Aug. 21, 1951 H. E. MALMSTROM 2,565,251

PLYWOOD PANEL

Filed April 30, 1948

Fig. 1

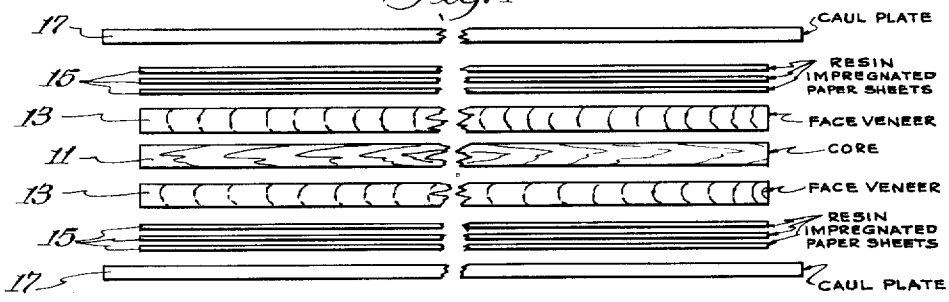


Fig. 2

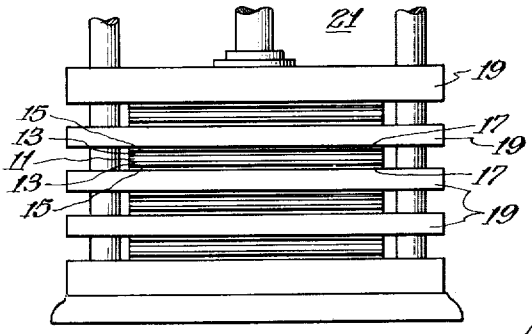


Fig. 3

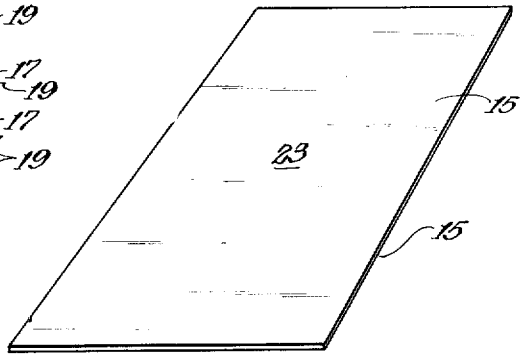
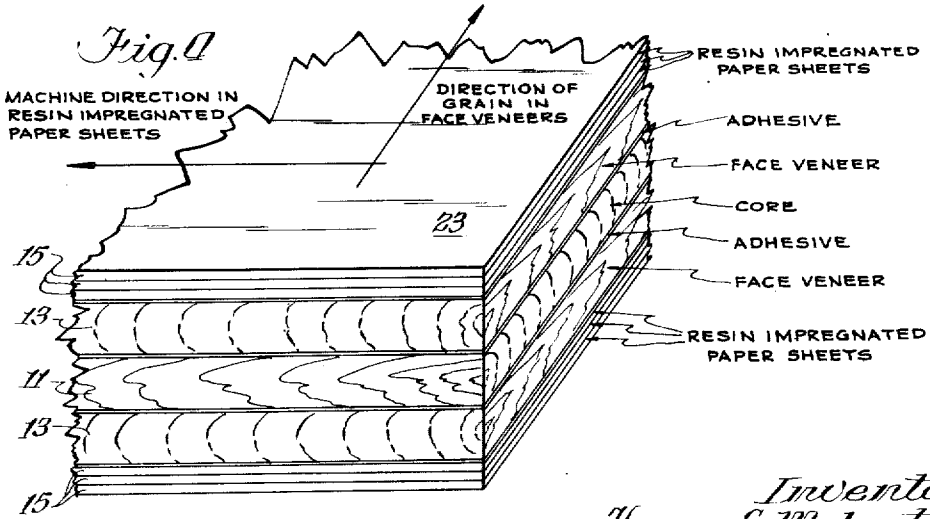


Fig. 4



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PLYWOOD PANEL

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4 Claims. (Cl. 154—45.9)

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The present invention relates generally to the manufacture of plywood which is provided on one or both faces thereof with a layer of plastic surfacing, and has for its principal object the improvement of the surface characteristics of certain types of such materials, and especially surfaced plywood having a core made from Douglas fir.

As is well known, large quantities of plywood are manufactured and used each year in the United States in the building trades and for other purposes, and a large proportion of this plywood is made from Douglas fir. This wood is available in certain areas in large stands of old trees which are several feet in diameter and which provide suitable logs from which veneer can be peeled, by the rotary cutting method, for use in the manufacture of plywood. Douglas fir, especially the peeler logs, are relatively free of knots, wind shakes and other defects which make peeling of some other species of logs difficult. In addition, Douglas fir plywood has the advantage of being relatively strong, easy to fabricate, and reasonably inexpensive.

Douglas fir plywood has, however, certain objectionable characteristics which make it less desirable than plywood made from some other species of woods, especially the hardwoods such as gum, poplar, birch, etc. One of these objectionable characteristics results from the fact that the surface of Douglas fir plywood is relatively soft and hence lacks wear-resistance and the ability to resist scuffing, marring and denting. Another serious objection to Douglas fir plywood, results from the fact that Douglas fir has alternate hard and soft grains, which have widely different densities and physical properties. This variation in the grain density produces appreciable dimensional changes across the grain of rotary-cut veneer as the moisture content is changed, and when the veneers are laminated into plywood, this manifests itself in the form of grain-raising and checking of the face veneers. Grain-raising prevents the obtaining of completely smooth surfaces and is very objectionable when the plywood is to be painted or finished with glossy paint or enamel.

Checking is evidenced by relatively short, hairline cracks which follow the grain direction of the wood, and these checks develop most rapidly when the face of the panel loses moisture. An explanation of the cause of checking in the face veneers of Douglas fir plywood panels is given in U. S. Patent No. 2,150,658, to Osgood. As pointed out in this patent, the shrinkage of wood during

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drying is many times greater in a direction perpendicular to the wood fibers than in a direction parallel to the fibers. Therefore, if a normal plywood panel is losing moisture, all veneers will be in a state of tension in the cross-fiber direction, and if this tension is sufficient, the veneers will break apart at any unbonded (or free) surface, thus developing checks. In this connection it should be noted that it is the cross-fiber relationship of the constituent plies of the panel which gives rise to the conditions producing checking.

The Osgood patent suggests that if the panel is bonded together with the constituent veneers at a sufficiently low moisture content (below about 5% by weight) no further loss of moisture will occur in any condition approaching normal use conditions. Thus, all veneers in the cross-fiber direction should be in a state of compression as the panel moisture increases, and checking should be minimized. However, this desirable result is not attained in practice, due to the occurrence of the phenomenon known as compression-set. When Douglas fir, and other woods, are maintained in a state of compression in the cross-grain direction over a period of time, a self-relief of stress occurs, this being known in the trade as compression-set. Thus, when the process of compression-set is complete, plywood veneers, although initially resistant to checking, will shrink upon loss of moisture and will again reach the state of tension which produces surface checking.

Checking is especially objectionable if the panels are to be used for walls, doors, or other architectural applications where the surface is to be painted or finished with a glossy paint or enamel. Refinishing over the cracks or checks may result in a temporary hiding of the defect but as soon as the surface veneer undergoes a subsequent loss of moisture, the checks will reappear or new ones will develop.

It is known that these difficulties can be overcome and that Douglas fir and other plywood panels having hard, wear and dent-resistant surfaces, which are resistant to checking, can be produced by covering the surface of the panel with a plastic film or overlay containing a high percentage of a thermoset resin. In the past, these high resin content surfacings have been produced by molding a high resin content laminate in a hot press and subsequently applying the molded laminate to the surface of plywood by a separate cold or hot gluing process, under the action of pressure. Surfaced plywood made

in this manner has been used for years in the production of plastic surfaced table tops, counters, and the like, and is considered a highly satisfactory product. It is, however, a relatively difficult product to manufacture, and is quite costly.

To overcome these disadvantages and to make possible the production of plastic-surfaced plywood at reasonable cost, it has been proposed to form the plastic surfacing directly on the plywood panel or on one or both of the face veneers used in manufacturing the panel. In carrying out this process, one or more sheets of paper containing an unreacted, thermosetting resin have been applied to and molded-on the panel or veneer surface, either as a separate process, or as an incident to the manufacture of the panel itself. Serious difficulties have been encountered, however, in the manufacture of satisfactory plastic surfacings by any of these direct surface-formation procedures.

In order to obtain a hard, dense surface which is resistant to wear and to marring and denting, it has been found necessary to provide a surfacing which contains a relatively high percentage of resin. In general, the wear resistance and the resistance to marring and to denting is improved in direct relation to the thickness of the plastic surfacing. A plastic surfacing of only a few thousandths of an inch shows appreciable improvement while surfacings having a thickness of from about fifteen to thirty thousandths of an inch give very hard, highly resistant surfaces. To obtain high resin content surfacings, high resin content sheets must be employed, and when high resin content sheets are used, and especially when thick overlays or surfacings are formed, the desired wear, mar and dent resistance is obtained, but the surface is subject to checking. In fact, the checking may be even worse in the case of thick surfacings formed by direct surfacing procedures than in the case of ordinary wood surface panels. This checking difficulty has caused the art to resort to the use of low resin content sheets (10 to 30% based on the weight of the fiber), see for example the process of Birmingham Patent No. 2,343,740. This procedure overcomes checking in the plastic surfacing or overlay, but it does not provide the hard, dense, wear and dent-resistant surface which is desired. Further, panels surfaced with low resin content surfacings are not weather-proof and must be painted when used outdoors.

The present invention is concerned particularly with the overcoming of the difficulties previously encountered in the provision of plastic surfacing by direct molding operations which involve the use of resin impregnated paper sheets containing a high percentage of an unreacted, thermosetting resin, as above described. The invention is based on the discovery that checking in plastic surfaced, plywood panels made of Douglas fir and similar woods can be controlled to a very large degree by the relative positioning of the sheet or sheets of resin impregnated paper used in creating the plastic surface on the underlying wood ply. More specifically, the invention includes the discovery that the resin impregnated paper should be applied to the underlying wood surface in such manner that the machine direction of the paper extends crosswise of the grain in the wood surface. When the resin impregnated paper and the wood are joined together in this relationship, it becomes possible to produce, by direct molding procedures, a dense, hard, wear and mar-resistant plastic surfacing, which is substantially free from checking during the useful life of the panel. It is important to note that this highly desirable and important result is obtained despite the fact that cross graining of the constituent plies of plywood is itself primarily responsible for surface checking of unsurfaced plywood, as above noted. In other words, the invention includes the discovery that the paper sheets used in providing the plastic surfacing should be positioned in the direction which normally produces checking in unsurfaced plywood.

An illustrative embodiment of the invention and one method of manufacturing plywood panels in accordance with the invention are illustrated in the accompanying drawings, wherein:

Figure 1 is a view showing the arrangement or lay-up of the component parts of a plywood panel prior to the placing of those parts in the plywood press;

Figure 2 illustrates the general features of a plywood press as used in the plywood industry. Figure 2 also shows the manner in which a plurality of the lay-ups or panel assemblies illustrated in Figure 1 may be placed in such a press;

Figure 3 is a perspective view illustrating a completed plywood panel which has been provided with a plastic surface by the use of plastic-impregnated sheet materials in accordance with the invention, and;

Figure 4 is a fragmentary, enlarged, perspective view of a portion of the panel illustrated in Figure 3.

In the manufacture of plastic-surfaced plywood panels, there are at least four general manufacturing methods which may be used. The oldest of these methods is usually referred to as the "laminate process" and has been previously described. This is the process wherein a plastic laminate, which may comprise a plurality of sheets of resin-impregnated paper, is molded in a hydraulic press under the action of heat and pressure to provide a cured plastic sheet, which, as a separate operation, is subsequently glued to the base of a plywood or other wood core material. As previously noted, panels surfaced in this manner rarely develop checks, but the process is time-consuming and costly. The present invention is not applicable to this method, because in the laminate method of surfacing plywood, it is not important or critical that consideration be given to the relative direction of the grain of the base veneer and the machine direction of the plastic impregnated paper used in producing the laminate.

The other three methods used for surfacing plywood are all of the direct-surfacing type, i. e. the plastic surface is formed directly on the wood surface, and the invention is useful in connection with all three of these processes. One direct surfacing method which has been used for surfacing plywood is the so-called "veneer method." In the practice of this method, the plastic surfacing material, which may comprise one or more sheets of impregnated paper containing an uncured or only partially cured thermosetting plastic material, such as phenol-formaldehyde resin, is placed upon one side of a single wood veneer and the combination of unreacted paper and veneer is placed in a conventional plywood hot press. Several veneers can be surfaced at one time by placing the veneers back to back and employing caul plates between the plastic layers. The paper veneer assemblies are cured in the hot press for sufficient periods of time to bring

the resin to a thermoset condition. When the impregnated paper sheets contain a phenol-formaldehyde resin in amounts within the range of from about 35 to 60% by weight, pressures of the order of about 200 to 350 pounds per square inch, and temperatures in the range of about 250 to 325° Fahrenheit may be used during curing operation.

The surfacing sheets contain sufficient resin to bond themselves together in the case of a plurality of sheets, and also sufficient resin to bond the sheets to the face veneers during the hot-press operation. After curing, the veneer-surfacing sheet combinations are withdrawn from the press, and allowed to cool. The resulting laminate may then comprise one of the component laminations in the manufacture of a plywood panel by either the hot or cold gluing method. In assembling a plywood panel the plastic layers are turned outwards on one or both sides of the veneer layup. Any odd number of veneers may be used between the two surface face veneers with a glue line being present at each wood-wood innerface.

In another direct surfacing process, termed the "panel process," the plywood panel is manufactured separately and the plastic surfacing material is applied as a separate hot pressing operation. In this method, one or more sheets of paper containing uncured or partially cured plastic material are placed on one or both sides of the panel and the assembly is placed in a hydraulic hot press; commonly caul plates are used between the press platens and the plastic papers. Heat and pressure are then applied as specified above in the veneer process.

The third direct-surfacing method employed in the manufacture of plastic surfaced plywood, and the method which is most commonly followed in the art, is the so-called "one-step process." In the practice of this method, the various component parts of the plywood, including the unreacted resin impregnated sheet or sheets which provide the plastic surface, are first assembled in the position which they are to occupy in the completed panel to provide a complete assembly or lay-up. An odd number of veneers are used, as in common plywood manufacturing processes, with a glue line at each wood-wood innerface. A plurality of the panel assemblies are placed in a plywood hot-press, usually with caul plates as separators, and there subjected to heat and pressure sufficient to accomplish simultaneously the curing of the glue-line adhesive which join the component parts of the panel core and to effect the curing of the resin in the surface sheet or sheets. The surface-forming sheet or sheets are joined to the wood (and to each other if more than one sheet is used) by the flow of the impregnating resin during the hot-press operation.

Since the one-step process is the most important of the various methods of producing plastic-surfaced plywood, from a commercial viewpoint, the invention will be described in conjunction with this process. It will be understood, however, that the principles of the invention are applicable to any of the other known methods for directly surfacing plywood.

In Figure 1 there is illustrated a typical lay-up for a three-ply, plywood panel which is to be provided with a plastic surface in accordance with the invention. The lay-up includes a core 11, a pair of face veneers 13, which are placed over the core 11 with the grain in the face veneers running at right angles to the grain in the core, as is conventional in plywood manufacture. A suitable glue or other adhesive material will be applied to the faces 11 of the core before the veneers are put in place. One or more resin-impregnated paper sheets 15 are positioned in the lay-up so as to overlie the outer face of each of the face veneers 13 and caul plates 17 are positioned to overlie the resin impregnated sheets. It will be understood that the number of wood plies may vary, depending on the use for which the panel is intended, panels containing from 3 to 11 wood plies being regularly manufactured at the present time.

Each of the lay-up assemblies with the caul plates 17 in place is then positioned between the platens 19 of a plywood hot-press 21, as illustrated in Figure 2, and when the press 21 is filled, it is operated to press the lay-up assemblies together under pressures which are usually of the order of from about 175 to 325 pounds per square inch. During the pressing operation, the platens 19 are heated, usually by steam, to temperatures within the range of from about 250 to 325 degrees Fahrenheit, and the lay-up assemblies are held in the hot-press 21 for a sufficient period of time (usually from about 7 to 20 minutes) to effect curing of the resin in the face sheets, the setting of the adhesives joining the core, and the veneers. The face sheets 15 are joined together and to the surfaces of the face veneers by the curing of the resin with which those sheets are impregnated. The panels are almost invariably manufactured in units which, when trimmed, are four feet wide by eight feet long, and the grain in the face veneers always extend the long way of the panel. Such a panel is illustrated at 23 in Figure 3, and in the sectional view of Figure 4.

Prior to the present invention, it has been customary to assemble the panel lay-ups in such manner that the machine direction of the paper sheet or sheets used in the provision of the plastic surface extends parallel to the grain of the face veneers. The machine direction of a sheet of paper is, of course, the direction parallel to the forward movement of the sheet on the paper machine when the paper is being manufactured.

In the practice of the present invention, the facing sheet or sheets of paper are assembled in such manner that the machine direction of the paper extends crosswise of the grain of the face veneers and hence crosswise of the length of the panel. This requires the use of resin-impregnated paper which is about 99 inches wide, but this relatively simple expedient has been found to substantially obviate checking difficulties in plywood having a hard, dense, wear and mar-resistant plastic-surface produced by the direct surfacing methods above described. The reasons for the marked improvement in the surface characteristics of the facing are not completely understood, but exhaustive tests have proven the utility of the discovery. In this connection, it should be noted that all of the facing sheets (it being customary to use more than one resin-impregnated sheet in most facings) should extend in the same direction for best results insofar as the minimization of checking is concerned.

The present invention accomplishes the desired result of eliminating surface checking in plastic-surfaced plywood panels by the use of various types of base sheets and by the use of various types of impregnating resins. For ex-

ample, the base paper for the resin-impregnated sheets may vary according to the pulp used in the furnish and the method of manufacturing. If a relatively strong sheet is desired, it is common to use a Mitscherlich or kraft pulp. Ground wood pulp may be incorporated to a minor degree with the chemical pulp or pulps in order to improve the formation. Generally stated, the base sheet which is to be impregnated, should be a fairly heavy, moderately dense, and moderately absorbent sheet. For surfacing Douglas fir panels, base sheets having a basis weight of from 25 to 100 pounds for 500 sheets 24 by 36 inches and containing a substantial percentage of a chemical pulp will be found most satisfactory. Such sheets have a caliper of from about 3 to 15 mils, a density within the range of from 0.5 to 0.8 gram per cubic centimeter, and can be readily impregnated by passage through a bath containing the impregnating resin to provide resin contents in the dried, impregnated sheets up to 60 per cent by weight. Either alcohol or water soluble resins may be employed, and after impregnation the resin-bearing sheet is moved through drying and curing ovens which effect evaporation of the resin solvent, and partial, controlled curing of the resin. It is rather difficult to impregnate satisfactorily sheets having a caliper of more than about 10 or 15 mils, unless the sheet is particularly open and absorbent. Also, sheets having a basis weight of more than about 150 pounds for 500 sheets 24 by 36 inches, tend to show a migration of the resin to the surface during the drying operation. If a decorative surface is to be produced, a high grade, alpha pulp, or even rag stock may be used. The particular weight sheet to be used in any given instance will depend to a large degree upon the weight of the plastic-surface or overlay which is desired and the physical characteristics which must be embodied in that surface. As previously noted, a plurality of sheets, which may be of somewhat different types, is usually preferable to a single, very heavy sheet. If the total weight of the plastic-surfacing material in the completed plywood panel is less than about 100 pounds per 1000 square feet of each surfaced side of the surfaced plywood, the surfacing or overlay is conventionally classified as light. If the surfacing is of greater weight, it is classified as heavy. Light surfacings usually include up to about five sheets of a 60 pound basis weight (for 500 sheets 24 by 36 inches) resin-impregnated paper and heavy surfacings may include as many as 15 sheets of this resin-impregnated paper.

The amount of resin contained in the impregnated sheets may also vary over a substantial range. For phenol-aldehyde, melamine-aldehyde, and urea-aldehyde resins, the impregnated sheets should contain a minimum of from about 35 to 40 per cent of resin, based on the dry weight of the impregnated sheet, and the maximum useful resin content is about 65%.

The resin used should be selected from the general class of resins known as laminating varnish resins. Also, the resin should be of the thermosetting type, which is to say that the resin should be one in which curing reaction is irreversible in character, and once the resin has hardened, it will not return to its original fluid state upon heating. It must be understood, however, that the term "thermosetting" or "thermoset" as applied to a resin is a relative term somewhat difficult of exact definition, because the curing reaction can continue even after the resin hardens. Generally stated, as the term is used in this application, a resin is thermoset when it becomes hardened or set to such a degree that a paper impregnated with the resin will retain the impression of a surface against which the resin is cured and will not flow thereafter to any substantial extent. As above noted, the hardness of the resin and the paper which it impregnates can be increased by further curing, since the curing or setting reaction is rarely, if ever, brought to completion in thermosetting plastic materials. Typical water soluble phenol-formaldehyde resins as used for impregnating the base sheets will have a solids content of about 70%, a viscosity of 100–200 centipoises at 75° Fahrenheit, a water tolerance of about 150 to 450%, and a pH value within the range of from about 7.8 to 8.6. Typical alcohol soluble phenol-formaldehyde resins for impregnating the base sheet will have a solids content of 60%, and a viscosity at 75° Fahrenheit of 200 centipoises.

The resin-impregnated sheets used in providing the plastic surface may contain various types of resins. The most commonly used resins for this purpose are the phenol-aldehyde, melamine-aldehyde, and the urea-aldehyde resins. The phenolic resins are the least expensive and have somewhat better weather-resistance characteristics than the melamine and the urea resins. The melamine resins, however, are particularly useful in producing decorative surfaces having good wear-resistance characteristics, and the urea resins are also particularly suited for decorative type surfaces.

The optimum resin contents when using base sheets of the type described above (i. e. a fairly heavy, moderately dense, moderately absorbent sheet having a basis weight within the range of from 25 to 100 pounds for 500 sheets 24 by 36 inches, a caliper within the range of from 3 to 10 mils, and a density within the range of from 0.5 to 0.8 gram per cubic centimeter) are as follows: For water soluble phenol-aldehyde resins from about 40 to 55 percent; for alcohol soluble phenol-aldehyde resins from about 35 to 45 percent; for urea-aldehyde resins from about 40 to 60 percent; and for melamine-aldehyde resins from about 45 to 65 percent; all percentages being based on the weight of a completely dry, resin-impregnated sheet. At the time of use, the phenolic resin-impregnated sheets should have a volatile content within the range of from about 4 to 12 percent, based on the total weight of the sheet, and a percent flow at a molding pressure of 150 pounds per square inch, and a temperature of 300° Fahrenheit within the range of from about 1 to 6 percent.

The percent resin content is determined by a comparison of the weights of the dry base sheet and the completely dried, impregnated sheet. The volatile content is determined by heating the impregnated sheet in an oven at about 160° C. for a period of 10 minutes. Volatile contents of about 8 to 12% based on the weight of the completely dry sheet, are permissive in sheets containing water soluble phenolic resins, and about 4 to 8% are permissive where sheets contain alcohol soluble phenolic resins. For the urea and melamine resins, the volatile content should not exceed about 9 percent. The percent flow is determined by pressing a pack of sheets in a heated hydraulic press under approximately the same pressure, time and temperature conditions as are used in applying the resin-impregnated paper to

the plywood panel, i. e. pressures of from 150 to 300 pounds per square inch, applied for from 5 to 10 minutes, at a temperature within the range of from 250 to 325° Fahrenheit. The percent flow is expressed as the difference between the initial weight of the pack of sheets and the weight of the molded laminate after the pressing operation, divided by the initial weight.

Example I

In the practice of the invention on a commercial scale in the manufacture of Douglas fir plywood panels by the one-step process, each of the individual assemblies or lay-ups was made by first placing on top of a standard, 18 gauge, galvanized, caul plate, three rectangularly-shaped sheets of a 60 pound basis weight paper, containing about 50% by weight (when dry) of a water soluble, substantially unreacted, thermosetting, phenol-formaldehyde resin. The dimensions of the paper sheets were approximately 49 inches by 99 inches and the machine direction in each of the sheets extended parallel to the 49 inch dimension. This was followed by a single veneer of ⅛ inch thick Douglas fir approximately 50 inches by 99 inches. The grain in the veneer ply extended in the direction of the 99 inch dimension, and thus was disposed crosswise of the machine direction in all three of the resin impregnated paper sheets. On top of this assembly, there was placed another similarly dimensioned, rectangularly shaped, ⅛ inch Douglas fir veneer to serve as the core of the panel, the grain in this veneer running crosswise of the grain in the first veneer.

To join the core and the face veneers, a coating of glue having a weight of approximately 50 pounds per 1000 square feet of coating on each glue-covered surface was applied to both sides of the core veneer prior to the placing of that veneer in the assembly.

After the placing of the glue-surfaced, core veneer another ⅛ inch veneer was added to the assembly, the grain in this veneer extending in the same direction as the grain in the first veneer. Next, three more sheets of the same paper, 49 inches by 99 inches, and arranged with the machine direction of the paper extending crosswise of the grain in the last-mentioned face veneer, were added to the assembly, following which a second galvanized caul was placed on the top of the completed lay-up. The single veneers used were sound, rotary cut Douglas fir veneers, which had been dried to a moisture content of less than 5% by weight. The face veneers were laid-up with the "loose" side against the resin impregnated paper, the loose side being the inside of a veneer sheet as it is peeled from the log, and being the side which contains the lathe checks.

The assembly or lay-up units were each inserted in one of the openings of a conventional, hydraulic, plywood hot-press, and subjected to a pressure of 175 pounds per square inch and a temperature of 275° Fahrenheit for 15 minutes. The assembly was then removed from the press, and the caul plates were separated from the surfaced sides of the panel, following which the panels were cooled.

The plywood produced by this process was found to have a hard, dense, surface which was resistant to wear, to marring and to denting. The surface was also highly resistant to checking over a wide variation in the ambient humidity conditions.

Example II

In certain instances, as previously indicated, it may be desirable to use resin impregnated sheets of differing resin contents or of differing types in the manufacture of plastic surfacing in accordance with the invention. For example, it may be found advisable to use sheets of higher resin contents in the outer portions of the plastic surfacing, in combination with sheets of lesser resin content in the inner portions of the surfacing. In a specific example of such a procedure, used in the manufacture of a heavy overlay, three-ply Douglas fir panel by the one-step process, the lay-up applied to the bottom caul plate was substantially as follows: Four sheets of a 60 pound basis weight resin impregnated paper containing 50% by weight (when dry) of a water-soluble, substantially unreacted, thermosetting, phenol-aldehyde resin (similar to the sheets described in connection with Example I) were placed on the caul plate. Over this, there were positioned four sheets of a 60 pound basis weight sheet containing from 38 to 40% of a water-soluble, substantially unreacted, thermosetting, phenol-aldehyde resin, and overlying this, there was provided one sheet of a 60 pound basis weight having a 50% resin content, similar to the first group of sheets. In order, the next elements of the lay-up were the face veneer, the core veneer, with suitable adhesive applied to the faces thereof, the face veneer, a paper assembly in the reverse order of the assembly just described, and finally the top caul plate.

In all instances, the paper sheets were so arranged that the machine direction in the paper extended at right angles to the grain in the face veneer to which the paper was applied. The lay-up units were placed in a plywood hot-press and subjected to substantially the same temperature and pressure conditions and press time as the units of Example I.

Example III

As an example illustrating the manufacture of Douglas fir plywood panels under commercial operating conditions by the use of the veneer process, the lay-up units for the hot-press were each made by placing three or more rectangularly-shaped sheets of a 50 pound basis weight paper, approximately 49 inches by 99 inches, and containing 50% by weight (when dry) of a water soluble, substantially unreacted, phenol-aldehyde resin on top of a galvanized caul plate, following by a single ⅛ inch veneer of Douglas fir approximately 50 inches by 99 inches. On top of this assembly there was positioned a second veneer of the same size and type, three more sheets of the same paper and another galvanized caul. The single veneers used were sound, rotary cut, Douglas fir veneers, which had been dried to a moisture content of less than 5%. The grain direction in the veneers was in the 99 inch direction. The machine direction in the three plies of paper applied to each veneer was in the 49 inch direction, and hence the machine direction of the paper was at right angles to the grain in the veneer to which it was adapted to be attached.

Each assembly was then inserted in one of the openings of a hot-press, and there subjected to a pressure of about 200 pounds per square inch at a temperature of 300° Fahrenheit for 8 minutes. Each of the assemblies was then removed from the press, the caul plates separated from the surface veneers, following which the two, plastic-surfaced veneers were allowed to cool.

A plywood panel was subsequently made by the following procedure: A core veneer of the same

thickness and moisture content as the veneers used in the production of the plastic-surfaced veneers above described, was passed through a glue-spreader which applied a wet glue thereto at the rate of 50 pounds of glue to each 1000 square feet of each of the two sides of the core. The glue used was a water soluble, phenol-formaldehyde type, having a viscosity of about 10 poise at 75° Fahrenheit and a solids content of 50%. The two plastic-surfaced veneers were placed on the two sides of the glue-bearing core with the wood surfaces of the veneers in contact with the glue, and the complete assembly was inserted in one of the platen openings of a hot-press. The assembly was pressed for 8 minutes at a temperature of 300° Fahrenheit at a pressure of 250 pounds per square inch. The resultant panel after removal from the press was cooled and then sawed to the conventional four feet by eight feet dimension.

Example IV

In the practice of the invention on a commercial scale in the manufacture of Douglas fir plywood panels by the panel process, the following procedure was followed: First, a three ply panel was produced in conventional manner by applying a wet glue to a ⅛ inch core veneer at the rate of 50 pounds of glue to each 1000 square feet of each of the two sides of the core, placing face veneers on both sides of the core, and inserting the assembly in one of the openings of a hot-press. The panel was there pressed for 6 minutes at 285° Fahrenheit and a pressure of 200 pounds per square inch.

After removal from the hot-press, the panel was cooled, but was not sanded or sawed to exact size. Three or more sheets of the 60 pound basis weight, resin impregnated paper described in connection with Example I, were then placed on each side of the plywood panel, and galvanized caul plates were placed on top and bottom of the lay-up to prevent the resin impregnated paper from coming in direct contact with the press platens. The grain direction in each of the face veneers was in the 99 inch or the long direction of the panel, and the machine direction of the resin-impregnated paper sheets used in providing the plastic-surfacing extended parallel to the 50 inch or short dimension of the panel. Thus, the grain direction of the face veneers and the machine direction of the paper were at right angles to each other.

Each of the panel-paper assemblies was then placed in one of the openings of a hot-press and there pressed for 8 minutes at 300° Fahrenheit at a pressure of 250 pounds per square inch. Following the pressing operation, the panel was removed from the press, cooled, and trimmed to the standard 48 inch by 96 inch dimensions.

The formation of a plastic surface on plywood by direct surfacing methods, involving the use of high resin content sheets, as described in the foregoing, makes possible the obtaining of a hard, dense, wear and mar-resistant surface on the panel, which surface is substantially free from checking. A surfacing formed in this manner will also substantially prevent grain raising, and especially when of the heavy type, will permit the use of the surfaced panels outdoors without requiring that the panel surface be painted. Investigations have shown, however, that it is possible to improve further the anti-checking characteristic of the plastic surfacing by predrying the veneers used in the plywood assembly

to a very low moisture content. Preferably, the veneers should be bone-dry, but this condition is almost impossible of attainment, and some moisture content will normally remain in the wood. Generally, if the moisture content of the face veneer and also the core stock is below 5%, materially increased resistance to checking will result. It is also possible to improve the resistance to checking in panels made by the veneer process by applying the resin surfaced face veneer to the underlying parts of the panel by a cold gluing process, and it will be understood that either or both of these other procedures may be used, where applicable, in combination with the present invention in instances where the greatest possible resistance to checking is desired, as for example, when the panels are to be used under conditions where extreme variations in temperature and moisture conditions will be encountered.

For the conventional uses to which plywood is put, the mere arrangement of the sheets used in the provision of the plastic surface (i. e. with the machine direction of those sheets extending crosswise of the grain direction in the face veneer) will be sufficient to effectively eliminate checking, and it is only in extreme conditions that either or both of the other expedients need be followed. The invention thus accomplishes the very desirable and very important result of providing a relatively simple, inexpensive, direct method of manufacturing plastic-surfaced plywood having hard, dense, wear, mar and dent-resistant surface or surfaces which are substantially free from checking, even when the plastic-surfacing is of the heavy type. The invention, as previously noted, is of particular importance in connection with the manufacture of plywood from Douglas fir, but it has application to other types of plywood as well. Various of the features of the invention believed to be new are expressly pointed out in the appended claims.

I claim:

1. A plywood panel having a surface which is dense, hard, and highly resistant to checking, which consists of a wood core and a plurality of wood face veneers, adhesively joined together in cross-grain relationship to provide a unitary structure, and a plastic surfacing integrally attached to the exposed surface of at least one of said face veneers, said plastic surfacing comprising at least one sheet of resin-impregnated paper containing from 35 to 60% by weight of a thermoset, aldehyde resin, each resin-impregnated paper sheet of which said plastic surface is composed being so positioned with respect to the associated underlying face veneer that the machine direction in each such sheet extends substantially at right angles to the grain in said underlying face veneer.

2. A Douglas fir plywood panel having a surface which is dense, hard, substantially free from grain-raising, and highly resistant to checking, which comprises a wood core and a plurality of face veneers of Douglas fir, adhesively joined together in cross-grain relationship to provide a unitary panel structure, and a plastic surfacing integrally attached to the exposed surface of each of said face veneers, each of said plastic surfacings comprising at least one sheet of resin-impregnated paper having a dry, impregnated, basis weight within the range of from 40 to 150 pounds for 500 sheets 24 by 36 inches and containing a thermoset, aldehyde resin in an amount within the range of from 35 to 60% of the weight of the said sheet, each of said resin-impregnated plastic sheets of which said plastic surfacing is

composed being so positioned with respect to the associated underlying face veneer that the machine direction in each such sheet extends substantially at right angles to the grain in said underlying face veneer.

3. A plywood panel having a surface which is dense, hard, and highly resistant to checking, which consists of a wood core and a plurality of wood face veneers adhesively joined together in cross-grain relationship to provide a untiary panel structure, and a heavy weight, high resin-content, plastic surfacing integrally attached to the exposed surface of at least one of said face veneers, each plastic surfacing comprising a plurality of superposed sheets of resin-impregnated paper containing from 35 to 60% by weight of a thermoset resin, and said paper sheets being so positioned with respect to the associated underlying face veneer that the machine direction in all of said sheets of which said plastic surfacing is composed extends substantially at right angles to the grain in said underlying face veneer.

4. A plywood panel having a surface which is dense, hard, highly resistant to checking, which consists of a wood core and a plurality of wood face veneers adhesively joined together in cross-grain relationship to provide a unitary panel structure, and a heavy weight, high resin-content, plastic surfacing integrally attached to the exposed surface of each of said face veneers, each of said plastic surfacings comprising a plurality of superposed sheets of resin-impregnated paper, each of which sheets has a dry, impregnated basis

weight within the range of from 40 to 150 pounds for 500 sheets, 24 by 36 inches, and contains a thermoset, aldehyde resin in an amount within the range of from 35 to 60% of the dry weight of said sheet, said plurality of superposed resin impregnated paper sheets of which each of said plastic surfacings is composed being so positioned with respect to the associated underlying face veneer that the machine direction in all of said sheets of which each of said plastic surfacings is composed extends substantially at right angles to the grain of said associated underlying veneer.

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