Dec. 14, 1948. J. C. MacKINNON ET AL 2,456,005

AIRCRAFT STRUCTURAL MATERIAL AND METHOD OF MAKING THE SAME

Filed Sept. 27, 1943

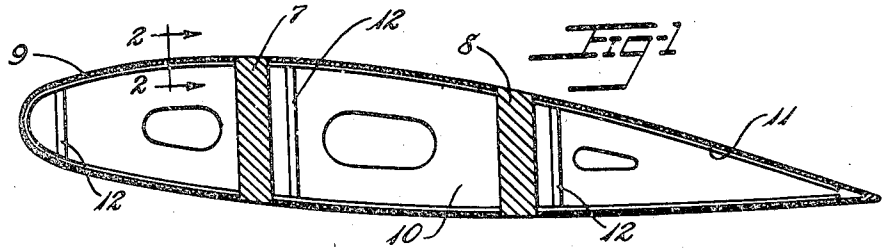


Fig-1

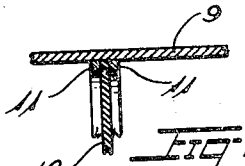


Fig-2

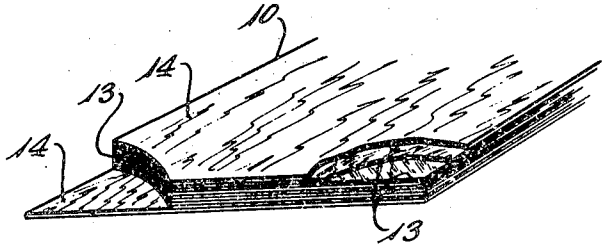


Fig-3

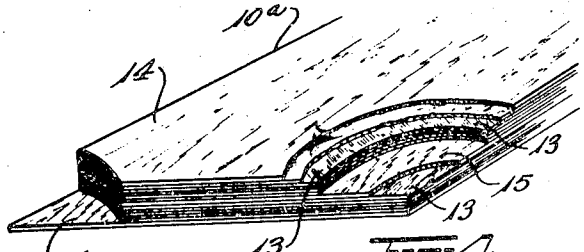


Fig-4

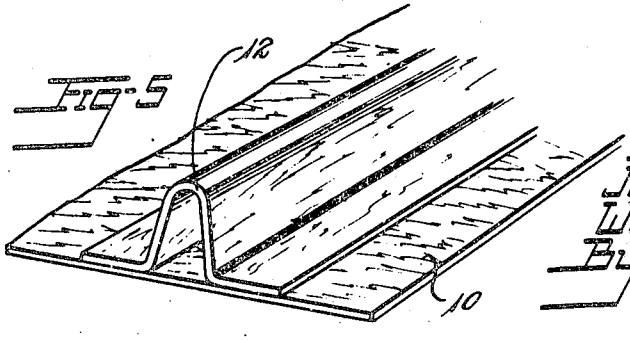


Fig-5

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AIRCRAFT STRUCTURAL MATERIAL AND METHOD OF MAKING THE SAME

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Application September 27, 1943, Serial No. 504,016

7 Claims. (Cl. 154—132)

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This invention relates to composite products comprising wood veneer material, fibers, and molded resins, and to methods of making such products, and is particularly concerned with the production of high strength, low weight materials especially adapted for use in certain aircraft structures and for other purposes.

In producing our composite products, we utilize three basic materials: thin wood veneer sheets, fiber sheets, and heat-moldable resins.

The wood veneer material preferably utilized in our invention is not the usual relatively thick sheet material employed in conventional plywood structures. According to Perry's "Modern Plywood" (1942), the customary thickness of wood veneer material is from 1/40" to 1/4" (page 98). In contrast to this relatively great thickness, we preferably utilize wood veneer sheets only .01" thick, this being the thinnest sheet obtainable commercially (Perry, page 106), variations up to .02" being contemplated, however, by references herein to wood veneer material of the order of .01" thick. Any wood material obtainable in such very thin sheet form may be used. African mahogany is especially satisfactory and spruce also gives good results.

The fibrous material utilized in the invention preferably comprises any suitable strength-giving fibers arranged in substantially parallel unwoven relation in tenuous web form. It is possible to use fibers of cotton, wool, flax, ramie, pineapple and the like, and even silk fibers and rayon or nylon flock, although some difficulty may be experienced in handling the silk and especially the artificial silk fibers because of their smooth surface characteristics. Because of its cheapness, ready availability, and twisted fibrous structure, cotton is most satisfactory and is generally to be preferred.

The cotton fibers may be arranged in tenuous web form in any known manner. Preferably, however, they are carded and then drawn and spread sidewise to produce an extremely tenuous web in which the fibers are laid in parallel relation. For use in the present invention, such drawing and spreading preferably should be continued until the fibrous web weighs not more than from about 0.3 to about 1 ounce per square yard. For best all-round results, the tenuity of the sheet should be substantially that represented by a weight of about ½ ounce per square yard.

The resin utilized may be any appropriate heat-moldable resin, including both thermo-plastic and thermo-setting types of resins. For most purposes, however, and especially for aircraft structures, it will be preferable to use a thermo-setting resin such as the phenol-formaldehyde resin sold as Resinox No. 790, as this particular resin is exceedingly tough and highly water resistant. Other phenol-aldehyde resins may be used and urea-aldehyde resins also are quite satisfactory in applications where their somewhat lower water resistance will not be detrimental. The melamine resins likewise will be found satisfactory in many instances. All such resins may be suspended in water, alcohol, or other appropriate solvent or dispersion medium for application to the fibers and wood veneer material as hereinafter described.

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In making the composite product of this invention the tenuous cotton web is impregnated with the resin in liquid form, the excess being removed by pressing, and then dried. Extensive experimentation has shown that best results are attained when about an equal weight of resin is associated with the cotton web so that the resin-impregnated web desirably should weigh not more than 2 ounces per square yard, although it is permissible in some cases to increase the total weight of the impregnated web to as much as 2½ ounces per square yard. Best results are secured when a fibrous web weighing about ½ ounce per square yard is evenly impregnated with about ½ ounce of resin to the square yard to produce a total weight of about 1 ounce per square yard in the impregnated sheet.

Next, a thin film coating of the same resin or one cohesively compatible therewith is applied to one face of each of two sheets of thin wood veneer material, the coating being dried as in the case of the cotton web.

Several plies of the resin-impregnated tenuous web then are plied up and the two wood veneer sheets are placed on the outer faces of the plied assembly with the resin-treated faces of the wood in contact with the resin-impregnated tenuous webs. It is also possible, especially in making thicker sheet materials, to insert one or more plies of wood veneer material between the cotton webs, the wood in this case preferably being coated on both faces and thoroughly saturated with the resin.

In either case the assembled structure is subjected to molding heat and pressure to integrate the structure and set the resin. The assembly should be molded under sufficient pressure to force the resin substantially into the wood structure of the face sheets but the pressure should not be sufficient to cause the resin to flow entirely through the wood. Consequently, the out-

er faces of the wood veneer sheets remain free of resin in the finished products.

In a typical case utilizing Resinox No. 790 resin and .01" African mahogany wood veneer, the assembly may be subjected to a pressure of about 60 lbs. per square inch and a temperature of approximately 300° F. for 20 minutes to bring about the desired results. Using these and similar materials, the pressure should not in any case be greater than about 75 lbs. per square inch, this being substantially lower than conventional molding pressures which normally range from 300 lbs. to 1,000 lbs. per square inch.

After molding, the material preferably should be allowed to cool in the press for some 15 minutes after which the pressure may be released and the finished sheet material removed from the press.

In the present products the fibrous webs are utilized in a quantity sufficient to impart to the structure tensile strength in the aggregate usually exceeding and always at least substantially equalling the tensile strength imparted by the wood veneer material in the aggregate.

It will be understood that the various plies of cotton fiber and of wood veneer material may be assembled with all the grains running in the same direction in order to concentrate the strength in that direction or some or all the plies of these materials may be oriented at the same or varying angles to each other in order to distribute the strength in various directions. Also, more than a single ply of wood veneer may be used in the surface section and the number of plies in the core section may be varied widely. In making large sheets, the plies both of cotton and of wood may be lapped at the joints, the resulting irregularity being adequately taken up during the molding operation.

The accompanying drawings illustrate typical applications of the principles hereinabove described.

Of the drawings,

Fig. 1 is a sectional elevation showing an aircraft wing structure of the "tension field" type embodying the material of the present invention in the web or bulk-head member.

Fig. 2 is a vertical section taken on line 2—2 of Fig. 1.

Fig. 3 is a fragmentary perspective view partially broken away and sectioned for clarity of illustration and showing a typical material of the present invention in a preliminary state, the constituent plies being assembled ready for the heat-molding operation.

Fig. 4 is a similar view illustrating a modified structure embodying the invention.

Fig. 5 is a fragmentary perspective view showing a stiffened structural member embodying material of the invention molded in irregular "hat-section" form in combination with plain sheet material embodying the invention.

Fig. 1 illustrates a typical use of the present material in the so-called "tension-field" type of aircraft wing structure. Such a structure usually comprises a leading spar 7, and a trailing spar 8, forming the backbone of the wing structure. About this backbone is fashioned a skin surface 9 contoured to function as a supporting air foil. The structure is strengthened at intervals along the length of the wing by interior webs on bulkhead-like structures which aid in resisting the crushing load of air pressures during flight, the term "tension field web material" having reference to these bulkhead-like members.

Thus, in the structure illustrated, a web sheet of the present material 10 cut to appropriate shape and provided with the usual apertures for inspection purposes is mounted somewhat like a bulkhead inside the wing structure, the edges of the material being glued to the skin surface 9 by means of any appropriate wood adhesive and the joint being reinforced by cap strips 11—11 or the like glued to the wing structure and to the web material 10. Hat sections 12, 12, hereinafter more fully described may be provided where required by stress conditions.

Appropriate material 10 for such "tension field web" use, as illustrated in Fig. 3, may comprise seven core plies 13—13 of tenuous cotton web material and two surface plies of thin wood veneer material 14—14, the several plies being treated and molded in the manner hereinabove described in greater detail. Using .01" wood veneer and cotton webs weighing about ½ ounce per square yard, such a combination of materials will produce a final molded product about 0.03" thick. Notwithstanding its thinness, this material has sufficient strength to perform effectively as the "tension field web" of aircraft wings.

An alternative structure 10*a*, especially adapted for somewhat thicker composite materials, is shown in Fig. 4 and comprises a central core ply 15 of thin wood veneer material thoroughly impregnated with resin and interposed between tenuous cotton web plies 13—13 disposed 5 plies on either side of the central wood ply, together with single thin wood veneer plies 14—14 on each outer face.

In general, "tension field web" material will include from 5 to 15 plies of cotton web material in conjunction with two or more surface plies of wood veneer material. Substantially greater thicknesses of material may be built up where required by multiplying the number of plies of either or both the cotton and the wood veneer material.

The composite material 10 or 10*a* may be molded in irregular shapes such as the hat section 12 shown in Fig. 5, the hat section being glued to a flat sheet 10 of similar material, or to other appropriate material, to form a stiffened sheet structure for use in aircraft as illustrated in Fig. 1. Such hat sections are molded in a variety of shapes and contours.

Authough especially useful in the "tension field" type of aircraft wing structures, the present materials are finding wide application in other portions of aircraft and particularly as hat sections, flooring, and bearing plates. It will likewise be understood that the material is useful in a wide variety of other applications outside the aircraft field, including vehicles used in other forms of transportation, as well as articles for personal use such as luggage and for interior finishes in buildings.

Numerous modifications and variations may be effected in details of the procedures, materials, and structures hereinabove described without departing from the spirit and scope of the invention. For example, one of the face sheets of wood veneer material may be replaced by other types of material or omitted entirely. An especially promising adaptation of the invention resides in retaining one face of the sheet free of resin as described, while saturating the opposite face, whether with or without veneer, and molding it with a knurled or non-skid impression to provide a non-skid surface useful as flooring. In such structures, as well as in certain other modified

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structures, the wood veneer sheets will be somewhat thicker than the preferred extremely thin sheets hereinabove described. The invention accordingly is not to be limited except as specifically indicated in the appended claims.

We claim:

1. A heat-molded composite product comprising a core section including a plurality of tenuous fiber plies each comprising unwoven fibers arranged in parallel relationship and in such tenuity as to constitute an unimpregnated fibrous sheet weighing not more than about one ounce per square yard; a surface layer comprising a sheet of wood veneer material of the order of .01 inch thick; and a monolithic mass of thermo-set resin bonding the fibers and wood into a unitary integral structure, the resin mass permeating and enveloping completely the entire core section including the tenuous fiber webs but extending only partially into the structure of the wood veneer surface layer, the outer exposed face of the wood veneer being free of the resin, the unwoven fiber webs being present in sufficient quantity to impart to the composite structure tensile strength in the aggregate at least substantially equalling that imparted by the wood veneer material in the aggregate.

2. A heat-molded composite product comprising a core section including a plurality of tenuous fiber plies each comprising unwoven cotton fibers arranged in parallel relationship and in such tenuity as to constitute an unimpregnated fibrous sheet weighing not more than about one ounce per square yard; a surface layer on each face of the core section, each comprising a sheet of wood veneer material of the order of .01 inch thick; and a monolithic mass of heat-molded resin bonding the fibers and wood into a unitary integral structure, the resin mass permeating and enveloping completely the entire core section including the tenuous fiber webs but extending only partially into the structure of the wood veneer surface layers, the outer exposed faces of the wood veneer being free of the resin, the unwoven fiber webs being present in sufficient quantity to impart to the composite structure tensile strength in the aggregate at least substantially equalling that imparted by the wood veneer material in the aggregate.

3. A heat-molded composite product comprising a core section including at least one ply of wood veneer material and a plurality of tenuous fiber plies each comprising unwoven cotton fibers arranged in parallel relationship and in such tenuity as to constitute an unimpregnated fibrous sheet weighing not more than about one ounce per square yard, the wood veneer ply being interposed between plies of the tenuous fiber webs; a surface layer comprising a sheet of wood veneer material of the order of .01 inch thick; and a monolithic mass of heat-molded resin bonding the fibers and wood into a unitary integral structure, the resin mass permeating and enveloping completely all the several plies comprising the core section but extending only partially into the structure of the wood veneer surface layer, the outer exposed face of the wood veneer being free of the resin, the unwoven fiber webs being present in sufficient quantity to impart to the composite structure tensile strength in the aggregate at least substantially equalling that imparted by the wood veneer material in the aggregate.

4. Aircraft "tension-field web material" of the order of a few hundredths of an inch thick and comprising a heat-molded sheet product comprising a core section containing from 5 to 15 plies of tenuous fiber webs each comprising cotton fibers arranged in such tenuity as to constitute an unimpregnated web weighing not more than about one ounce per square yard; surface layers each comprising a single sheet of wood veneer material of the order of .01 inch thick and a monolithic mass of heat-molded resin bonding the fibers and wood into a unitary integral structure, the resin mass permeating and enveloping completely the tenuous fiber webs but extending only partially into the structure of the wood veneer surface layers, the outer exposed faces of the wood veneer being free of the resin, the unwoven fiber webs being present in sufficient quantity to impart to the composite structure tensile strength in the aggregate at least substantially equalling that imparted by the wood veneer material in the aggregate.

5. Aircraft "tension-field web material" of the order of a few hundredths of an inch thick and comprising a heat-molded sheet product comprising a core section containing at least one ply of wood veneer material and from 5 to 15 plies of tenuous fiber webs each comprising cotton fibers arranged in such tenuity as to constitute an unimpregnated web weighing not more than about one ounce per square yard; surface layers each comprising a single sheet of wood veneer material of the order of .01 inch thick; and a monolithic mass of heat-molded resin bonding the fibers and wood into a unitary integral structure, the resin mass permeating and enveloping completely the wood veneer and tenuous fiber webs in the core but extending only partially into the structure of the wood veneer surface layers, the outer exposed faces of the wood veneer being free of the resin, the unwoven fiber webs being present in sufficient quantity to impart to the composite structure tensile strength in the aggregate at least substantially equalling that imparted by the wood veneer material in the aggregate.

6. Structural material comprising a base member in sheet form and a stiffening member adhered thereto, at least one of said members comprising a heat-molded composite product comprising a core section including a plurality of plies comprising unwoven cotton fibers arranged in substantial parallelism in tenuous web form, a surface layer comprising a sheet of wood veneer material of the order of .01 inch thick, and a monolithic mass of heat-molded resin bonding the fibers and wood into a unitary integral structure, the resin mass permeating and enveloping completely the tenuous fiber webs but extending only partially into the structure of the wood veneer surface layer, the outer exposed face of the wood veneer being free of the resin, the unwoven fiber webs being present in sufficient quantity to impart to the composite structure tensile strength in the aggregate at least substantially equalling that imparted by the wood veneer material in the aggregate.

7. A method of making composite products which comprises carding cotton fibers, drawing and spreading the carded fibers to produce a tenuous web weighing not more than one ounce per square yard and in which the fibers are arranged in substantially parallel relation, treating the tenuous web with a thermo-setting resin, arranging several plies of the treated web in superposed relation together with a surface layer of wood veneer material of the order of .01 inch thick, and subjecting the assembly to heat and

pressure to integrate the structure and set the resin, the molding pressure being not greater than about 75 lbs., per square inch so that the resin is forced substantially into the wood veneer structure but not entirely through it, the exposed face of the wood being substantially free of resin when the molding operation is completed.

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WALTER R. HICKLER.

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Certificate of Correction

Patent No. 2,456,005. December 14, 1948.

JOHN C. MacKINNON ET AL.

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 3, line 71, for the words "webs on" read *webs or*; column 4, line 51, for "Authough" read *Although*; line 52, for "type" read *types*; column 6, line 7, after the word "thick" insert a semi-colon; column 7, line 3, after "75 lbs." strike out the comma;

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 22nd day of November, A. D. 1949.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.