

Boards which are to be hot pressed (see next column) are assembled in a similar manner, but thin aluminium or zinc cauls are generally used instead of plywood cauls and two are placed between each board.

This gluing or cementing process is one of the most important in the manufacture of plywood. An inferior or unsuitable adhesive will cause plywood to be a most unreliable building material, even if best quality timber is employed. The plies must be strongly united together and must remain so when subjected to atmospheric conditions. The production within recent years of waterproof adhesives has been largely responsible for the high repute now held for the better graded plywood.

The adhesives used in plywood manufacture are: (1) Resin, (2) casein, (3) animal and (4) soya bean glues or cements.¹

1. *Resin Cements*.—Such are chemically produced, and carbolic acid (phenol) and formaldehyde are in common use in the preparation of what are known as *phenolic resins*. One group of these resins is obtained in liquid form ready for use and applied as described on p. 100. They are also available in a fine powder form to which a solvent, such as alcohol, is added as required. Another group resembles sheets of tissue paper; these solid thin films consist of sheets of paper which have been impregnated with the phenol-aldehyde solution. A film, cut to the required size, is placed between each pair of plies whilst being assembled and then taken to a hot press (see next column); the intermediate process of gluing already described is thereby eliminated.

These are reliable waterproof adhesives (*i.e.*, they will not decompose under the action of water), they are not liable to the attack of micro-organisms, are fire-resisting, do not stain the wood and have great strength. Resin adhesives are employed in the manufacture of all good class plywood where durability is an essential requirement. They are more expensive than the following adhesives.

2. *Casein Glues*.—Casein is a milk derivative. Rennet, or acids such as hydrochloric, is added to skim milk to hasten the separation and precipitation of the curd. The latter is finely ground after it has been washed, pressed and dried, and borax or other chemicals are added. It is obtained in powder form.

The merits of casein glue are its great strength and it is applied cold in the glue spreader or by a brush. The disadvantages are its liability to stain certain hardwoods, such as oak and mahogany, and whilst it is highly water resisting, it is not entirely waterproof.

3. *Animal Glue*, commonly known as *Scotch glue*, is prepared from the skins and bones of cattle, horses, etc. The skins are steeped in liquid lime for two or three weeks, washed, dried and the glue (glutin) is extracted by boiling; this glue is very strong. The bones are cracked in a mill, placed in benzol or other solvent to remove the fat, taken to a steam boiler where the glue is extracted, and finally purified by heating with alum, etc.

Animal glue is prepared for use by softening it by several hours immersion in from two to three parts cold water; it is then melted by heating in water-jacketed glue pots. It is applied hot at an approximate temperature of 140° F.

The better grade glue has great strength, but it is neither water nor heat resisting, and it is liable to the attack of micro-organisms. It does not stain the wood, although care has to be taken when applying it to sycamore, maple, and similar light-coloured timbers to prevent discoloration.

4. *Soya Bean or Oil Seed Residue Glue*.—This is derived from Manchurian soya beans, cotton seeds and peanuts. The oil is extracted and refined. It is obtained in

white powder form to which water is added. Carbon disulphide is added to increase its water-resisting quality; the glue is not entirely waterproof. Owing to its alkaline nature, it is apt to stain woods containing acid (*i.e.*, oak). It is applied cold and is extensively used for Douglas fir veneers.

Vegetable Glue and Blood Albumen Glue are also used. The former is derived from tapioca starch and is applied cold; it is not waterproof. The latter glue, produced from blood obtained from slaughterhouses, is used in conjunction with casein; it is applied hot, and whilst it is not absolutely waterproof it is highly water resisting. Both glues are liable to stain certain hardwoods.

6. *Pressing*.—The glued plywood boards must now be subjected to the necessary pressure to effect a sound bond between the glued sheets. This operation takes place in either a cold press or a hot pressure machine. These machines are operated by hydraulic power.

Cold Pressing.—The cold press has a movable lower cast iron plate (called a *platen*) which operates between four corner vertical pillars secured at the base and supporting a heavy iron headpiece. Both the top of the platen and the underside of the headpiece have machined flat surfaces. The pile of glued boards, assembled between the thick cauls, as described in the previous operation, is placed in the centre of the press upon transverse steel beams laid at intervals on the platen; a similar number of steel beams is placed on the top caul and immediately over the lower beams. The press is now operated, the platen being raised by hydraulic rams to bring the upper steel beams in contact with the headpiece. As the pressure is gradually increased, operators fix vertical clamps or turn-buckles to the projecting ends of the steel beams; each pair of beams (the lower and upper) is thus connected by two clamps. When the desired pressure has been reached—indicated by a pressure gauge—the clamps are uniformly and finally tightened. The platen is then lowered and the batch, *still clamped*, is removed to the drying room; the clamps are not removed until the glue has set.

The maximum pressure and the time during which the boards are clamped depend upon a number of factors, such as the type of glue used, the area and thickness of the boards, the nature of the wood and the moisture content. Thus, valuable decorative veneers, casein glued, may only be subjected to a maximum pressure of 80-lb. per sq. in. for two hours in order to avoid staining; ordinary commercial plywood batches, soya bean glued, may be subjected to a maximum pressure of 150-lb. per sq. in. and the clamps should not be removed within eight hours. The normal practice is to leave the clamped batches overnight and to remove the clamps during the following morning.

Hot Pressing.—Resin cemented and hot glued plywood boards must be hot pressed to ensure a strong bond between the plies; some manufacturers also use hot presses for casein glued boards.

A hot press consists of a bottom metal table, pressure head and a dozen or more intermediate hollow steel platens spaced at regular intervals. Not more than two assembled boards, with their zinc or aluminium cauls (see preceding column), are placed between each pair of platens, and the latter are heated by steam admitted to them through flexible-jointed pipes. The press is then closed,

¹ A liquid glue sets when the excess moisture is removed by pressure, but will re-absorb moisture and is therefore not waterproof. A cementing material, such as one of the resin adhesives, does not absorb moisture and is accordingly waterproof. In the plywood industry the words "glue" and "cement" are now considered to be synonymous.