile structure of this nature. For example, the wadding can be treated with a vulcanizable rubber solution in naphtha and impregnation accomplished by passing between a pair of steel rolls to force the adhesives through the wadding and cause formation of thin films about the fiber or textile elements; the wadding is then dried as by drawing air through it, and compressed by passing through calendering rolls. A compact mass of fibers individually surrounded by thin films of elastic rubber is thus obtained and the fibers are held together at their points of contact by adjacent fibers and by the adhesive. The points of contact, however, form but a small part of the fiber length and the sheet is very porous with relatively large air spaces. Because of this porosity it is possible to subsequently incorporate relatively large quantities of a resin binder.

When rubber is the adhesive, it is semi-cured by heat during the drying operation. About 33 per cent of the total weight is found to be the optimum amount of rubber included for best results though the proportions can be varied. In the pressing operation the bulk is reduced to about one-half, and by so doing the tensile strength of the sheet is increased from about 10 pounds per inch in width to about 45 to 48 pounds.

Types of adhesives other than rubber and which possess elastic properties can be substituted with equivalent results. Such adhesives include artificial rubber, rubber substitutes and thermo-plastic materials with rubber-like properties as the vinyl resins.

The sheet of compressed wadding, having the adhesive incorporated therein, is treated with a resinous binder of a fusible nature, and the resinous binder is readily applied by running the wadding through a solution of the resin and then between scrapper bars or squeeze rolls to regulate the quantity of resin in the wadding. It has been found that the preliminary treatment with adhesives such as rubber, sufficiently stations or fixes the fibers with relation to each other so as to withstand saturation with the resin, provided any solvent in the resin is not likewise a solvent for the adhesive. The porous nature of the wadding permits it to absorb a high quantity of resin with a uniform distribution throughout its structure with the result that a resin film forms about the individual fibers or fibrous elements previously treated and coated with the adhesive. The wadding sheet is then subjected to drying to remove any volatile present in the resinous binder.

The character of the fusible resin used in this process can vary over a wide scope; and it is necessary only that the resin become sufficiently fluid, either by heating or by placing it in solution, so as to have at least no more than a dough-like consistency during the saturating step and also that in a molding operation it fuses or flows sufficiently under the action of heat or pressure to permit extensibility of the wadding. It is more usual for the solutions to be quite fluid

and have a consistency somewhat similar to that of cream; but the application is not restricted in its viscosity requirements, and solutions as thin as water can be readily used without disruption of the wadding to yield uniformly saturated sheets. Nor is the invention dependent on the type of resins used; the resins can be thermoplastic as well as thermosetting in nature, though thermosetting phenol-formaldehyde resins are preferred on account of the properties contributed by them.

For best results a wadding with about 40 per cent by weight of resin is preferred; this is found to give adequate distribution of the resin in the molded article. Lower proportions of resin can, however, be used. In a wadding ready for molding, therefore, the optimum proportions by weight are about 33 per cent of rubber and 40 per cent of resin.

The subsequent drying operation need not depart from standard practice. There is this advantage, however, that because of the permeability air can be blown or drawn through the wadding. The resin upon drying or solidifying tends to lock the fibers more or less in the compressed form.

In the impregnated compositions the fibrous elements are not fixedly positioned to one another, but instead under the action of normal molding conditions become very mobile and flow very readily while maintaining their approximate positioning with regard to one another. The textile sheets of this invention have been found to flow with such ease and accuracy during molding that deep-drawn articles can be molded from flat sheets without any preforming or preliminary packing into a mold; and the molded products therefrom are free from unsightly breaks and jagged pieces of fabric, being uniform and free from stress or strain marks. Apparently in the molding operation the fibers have increased mobility due to the rubber coatings. This property is strikingly demonstrated in the molding of head coverings such as safety helmets or caps worn by mine and construction workers. Helmets produced heretofore from resin-treated woven canvas have frequently shown broken and torn sections particularly in the crown where it is subject to stretch in the molding operation. Where the fabric is torn the helmet is naturally weak as the resin in such areas lacks the beneficial reinforcing of the cotton fibers. The flow characteristics of this new material on the other hand are such that the fibers are equally distributed over the entire area and there is freedom from any tears; the strength over the entire area is substantially uniform.

According to reasonable expectations articles molded from wadding containing resins should be rigid or have but little flexibility. Surprisingly, however, articles molded from the compositions of this invention show remarkable flexibility and freedom from brittleness and thereby combine the desirable properties of resin-bonded structures with those of vulcanized rubber structures. In sheet form they possess high tensile strength, high water resistance, and good electrical properties; and they may be punched, cut, machined or otherwise operated upon.

In the accompanying drawing there is illustrated by way of example an article molded from the composition of the present invention in which

Fig. 1 is a cross-section of a mold for making helmets;

Fig. 2 is a perspective view of a molded helmet; and

Fig. 3 is an enlarged cross-section of an impregnated wadding.

A mold for a helmet H shown in Fig. 2 comprises a cavity mold 10 and a force or plunger 11 both having a configuration corresponding to the helmet. To guide the plunger pins 12 thereon engage openings 13 of the mold. The mold sections are provided with heating channels 14. The sheet W of material to be molded is located between the cavity mold and the plunger, and the assembly is then placed between the platens of a press whereby pressure is applied to the plunger.

In order to maintain the material being molded under tension there is provided a rim plate 15 of sufficient weight to give the tension required. With the wadding of the present invention no plate is necessary, but it is desirable for holding the sheet in place and for assuring against uneven distribution. It should not, however, be of such weight as to cause breakage of the sheet for the sheet distributes itself with uniformity upon entering the mold cavity without tearing. The rim plate is held in position by dowels 16.

The wadding W is diagrammatically illustrated in Fig. 3 on an enlarged scale to show the disposition of the fibers 20 with the adhesive coating 21 and the resin coating 22 in approximate layers 23, 24 extending in different directions and obtained by the placing of the slivers from the carding machine. The enlargement of Fig. 3 is intended to show the fibers 20 and coatings 21.

Molded helmets are tested by dropping a heavy weight on the crown and noting the height required to cause failure. In order to obtain comparative test figures, bowls of the approximate shape of helmets and about 3 inches in diameter were molded, one set from the wadding of this invention and another set from canvas impregnated with resin as used in helmet manufacture. The bowls were subjected to the Olsen repeated impact test in which a weight of about 1 pound was raised $\frac{1}{2}$ inch for each successive blow and dropped on the bottoms of the inverted bowls until failure occurred. The data obtained, when reduced to bowls of the same thickness of .075 inch, gave an average height in inches to produce failure in the canvas bowls of 31.2 inches and in the bowls molded from the wadding of this invention a height of 36.6 inches. Helmets molded from the wadding have shown a similar superiority over helmets molded from canvas, though actual comparative test figures are not available.

Sheet waddings impregnated with adhesive, preferably rubber, and further impregnated with resin as set out in the foregoing, find utility in widely varying articles. The surprising flexibility and freedom from brittleness of the material in molded form make it particularly desirable for punching stock; and the excellent electrical properties enhance its value for this purpose and insulating parts generally. The electrical properties have been found to be definitely superior, and this is apparently due to the fact that the fibers lie parallel to the surfaces and do not extend toward the surfaces as in woven or paper fabrics.

The impregnated waddings can have other constituents added such as pigments and other loading substances; among such substances are molding material fines or powder obtained by grind-

ing a blended composition of wood flour and heat-reactive resin. They can also be combined with other sheet materials and particularly rubber sheets which are elastic and therefore do not interfere with the moldable properties.

The molding operation follows the usual practice. In general pressures of about 2000 pounds per square inch are used and the mold parts are heated to about 300° F. The molding period is about six minutes during which the resin fuses and then sets, if thermosetting in nature, to form an infusible binder. The rubber adhesive is more or less cured at the same time.

What is claimed is:

1. Article molded under the action of heat and pressure involving internal displacement of a composition comprising in combination a continuous sheet structure of overlapping fibrous elements substantially parallel to the sheet surface and laid as dry non-felted slivers and in unstable dimensional relation with each other, an adhesive applied to the fibrous elements, and a binder for the structure comprising a fusible type of resin.
2. Article according to claim 1 in which the sheet structure comprises fibrous slivers positioned in a predetermined manner.
3. Article according to claim 1 in which the adhesive is rubber.
4. Head covering molded from a composition of a continuous sheet structure of overlapping fibrous elements substantially parallel to the sheet surface and laid as dry non-felted slivers and in unstable dimensional relation with each other, an adhesive applied to the fibrous elements, and an impregnant for the structure comprising a fusible type of resin.
5. Moldable composition comprising in combination a continuous sheet structure of overlapping fibrous elements substantially parallel to the sheet surface and laid as dry non-felted slivers and in unstable dimensional relation with each other, an adhesive applied to the fibrous elements, and a binder for the structure comprising a fusible type of resin, said composition being moldable into shapes involving substantial dimensional flow between the fibrous elements.
6. Moldable composition according to claim 5 in which the sheet structure comprises fibrous slivers positioned in a predetermined manner.
7. Moldable composition according to claim 5 in which the adhesive is rubber.
8. Method of molding articles which comprises forming a wadding by laying slivers of fibrous elements into a sheet structure with the elements substantially parallel to the sheet surface, supporting the structure between belts to fixedly hold the fibrous elements, passing the assembly of belts and structure through a bath of an adhesive, impregnating the structure with a fusible type of resin, and subjecting the composition so formed to a molding operation.
9. Method of preparing a moldable composition which comprises forming a wadding by laying slivers of fibrous elements into a sheet structure with the elements substantially parallel to sheet surface, applying an adhesive to the structure, and impregnating the structure with a fusible type of resin.
10. Moldable composition comprising in combination a continuous sheet structure of overlapping cotton fiber elements substantially parallel to the sheet surface and laid as dry non-felted slivers and in unstable dimensional relation with each other, an adhesive applied to the

fibrous elements, and a binder for the structure comprising a fusible type of resin, said composition being moldable into shapes involving substantial dimensional flow between the fibrous elements.

11. Moldable composition comprising in combination a continuous sheet structure of overlapping fibrous thread elements substantially parallel to the sheet surface and laid as dry non-felted slivers and in unstable dimensional relation with each other, an adhesive applied to the fibrous elements, and a binder for the structure comprising a fusible type of resin, said composition being moldable into shape involving substantial dimensional flow between the fibrous elements.

12. Moldable composition comprising in combination a continuous sheet structure of overlapping cotton fiber elements substantially parallel to the sheet surface and laid as dry non-

felted slivers and in unstable dimensional relation with each other, an adhesive applied to the fibrous elements, and a binder for the structure comprising a fusible type of thermosetting resin, said composition being moldable into shapes involving substantial dimensional flow between the fibrous elements.

13. Moldable composition comprising in combination a continuous sheet structure of overlapping cotton fiber elements substantially parallel to the sheet surface and laid as dry non-felted slivers and in unstable dimensional relation with each other, an adhesive applied to the fibrous elements, and a binder for the structure comprising a fusible type of thermoplastic resin, said composition being moldable into shapes involving substantial dimensional flow between the fibrous elements.

EDWARD H. GROSS.
ALBERT J. HANLEY.