1. Aircraft propeller. 2. Bowling pins. 3. Shoe lasts. 4. Wagon pole. 5. Wagon axle. 6. Wagon bolster. 7. Rifle stock. 8. Baseball bat. 9. Wagon-wheel hubs. Separate views at the right show laminated shoe lasts

Typical articles of built-up plywood from the Forest Products Laboratory

Wood That Is Stronger Than Steel

How Thin Veneers and Water-Proof Glue Have Conspired to Build a New Industry

By Robert H. Moulton

THE weakness of wood is in its grain—the fact it is made up of a bundle of fibers. Each of these by itself will stand a considerable pull, but each fiber in the bundle is held loosely to its neighbors on all sides. To make a wood that is capable of standing strain in all directions, it is necessary to combine several layers cut at various angles to the grain. Thus is made "plywood," said to be literally "stronger than steel." It is revolutionizing airplane construction, and it will enter conspicuously into postwar industry. It is even possible that as a wall-covering the thinner varieties will compete with wallpaper; they possess all the beauty and durability of heavy wood paneling, for their composite nature prevents them from warping. Thin plywood has been found, in toughness and flexibility, to compete favorably with textile fabrics in the manufacture of airplane wings.

If anyone should say offhand that, weight for weight, wood was stronger than steel, he would be laughed at. However, the Forest Products Laboratory at Madison, Wis., which is responsible for our knowledge of plywood and the various uses to which it may be put, has devised a testing machine which proves this very thing; only, of course, the strength of the wood is estimated by the pull it will stand running with and not against the grain. For example, a toothpick of pine wood placed in this machine and weights applied, with the idea of pulling the toothpick apart in the middle, will usually stand a pressure of

from 75 to 100 pounds before it gives way. As against this, a 3-inch length of steel wire, of the same *weight* (not the same diameter) as the toothpick, generally gives way when the tension reaches about 30 pounds. Various tests with this machine have shown that all of the denser woods can beat steel by from three hundred to six hundred per cent. When tested across the grain, however, the best of wood shows only from one-fourth to one-half the strength of steel. That's why plywood was invented.

The panels used in the manufacture of plywood vary in thickness according to the article to be made of it. In the case of material for airplane wings, for example, they are only 0.1 inch in thickness. Gluing thin veneer into a very thin panel of plywood has always been an extremely difficult matter for the manufacturer. The principal cause of trouble has been the excessive swelling and shrinking of the thin plies due to their absorption of water from the wet glue, which causes overlaps and a considerable amount of wrinkling. A second source of trouble is in the handling of the very thin material when it has been coated with a wet glue, since it is very fragile and easily ruined when handled wet.

To overcome these difficulties the Forest Products Laboratory has evolved a process which consists of making a sheet of glue by coating thin sheets of tissue paper with blood glue, allowing it to dry, and using the coated paper as the glue layer for plywood. The

process of making the panel then consists merely in laying alternately as many sheets of thin veneer and sheets of this glue tissue as may be required to build up the panel desired. These sheets are then pressed in a steam-heated press which activates the glue. The result is an extremely thin panel in which the moisture content has been changed not more than one or two per cent. This simple method eliminates the troubles resulting from the use of a wet glue, and makes the handling of the thin material an easy matter.

The extremely thin plywood secured in this manner and tested on airplane wings built especially for the purpose proved surprisingly strong. It was found that it gave between six and eight per cent added lifting power over the linen ordinarily used, by reason of the fact that the "flap" of the cloth is entirely eliminated. Weight for weight, its strength proved to be approximately the same, and it is quite likely that in the future all wings may be covered with this material.

When plywood was first thought of in connection with airplanes, an apparently insurmountable difficulty presented itself. A machine that had to be out in all kinds of weather and spend much of its time in a dense fog and in thick clouds—often approaching 100 per cent humidity for long periods—must not be held together in any way by glue that water would dissolve. To overcome this difficulty two new glues were evolved

(Continued on page 212)

Left: Spreading casein glue on veneer sheets, the glue being applied cold. Center: The toughness test on thin plywood, in which the height is observed from which a steel ball must be dropped to splinter the sheet of veneer as it lies stretched over a hollow frame. Right: Machine that applies tape to the bundle of veneers, to hold the strips together prior to the application of the glue

The manufacture and testing of plywood at Madison

Fifteen stumps a day without dynamite

The Tripod Stump-Puller

THE direct application of the power to uproot the stump vertically instead of at an angle, so that the useful component of the force exerted is practically that entire force instead of half or less thereof, and the virtual absence of a hole to be filled where the growth is displaced, are among the virtues claimed for a tripod stump puller which we illustrate herewith. The machine is powerful and is capable of lifting huge stumps without the assistance of dynamite, although the use of the latter is a valuable ally in cracking the securely entrenched tree growth.

The tripod pullers, with respect to types, are three-fold in number, screw, windlass, and lever machines, the last-named being more widely used. No anchor stump is necessary in using the lever pattern, the puller being set immediately over the stump and the machine is moved for each succeeding performance. The stump is displaced by chains encircling one of the larger roots.

The tripod stump puller has proven its efficiency in uprooting huge white and Norway pine stumps growing in the sandy soil of Michigan, and has a limited use in the Mountain and Pacific Coast States as well as the South. Four men and an equal number of horses constitute an efficient working unit, the Office of Farm Management, U. S. Department of Agriculture, having assembled data indicating that on five tracts of land crews averaged 79 stumps a day for over 140 days. The tripod machines cost from \$125 to \$200.—By S. R. Winters.

A Big Lifting Barge

THE accompanying picture shows the largest derrick barge on the Pacific doing a rather novel stunt—lifting a building tower at the shipyards, and moving the tower a distance of about one block. The tower weighs about 65 tons, is 65 feet in height, and carries two derricks on its deck, one of these being 100 feet in height.

A number of cables were connected to various parts of the building tower and the derrick barge walked off with it easily. Had it not been for this barge it would have been necessary to take the tower apart, which would have required much time and entailed quite an expense.

The new barge recently performed another novel job. It lifted a 150-ton deckhouse from topside of a steamer and with great ease deposited it on a nearby wharf. The task under the old system would have consumed several days and the labor of a gang of men. The work was done by cutting the deckhouse in half and transporting each 75-ton half.

A short time ago the derrick barge succeeded in pulling a new steel tanker from the mud after a number of powerful tugs had worked three days and failed. The owners were preparing to dredge around the tanker, which was on the mud a distance of about 50 feet. The top lift line and the heavy load line of the barge were connected to the tanker and she was pulled back into the water in half an hour.

The steel derrick, it is estimated, will be able to lift the stern of a big vessel well out of the water so as to enable the workmen to replace a propeller, and the vessel would not have to go into dry dock. Above the wooden hull towers a triangular girder frame of steel 85 feet high. The boom is a lattice girder of steel 100 feet long and is designed to take 100 tons at a 50-foot radius and an 18-ton weight on its maximum working radius. Complete electric outfit is provided and a large air-compressor for working drills and other tools, or for supplying air to pontoons, or for forcing water out of wrecked hulls. Living accommodations are provided for a large crew of men and the barge carries sufficient fuel and fresh water to remain outside on a wrecking job for several weeks at a time. A feature of this barge is the hydraulic weighing machine. This device records the object lifted to the minimum of a pound.—By C. W. Geiger.

Barrel Rigged to Haul Water

OFTEN the farmer needs to carry water about the premises in larger quantities than could be carried in a bucket by hand. Even if a water system is employed he does not care to install an extra conduit to such places as the temporary hog watering trough, the concrete mixing vat, the garden to water crops during an extended drouth, etc. The photograph herewith shows how one farmer rigged a 50-gallon kerosene barrel to be easily carried full of water by rolling it on the ground to any desired place on his farm. Description of how this outfit is put together is superfluous.

The barrel is filled by removing the bung plug or stopper and then replacing it till arriving where the water is desired when it can be removed to draw out the water; the man whose outfit we illustrate has a faucet screwed into a hole bored in one of the heads to draw the water as needed, taking it out and putting in a short wooden stopper in its stead that will pass the shaft pieces when the barrel is rolling. The lag

A "lawn" of concrete and green paint

screws form spindles for the rear ends of the shafts to turn on and the load can be carried up considerable grades without much effort. One might think it would not be a paying idea to consume the necessary time

Barge-mounted derrick that gives good service in San Francisco waters

to prepare this rigging but it is to be considered that when a haul is made with this barrel you have fifty gallons where it is needed, whereas you would perhaps not have more than two with a bucket. Nothing

Upsetting rims instead of expanding them

A handy substitute for the water bucket

needs to be done to the barrel more than to bore a hole in one of the heads to draw off the water as desired if you prefer it to the bung hole in the side and there is but a trifle of expense to buy the material needed, only a few nails, two lag screws, a few scantling, etc.—By L. M. Jordan.

The Concrete Lawn

THE waterless, mowerless, weedless, gopherless lawn has made its appearance in Los Angeles, according to a recent item in one of the local papers. Everything about this lawn is according to the usual specifications governing be-grassed and be-flowered front yards, with the single rather important exception that the "lawn" is of concrete, painted green. At a distance it doubtless looks pretty much like a grass lawn, though at close quarters we should think it might leave something to be desired, unless the proprietor (and inventor) has gone to the trouble of painting in individual blades of grass. The idea, of course, is to have a lawn that will stay fixed without any fixing—no mowing or cutting, no seeding, no rolling, no bare places, no trouble of any sort. Just how many people who care enough for the open to live in a neighborhood where the lawn problem exists, would be satisfied with this counterfeit presentment of a sure-enough lawn we do not know, but for all such, here is the idea.—By Frank B. Howe.

Mounting Pictures Smooth and Flat

HOW many times have you pasted down a paper or mounted a print to find that when it dried it had buckled disappointingly? Ordinarily the paste is applied on the mount, the difficulty being that the exact limits to be thus covered is a matter of guesswork to meet the uncertain expansion of the print which is immersed in water before mounting; with the result that the print often exceeds the predetermined limits of the amount of the area covered with paste to receive it; on the other hand the print frequently falls within this area, leaving a margin of irremovable paste. The following method is free from such objections and difficulties: Keep the mount flat and with a small wad of cotton wetted in clean water, slightly dampen the approximate area to be covered by the print. Cover the back of the print with paste—preferably arabol—smooth and thin. Apply the print to the mount and with aid of a paper blotter and a small roller, smooth the print from its center outward. No paste will appear outside the limits of the print; any dampness exceeding these limits will evaporate. Any paper shreds left by the blotter, etc., may be wiped clean from the print's surface with the same damp wad of cotton.

Tire-Rim Upsetting Machine

IN welding tire rims the method commonly used has been to weld the rim with the diameter less than the size required, and afterward expand the rim while cold to the correct diameter. For this purpose a tire-expanding machine was used and a low carbon steel is required as high carbon steel is more liable to break in the stretching process. In order to use the upsetting principle to obtain the correct diameters a new machine has been developed by a Chicago manufacturer. This machine contracts a tire rim to the correct size instead of expanding it. It differs from the usual tire setting type of machine in being motor driven instead of employing hydraulic power and the rim is held nearly vertical instead of in a horizontal position while being contracted. A toggle motion controls the jaws or dies and a combined movement of $3\frac{1}{4}$ inches across the diameter of the circle is obtained. The machine in operation runs continuously and makes eight strokes per minute. A wedge adjustment operated by a hand-wheel is provided to take up wear or to suit special conditions.—By Allen P. Child.