C. S. I. R. O.

FOREST PRODUCTS NEWS LETTER

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WASTE WOOD BOARDS AND CORESTOCK

Estimate of the Possible Fields for Development and Economics of Manufacture in Australia

by

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Introduction

Over the past several years laboratory studies have been carried out at this Division on both sawdust-synthetic resin combinations and sawdust-blood combinations as possible materials for production of boards and panels. These studies have been based primarily on using a dry mix technique, the waste wood being first dried to a fairly low moisture content so that the initial mix resulting from its combination with either a powder or liquid binder remained relatively dry prior to pressing.

In the course of this work, which has been carried out on a laboratory scale, such relationships as the effect of size of sawdust particle, the proportion of binder used, the sawdust moisture content, the pressing pressure, the pressing temperature, and the pressing time on the properties of the resultant board, have been examined.

In addition, an examination of overseas commercial manufacturing techniques and equipment was made, a number of commercial plants being visited by the author during the latter half of 1949.

These studies have shown that a variety of products can be successfully manufactured from waste wood and readily marketed. Products which may be manufactured and, in fact, are in commercial production, include medium density wall board for lining, internal sheathing for partition purposes, and core stock for the furniture and allied industries. These products may be plain, paper or veneer faced. The combinations are also marketed in the form of flooring blocks and tiles, and a range of moulded products. The products can be sawn, sanded, shaped, nailed, screwed, glued and processed with no more difficulty than solid timber of similar density.

As a result of the work, it is believed there is scope for the development of waste wood-binder products in Australia. The extent of the development which can occur will depend on a number of factors, the most probable being the price, quality and stability of the products in relation to the markets which they can supply.

Materials Used

The wood waste used may consist of sawdust, planer chips or shavings, chipped or hogged veneer, or slab wood and the like. The binder can consist of animal glue, starch glue, casein glue, blood glue, synthetic resin, and in some cases, the resinous properties of naturally occurring materials such as tannin, lignin, and the products of wood decay. In addition, binders of the nature of Portland and magnesite cements to produce building products (wall slabs, ceiling slabs and hollow building blocks) having characteristics somewhat different from those earlier mentioned, may also be used. The question of the actual choice of a particular binder for a particular end use will naturally depend on technical suitability, availability and price. These aspects are discussed later in this paper.

Size of Plant

Plant size will depend largely on the assumed or determined market potential. A 1-ton per hour plant manufacturing medium density board (equivalent to some 1,200 sq. ft. of ½-in. thick board, or 960 sq. ft. of 5/8-in thick board per hour), is generally regarded as about the smallest which can operate permanently on an economic basis. Two English plants inspected appeared to be operating successfully with a production capacity very slightly in excess of this. An impression of the production capacity of a plant of this size is given by the recognition that the output from a one-lathe veneer plant, under Australian conditions, also averages about one ton per hour.

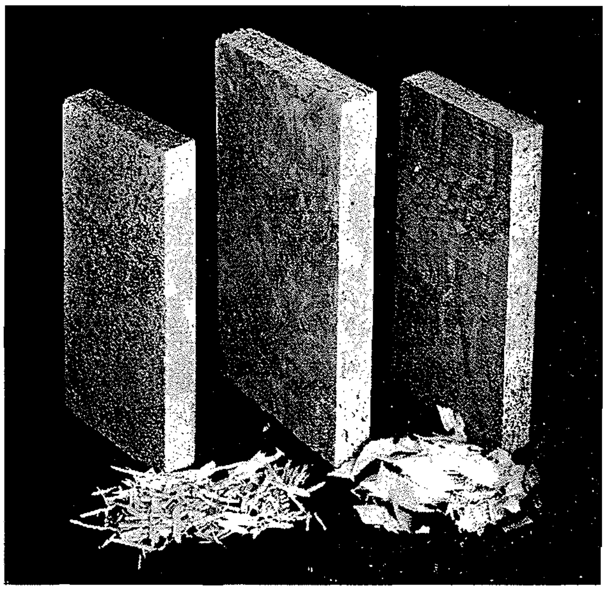
In special circumstances, however, or for a limited period, a plant with a production rate as low as ½-ton per hour could, no doubt, operate effectively.

Equipment Required

The equipment required for the manufacture of marketable wood waste-binder board, on a batch basis, is not extensive, but it needs to be in good condition, and process control needs to be maintained closely. The majority of plants operating commercially operate on a batch principle. It should be noted, however, that an English machine has recently been developed commercially to produce waste wood-resin board on a continuous principle. The raw materials (sawdust, shavings or chipped veneer, and urea or phenol-formaldehyde resin) are fed into one end of the machine, with or without facing paper, and the finished board in a continuous 4 ft. wide sheet of plain or paper faced product is discharged from the other.

The basic items of plant required for operation with batch technique comprise grinding mills, sawdust or chip driers, trough mixers and multi-daylight hot presses. Other essential equipment includes materials conveying systems (conveyor belts, exhaust fans and cyclone separators), materials storage floors or bins (for waste wood as received, for dried wood material, and for the wood binder), and where the process and driers are steam heated, a steam raising boiler. Ancillary equipment required comprises suitable caul plates or trays for the pressing operation, trim saws for sizing the processed sheet, and in some cases, a hogger, a magnetic separator, loaders and unloaders, and a cold press for preforming. Where liquid binder is used a suitable pump for piping to the mixer may also be installed.

On the basis of a production rate of approximately one ton of ½-in. or 5/8-in. thick board per hour, the basic equipment required would probably comprise two 25 H.P. grinding mills, two 6 ft. x 20 ft. rotary drum driers (actual capacity will depend on the moisture content of the waste wood), three 8 ft. x 4 ft. mixing troughs, and two 10- or 12-daylight hot presses. Each press would have a production rate of approximately ½-ton per hour.



SAMPLES CUT FROM TYPICAL WOOD WASTE-BINDER BOARDS.
(a) The central sample has a chip veneer waste core with a shavings face: the component materials are shown in front.
(b) The outer samples show plain and veneer faced core stock at left and right respectively.

Plant Power Requirements

Approximate estimates on such information as can be obtained indicate that, for batch process manufacture at the rate of one ton per hour, using steam as the heating medium for driers and presses, the steam demand should be of the order of 5,000 lb. to 7,000 lb. per hour.

The consumption of electricity under these conditions is estimated at some 80 to 150 k.w.h. per one ton of production, the actual amount depending among other factors on whether a hogger is operated.

Manufacturing Methods

Commercial board manufacture involves no difficult or involved techniques. Typical batch system plant processing commences with the receipt of the raw wood waste either in the form of particle or solid material: if the latter, it is passed to a hogger.

The hogged or small size waste is then passed to grinding mills for final sizing. From there the milled material is picked up by an exhaust blower and ducting system and passed to the cyclone separator, the air and dust being exhausted. The wood material is then passed into driers (rotary drum driers are frequently used) to be dried to a moisture content approximating 6 or 7 per cent. From these units it is passed through a cyclone system to the storage bins.

As required, the dry wood material is weighed (or measured) into a mixing vat and the required quantity of binder added either as a liquid or powder. The former is generally preferred as segregation is avoided, and it may be sprayed fairly easily into the mixing vat. For the manufacture of certain special types of waste wood board the binder is added to the wood material by passing the latter through a specially designed series of rollers attached to a suitable container holding the binder.

The amount of binder added usually averages about 10 per cent. of the weight of the dried wood material, the actual amount varying somewhat with the final properties required or the end use intended. A water soluble binder has advantages, as cleaning of distribution pipe or spray nozzles is thereby facilitated. Commercial mixing times average about 10 minutes per batch. From the mixer the waste wood-binder combination is passed to measuring boxes and conveyed to a tray filling site. These trays may be designed either with permanent sides and dismountable base plates, or as caul plates with which are used dismountable sides. With the trays filled and levelled to provide for a compression ratio ranging from about 3:1 to 6:1, they are loaded into a press loader for transfer into the press.

Pressing time depends on the thickness of product required, the temperature of pressing and whether or not a preforming technique is used. For ¼-in. thick board a pressing cycle of about 15 minutes would be reasonable: for 5/8-in. thick stock the pressing cycle would range up to about 35 to 45 minutes. Commercial pressing pressures used range from about 200 lb. sq. in. to about 450 lb. sq. in. depending on final board density required and type of wood waste material used. Pressing temperatures used for medium density boards usually range from about 250°F. to about 300°F.

On the completion of pressing the boards are demoulded and passed to trimming saws and storage.

Labour Requirements

Labour required for wood waste board manufacture naturally varies with plant organization. With batch process operation it is believed that the labour demand (plant operatives only) approximates 20 man-hours per ton of production: this does not include administration (office) staff or employees in despatch, but does include boiler attendant, trim sawyers, plant engineer and foreman, in addition to actual manufacturing personnel.

On the basis of continuous process operation it is considered labour demand would approximate 6 man hours per ton of production, again not including office or despatch personnel.

Plants Costs

Approximate estimates covering installed boiler plant, conveyors, grinding mills, a magnetic separator, exhaust fans with ducting and cyclone separator, driers, mixers, press loaders, trimming saws, weighing gear, storage bins and fittings indicate that plant construction costs are probably of the order of £50,000 to £60,000 for a production rate of one ton per hour. These costs do not, however, include the cost of factory space or a new building if required (possibly a further £25,000 to £35,000). Nor does it include the cost of land, office space and equipment, staff facilities, or handling trucks. Including these latter items, therefore, it is estimated that total capital required to set up an *independent* plant to produce 1 ton of product per hour probably approximates £100,000.

In the above estimates £3,000 has been allowed for each of two driers, £500 for each of three mixers, £12,000 for each of two presses and £1,200 for each of two loaders. Boiler plant has been estimated at £6,000.

Manufacturing Costs

Commercial plant operating costs have not been disclosed but for the following approximate estimates it has been assumed that total capital cost for a plant to produce one ton per hour is £100,000, that wood waste delivered to the factory costs £2/10/0 per ton, that 10 per cent. of binder is used, that the labour rate is 6/- per man hour (£12 per week), that steam and electricity charges are £2/17/0 per ton of production, and that a depreciation rate of 15 per cent. is charged. Insurance, workers' compensation, and administration charges are made on the basis shown below.

It is assumed that the plant operates on a two shift basis at least.

TENTATIVE ESTIMATE FOR MANUFACTURING WASTE WOOD BOARD

(Assumptions as given previously)

	Cost per ton of product £. s. d.	
1. Overhead or Fixed Charges Including Depreciation @ 15%; Insurance @ 10/-%; Administration and Office charges; and Interest on Working Capital; *but not including interest on capital invested.*	5 3 0	
2. Conversion Costs		
(a) Labour @ 6/- per man-hour (say 20 man-hours per ton, including holidays, etc.)	6 0 0	
(b) Workers Compensation (73/-%)	5 0	
(c) Steam (say 5.000 lb. per hour)	2 0 0	
(d) Electricity (say 100 k.w.h. @ 2d. per k.w.h.)	17 0	
(e) Maintenance	10 0	
(f) Despatch and Contingencies	1 0 0	
3. Raw Materials		
(a) Wood Waste @ 50/- per ton (assume 90% recovery)	2 15 0	
		£18 10 0
(b) 10% Binder (200 lb.)		
(i) Using binder at 9d. per lb.	7 10 0	£26 0 0
or (ii) Using binder @ 1/6d. per lb. .. or	15 0 0	£33 10 0

On the above basis, approximate production costs will vary from about £26.0.0 per ton with binder at 9d. per lb. to £33.10.0 per ton with binder at 1/6d. per lb. Assuming each ton of production is equivalent to 1,200 sq.ft. of ½-in. thick board or 960 sq. ft. of 5/8-in thick board, then with the lower priced binder this gives a production cost ranging from approximately 5d. per sq. ft. for ½-in. thick board to 6½d. per sq. ft. of 5/8-in. thick board. With the higher priced binder (i.e. 1/6d. per lb.) the production cost of ½-in. thick board would be about 6½d. per sq. ft., and that of the 5/8-in. thick board approximately 8½d. per sq. ft. An increase in binder cost from 9d. to 1/6d. per lb. increases the board cost by approximately 1½d. per sq.ft. for ½-in. thick board and 2d. per sq. ft. for 5/8-in. thick board.

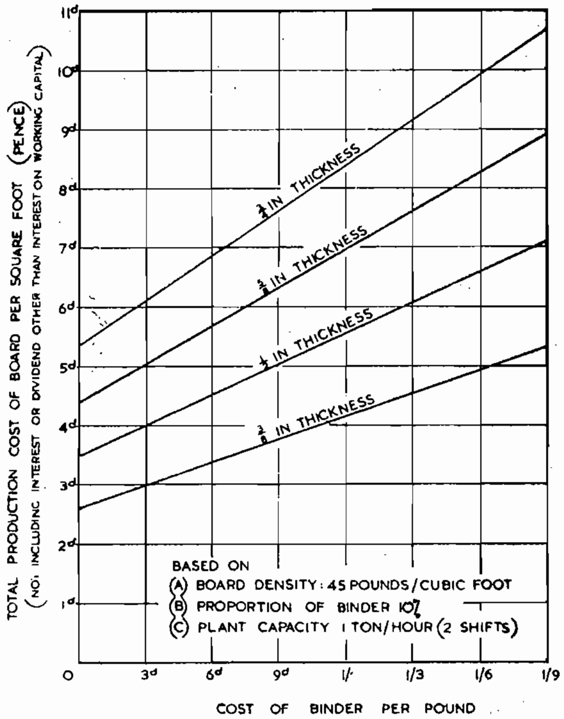
In the accompanying graph is shown an indication of the effect of binder costs on production costs (*not including interest or dividend other than interest on working capital*) for several thicknesses of board.

Even were there no charge for binder in these boards, it is clear a basic cost of approximately 3½d. per sq ft. is incurred in the case of ½-in. thick board, and 4½d. in the case of 5/8-in. thick board.

On these thicknesses of board the relation between board cost and binder cost is, therefore, for the former to increase by approximately ½d. per sq. ft. in the case of ½-in. thick board, and ⅝d. per sq. ft. in the case of 5/8-in. thick board, for each increase in binder cost of 3d per lb.

The question of achieving economy in waste wood board production costs by a reduction in the proportion of binder used warrants comment.

With binder at 9d. per lb. and assuming a case where consideration is given to reducing the quantity



PRODUCTION COST OF WASTE WOOD BOARD PER SQUARE FOOT AS AFFECTED BY COST OF BINDER
(NOT INCLUDING INTEREST OR DIVIDEND OTHER THAN INTEREST ON WORKING CAPITAL)

of binder in a ½-in. thick board from 10 per cent. to 8 per cent. (a reduction of 20 per cent. in the quantity of binder used), then the saving obtained is of the order of ½d. per sq. ft.

The Suitability and Economy of some Possible Binders

In general, the types of wood adhesives which have been found practicable by the plywood industry appear to offer most scope for use in waste wood or reconstituted boards. These include animal glues, casein glues, blood glues and urea or cresylic or phenolic resins. Of these four types, the blood binders and synthetic resins are believed to offer most scope for use in Australia, with tannin formaldehyde resin also showing interesting possibilities.

Blood binder is made from blood, caustic soda and hexamine and its manufacture is not difficult. It would cost approximately 7d. to 8d. per lb. (assuming the price of dried blood is not greater than 1½d per lb.). This binder should be satisfactory for conditions where a light coloured board is not required, or for use where a board is to be either surfaced, or faced with another material.

On the basis of suitability of physical properties the synthetic resins are generally regarded as particularly satisfactory. At present, urea formaldehyde resin is priced at approximately 1/6d. per lb. with a possibility of reduction in price for relatively large bulk lots. It is at least 9d. per lb. dearer than the blood glue. This latter difference is equivalent to about 1½d. per sq. ft. on the basis of ½-in thick board. Manufacturing cost with urea formaldehyde binder would probably be about 6½d per sq. ft. for ½-in. thick board and about 8½d. per sq. ft. for 5/8-in. thick. Urea formaldehyde resins cause no darkening of the pressed face, so that where light coloured wood is used clear or light coloured finishes can be applied direct to the pressed face. The synthetic resins give somewhat better water resistant properties than the other binders mentioned. Although this is not generally critical in core stock, nevertheless it does provide additional guard against loss of stability under the less satisfactory conditions of storage or use.

Overseas commercial practice has to date favoured the synthetic resins as the binding material, principally urea or cresol-formaldehyde resin. Both powdered and liquid resins have been used, with the latter the more general. This trend may be partly affected by the question of price of resin, the overseas price generally being lower than the Australian price.

The Field Application of Waste Wood-Binder Products in Australia

As referred to earlier, a variety of moulded or pressed products can be manufactured from milled waste wood and binders by a dry mix process. In particular, the production of board or panel material would seem to be attractive.

Manufacture of hardboard by the dry process in, say, 3/16-in. or 1/4-in. thicknesses is not regarded, however, as offering an attractive field for development. This field is at present being supplied by hardboard manufacturers operating wet processes in Australia on a large scale, and production capacity is increasing. These boards are of high quality and very competitively priced.

A much more attractive field for waste wood boards, and one in which the economics of the process should permit competition with established methods of production is believed to be in the manufacture of medium density core board. This product, in thicknesses ranging from, say, 5/8-in. up, is widely used by the furniture and allied industries.

It is understood that core stock manufactured by orthodox methods, and comprising 5/8-in. core board centre with cross banding to give a total thickness of 3/4-in. is at present priced not lower than 2/8d. per sq. ft. (wholesale) in Melbourne. This should give an ample margin for competition, particularly as for many uses, waste wood core board would not require cross banding, the face and back veneers being applied direct to the core board itself. For this latter veneer-faced stock, it may even be possible to apply the face and backs at the same time as the core material is formed and pressed.

With respect to 5/8-in. thick waste wood core board without cross banding, it is considered that it should be competitive with solid wood core board (without cross banding) if it can be manufactured at a cost to give a wholesale price in Australia not greater than, say 1/2d. per sq. ft.

HIGH PRESSURE IMPREGNATION OF EUCALYPTS

The shortage of durable species timbers for such uses as rail sleepers, cross arms etc. is directing attention to the project of the Division of Forest Products for preservation by high pressure impregnation. Normally pressure treating plants operate at 200 lb/sq. in. but this is not adequate for the treatment of Australian hardwoods and in many cases under such conditions penetration is negligible. Experiments in the Division have shown that with pressures of 1,000 lb./sq. in. good absorptions can be obtained with many species of eucalypt. A pilot plant has been designed to treat several thousand sleepers of a wide range of species for service tests of the process.

A treating cylinder operating at 1,000 lb./sq. in. is a costly piece of equipment and to this must be added the increased cost of high pressure pumps, valves etc. On the other hand, the cylinder and its immediate accessories is only part of the overall cost of pressure treating plant. Fortunately also the new high pressure treatment takes much less time than the conventional treatment and, providing time is not lost in opening and closing the door of the cylinder, the capital cost of plant per sleeper treated may not be greater with high pressure plant than with conventional equipment. The method of door closure is therefore obviously an important feature of the design.

Conventional closures in high or low pressure cylinders are unsatisfactory and it has been necessary to design a new rapid method of closure. With this design, although the load on the door at working pressure is more than 600,000 lb., it is anticipated that opening or closing the cylinder door will occupy one minute only.

After numerous delays in manufacture and subsequent transport, the equipment is now at the Division. The cost of the cylinder unit has been provided jointly by the Forests Commission of Victoria and the Victorian Railways. It is hoped to complete the installation and commence treatments early this year.

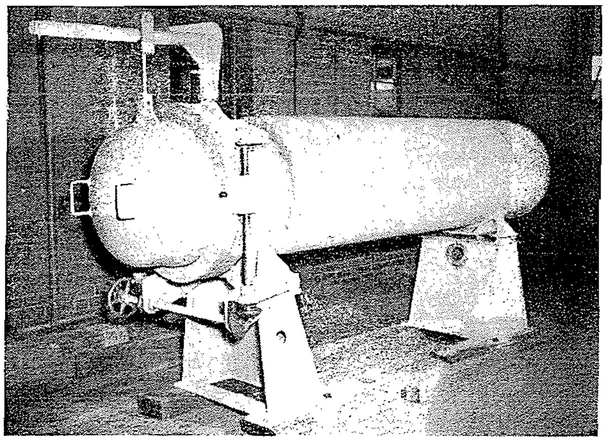


Fig. 1. A general view of the pressure cylinder. Its length is approximately 12 ft., its internal diameter 25 in. and the working pressure 1000 lb./sq. in.

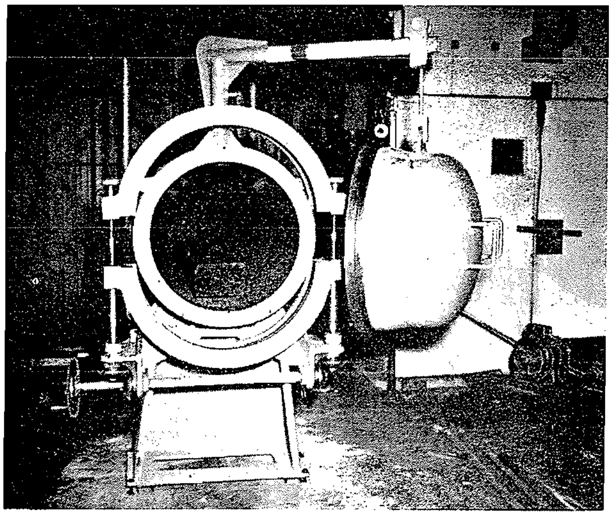


Fig. 2. View of cylinder with door swung open.

WHY DOES WOOD SHRINK?

By IAN J. W. BISSET, Wood Structure Section

This is a question which every person who deals with wood is bound to ask sooner or later. Another question which is asked equally often and which perhaps has greater practical importance is "how much does wood shrink?" The person who asks the latter question may also want to know whether the tangential shrinkage of wood is the same as the radial shrinkage; whether longitudinal shrinkage has any practical significance; whether the shrinkage of wood near the centre of a tree is the same as that near the outside, or whether the shrinkage of wood from leaning trees is the same as that of wood from trees which have grown vertically. If this person is told the percentage values of radial, tangential and longitudinal shrinkage of the species of wood he proposes to use, then he can make allowances when he is cutting the green timber so that when the timber is dry it may be trimmed to its final size with a minimum of waste. From the practical point of view there the matter ends.

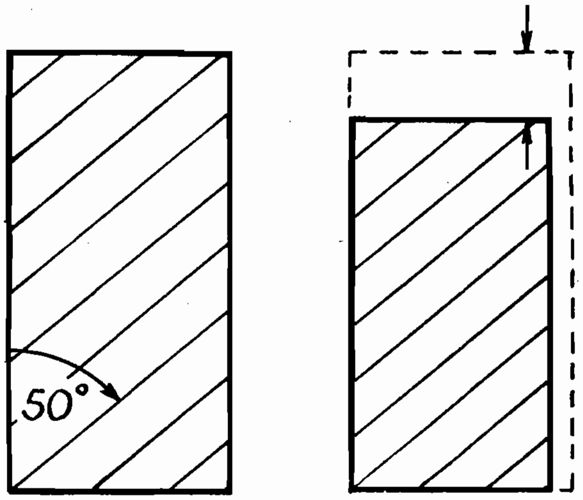
However, there are many users of wood interested in all aspects of timber who would seek some further explanation. Any theory of shrinkage in timber must account not only for the fact that shrinkage does occur upon drying but also that its magnitude is different in different directions, e.g. it is usually greater in a direction perpendicular to the grain than it is in the direction of the grain.

A theory which does appear to offer an adequate explanation of these facts is based upon our knowledge of the ultimate structure and composition of the walls of the fibres, which are the cells of which wood is composed. This basic information was described in News Letter No. 180, so that only brief reference need be made to it here.

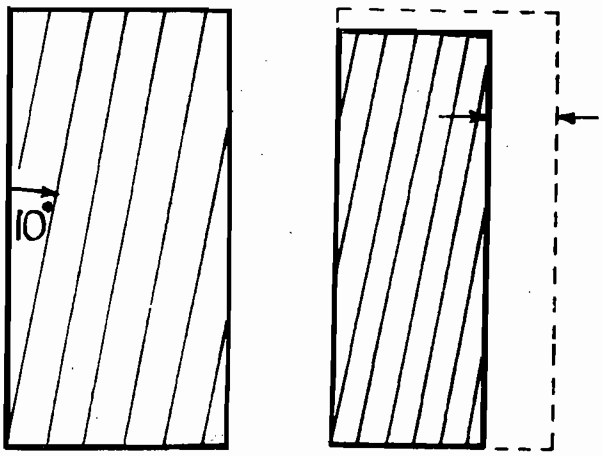
The cell wall of each individual fibre consists for the most part of cellulose. The cellulose is present as numerous fine strands which over parts of their length are parallel to one another forming elongated rod-shaped crystalline regions. These sub-microscopic crystalline rods of cellulose are arranged with their long axes forming spirals in the fibre wall and are separated laterally by other cell wall substances, particularly lignin and hemicellulose.

The hemicelluloses swell considerably in water and in freshly felled timber these substances separating the cellulose rods are in a highly swollen condition. Because of their extremely regular and dense structure, water cannot penetrate the minute crystalline rods of cellulose. Upon drying, water is progressively removed from the swollen hemicelluloses and lignin, and these substances gradually decrease in volume in much the way that gelatin does under similar conditions. This results in the lateral drawing together of the cellulose rods so that the volume of the whole cell wall becomes less, or as we say, shrinks. Now it will be recalled that the cellulose rods are spirally arranged in the fibre wall, so it will be apparent that if the lateral separation of the spirals decreases the spiral will tend to tighten. It will also be apparent that if the spiral is very steeply inclined to the long axis of the fibre, little change in the length of the fibre occurs, whereas if the spiral is flat then a relatively greater change in the length of the fibre will occur. Thus whereas the shrinkage of the individual fibres is governed by the removal of water from the hygroscopic substances separating the minute rods of cellulose, the direction in which shrinkage occurs is governed by the direction in which the rods are aligned.

These considerations are of particular importance in explaining the variation in shrinkage within stems. In recent years it has been established that the steepness of the spiral arrangement of the cellulose rods within the fibre walls is determined by the fibre length in such a manner that in long fibres the spirals are steep, whereas in short fibres the spirals are flat (see Figure 1). Now within a stem of a softwood such as radiata pine the fibre length increases in successive growth rings from its centre, so that the spiral arrangement in the walls of fibres from successive growth rings becomes steeper. As an example, the fibres from the first formal growth ring of a stem may be 1/25 in. in length and the cellulose rods may make an angle of 45° with the longitudinal axis of the fibre, whereas fibres from the twentieth growth ring may be 1/6 in. in length and the cellulose rods may make an angle of only 10° to the longitudinal cell axis.



Specimen of wood containing short fibres with large micellar spiral angle.



Specimen of wood containing long fibres with small micellar spiral angle.

Fig. 1—Illustration of large longitudinal and small tangential shrinkage in short-fibred specimen of wood. In long-fibred specimen tangential shrinkage is larger and longitudinal shrinkage smaller.

Now it will be recalled from the previous argument that cells with flat spiral arrangement of cellulose (short cells) would be expected to possess a high longitudinal shrinkage, whereas cells with a steep spiral arrangement of cellulose (long cells) would be expected to possess a low longitudinal shrinkage. Thus within the stem of a softwood highest longitudinal shrinkage and least lateral shrinkage would be expected to occur in the first growth ring and that as the fibre length increased in successive growth rings, the longitudinal shrinkage would become progressively less and the lateral (tangential) shrinkage become progressively greater. That that is so is shown by Figure 2, illustrating the variation in longitudinal and tangential shrinkage in successive growth rings of a conifer stem.

It will be seen that as the longitudinal shrinkage decreases from 1.5 per cent. in the first growth ring to 0.1 per cent. in the twelfth ring, the tangential shrinkage increases from 4 per cent. to 8 per cent. These are oven dry shrinkage values. When the wood is air-dried to approximately 12 per cent moisture content the values will be slightly more than half those first given. The difference in shrinkage behaviour of early and late wood from one growth ring can also be explained in terms of the spiral arrangement of the rods of cellulose in the fibre wall. In many species of timber the early wood fibres are shorter than the late wood fibres and therefore the spiral angle is greater in the early wood fibres. This explains the fact that often the longitudinal and transverse shrinkage of early wood is different from that of the late wood.

It is known that there are considerable differences between the radial and tangential shrinkage of wood. Such differences can be attributed to the medullary ray cells which are arranged in the wood with their length in a radial direction at right angles to the fibre length. The cross-banding effect of rays and fibres restricts the shrinkage of a block of wood in a radial direction. Tangentially there is no such hindrance and this probably accounts for the fact that the tangential shrinkage may be nearly twice the radial.

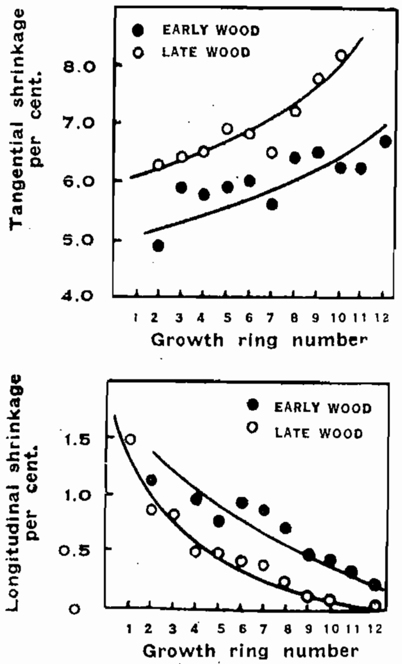


Fig. 2—Variation of tangential and longitudinal shrinkage in successive growth rings from the pith outwards of a rapidly grown tree of *Pinus radiata*.

SHARPENING SAWING CHAINS WITH A SAW GULLETING MACHINE

By C. H. C. Hebblethwaite, Utilization Section

Introduction

A method has recently been developed by which the sawing chains used on power chain saws can be accurately sharpened by grinding on stock pattern gulleting machines.

Some chain saw manufacturers supply grinding equipment for sharpening sawing chains; however, in the course of investigations made by the Utilization Section of the Division of Forest Products into the use of chain saws, none of the grinding attachments have been seen on which all the necessary grinding operations can be performed.

The method described in this article was developed as the result of a request received from a Victorian firm for assistance in developing a saw sharpening service in connection with their agency. The scratch type sawing chains to be serviced belonged to a make of saw with which a filing vice is supplied for hand filing. The filing vice is incorporated in the gulleting machine, where full use is made of it as a support for the sawing chain, and for checking tooth height. Brief descriptions of the vice, hand filing and gulleting machines are given below so that the advantage of this piece of equipment can be appreciated.

Description of Filing Vice

The body of the vice (Fig. 1) is a piece of steel with a groove cut in the top edge to support the sawing chain. A setting post is provided for punch setting the side cutter teeth. A jointing post, on the right of C is formed from a U-shaped piece of metal which can be adjusted for height. The top surfaces of each member of the post are ground to three pairs of flat surfaces of corresponding height. By means of these the groups of teeth can be filed to their correct heights. The filing vice can pivot on bolt C. A scale G, with radius struck from C, is fastened to the vice. H is a pointer.

The vice may be moved about a vertical axis (Fig. 2) on the pivoting rod A. Movement on this axis can be determined by scale I and pointer J; the whole may be locked in position by set screw L.

Grinding the Front of Teeth

With the sawing chain in the filing vice, D should be locked in the vertical position. Loosen bolt C and and tilt vice until desired angle of hook + or — on the G comes opposite pointer H. Loosen (Fig. 2) set-screw L and move filing vice until desired bevel angle on scale I comes opposite pointer J. Lock L. By suitably varying these adjustments, the vice is brought into position for grinding the three types of teeth. The grinding wheel is now adjusted so that the fronts of the teeth can be ground without touching the links of the sawing chain. Grinding is carried out by pulling the wheel down to its full extent and gently bringing the teeth in contact with it.

Setting the Side Cutters

It is advisable to remove the filing vice from the machine and support it in a bench vice while the side cutter teeth are set.

Jointing and Topping

Change the gulleting wheel for one with a face as wide as the tops of the teeth are long.

Adjust the jointing post as described under hand filing.

Slacken bolt C and adjust the vice to the required back angle (on right hand scale of G) and lock C.

Slacken L (Fig. 2), K (Fig. 1), and move the vice back (in the case of the side cutter teeth on the far side of the sawing chain), at the same time bringing the wheel down on to the top of the first tooth to be ground. When the top bevel surface of this tooth is fully in contact with the surface of the wheel tighten K and A and adjust the grinding wheel for travel.

The side cutter teeth are gauged on the top pair of surfaces, the offset raker teeth are gauged on the next pair approximately .010" lower and the centre raker teeth on the lowest pair about .022" below the side cutters.

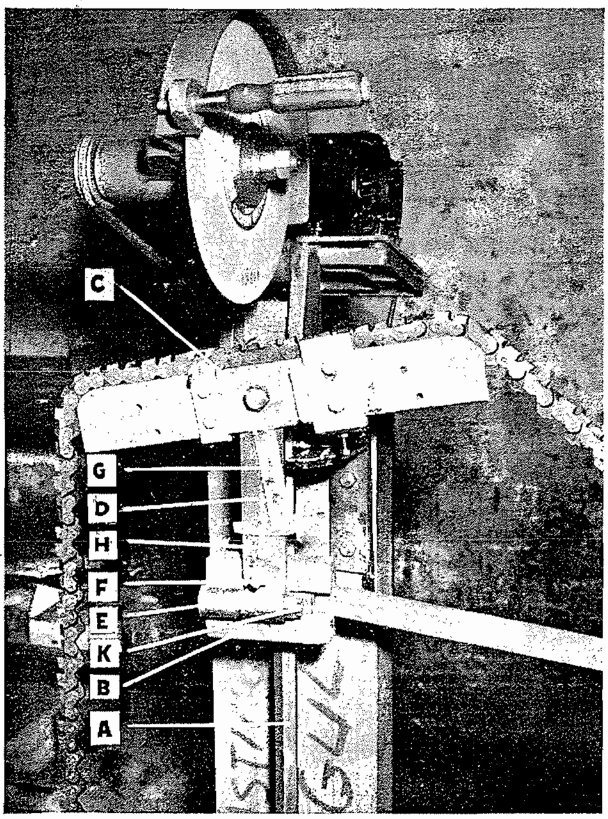


Fig. 1—Front view of gulleting machine with filing vice fitted.

Hand Filing

With the sawing chain supported in the vice the sharpening proceeds as follows:—

(1) Lightly file the fronts of each group of teeth up to their points, maintaining the original angles of hook and bevel.

(2) Punch set the side cutters against the setting post.

(3) Adjust the jointing post so that the tip of the lowest side cutter barely projects above the topmost pair of surfaces on the jointing post and lock the post in position. Holding the file flat, lightly file the tops of each group of teeth to their appropriate heights without further adjustment of the jointing post.

(4) Maintaining the original bevel and back angles, lightly file the tops of the teeth to their points until the flats produced by jointing are removed.

Individual sawing chains can be satisfactorily maintained by this method; however, it has several disadvantages for use in providing a saw sharpening service, mainly that it is time consuming and requires fairly experienced saw filers.

Modification of the Gulleting Machine

By incorporating the filing vice into a gulleting machine, operations 1, 3 and 4 can be carried out by grinding, in fact 3 and 4 may be done simultaneously.

A stock pattern gulleting machine fitted with 12" grinding wheel, powered by a ½ H.P. electric motor and with the filing vice mounted is shown in Fig. 1.

The filing vice is mounted on a vertical support D fastened to the existing circular saw supporting bracket B. D is hinged at E to allow to and fro movement, and can be secured by adjusting screw F and lock nut K. These adjustments are varied according to the kind of tooth being sharpened. As each tooth is ground it is passed to the right and through the jointing post, where it is checked for height.

By using this modified machine, sharpening time is reduced, tooth profiles are more accurately maintained, and sawing chains can be sharpened by persons other than experienced saw filers.

The subject has been dealt with more fully in a report to be published shortly.

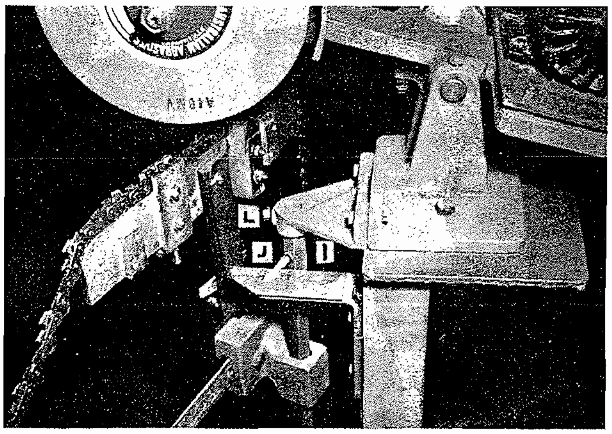


Fig. 2—Side view of gulleting machine showing scale for front bevel adjustment.

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to Forest Products News Letters—Nos. 180-183 (1950)

TECHNICAL INDEX.

AUTHOR INDEX.

THE FORESTRY AND FOREST PRODUCTS COMMISSION FOR ASIA AND THE PACIFIC

An historical step in the field of forestry and forest products was the inauguration at Bangkok, Thailand, on October 9, 1950, of the Forestry and Forest Products Commission for Asia and the Pacific. This region embraces India and all countries eastward to and including Japan, and southwards including Australia and New Zealand.

Established under the auspices of the Food and Agriculture Organization of the United Nations, the Commission's objective is to promote better mutual understanding of the forestry and forest utilization problems of the member countries and to advance the adoption of sound procedure in these two important fields of work. Twelve countries were represented at the inaugural session, the Australian delegate being Mr. C. S. Elliot, Assistant to the Chief of the Division of Forest Products, C.S.I.R.O. Meetings of the Commission will be held biennially, the proposal being that the next session will be held in Malaya. Between sessions, the work of the Commission will be conducted by an Executive Committee, consisting of the Chairman, two Vice-Chairman and the Secretary General. For the ensuing term, His Serene Highness, Prince Suebsukswasti Sukswasti, Dean of the College of Forestry and Director of the Forest Industry Organization of Thailand, was elected as Chairman and Dr. C. H. Holmes, Senior Assistant Conservator of Forests, Ceylon, and Shri M. D. Chaturvedi, Inspector General of Forests, India, were elected as 1st and 2nd Vice-Chairman. Dr. M. A. Huberman, Chief of the Forestry and Forest Products Working Group for Asia and the Far East, F.A.O. Office, Maliwan Mansion, Phra Atit Road, Bangkok, is the Secretary-General.

Ramsay, Ware Publishing Pty. Ltd., 117-29 King St., Melbourne, C.1.

C. S. I. R. O.

FOREST PRODUCTS NEWS LETTER

This monthly bulletin is prepared for general circulation by the Division of Forest Products, C.S.I.R.O., 69-77 Yarra Bank Road, South Melbourne, S.C.4., and will be supplied free on request to members of the timber trade and timber users who wish to keep abreast with current developments in the field of forest products

No. 185 — 1951##185 — March-May, 1951

WHAT WOOD IS THIS? — Part 3

By M. M. Chattaway, Wood Structure Section

Rays. Wood rays are strips of tissue extending from the outer layers of the tree towards the pith. They serve the dual purpose of conducting manufactured food materials from the periphery of the stem inwards and also of food storage. They are alive throughout the sapwood. On the cross surfaces they often appear as straight lines differing in shade from the background; they may change direction slightly in their course through the wood and may vary considerably in width in different timbers, and sometimes even in different samples of the same timber. On a radial (quartersawn) surface of the wood they appear as ribbons of horizontally running tissue which may differ considerably in colour from the rest of the wood. Large rays are visible as "flecks" on the tangential (backsawn) surface—as in sheoaks and silky oaks. Small rays may in some cases be visible on the tangential surface as faint horizontal lines, owing to their regular arrangement in tiers (Fig. 9).

Ray width is estimated by comparison with the tangential width of the pores. This has been found to give much more useful results than any attempt to assess absolute width.

Broad and conspicuous on the cross surface—as in sheoak or silky oak (Fig. 7 of last article).

As wide as or wider than the pores. (Fig. 7 of last article). (e.g. sassafras).

Narrower than the pores. (All figures except 7 of last article, i.e. the great majority of timbers).

Not clearly visible, even with a lens. This may be due either to the very small size of the rays, or to the lack of any colour contrast (e.g. brush box and some eucalypts).

Conspicuous on radial surface owing to colour. This is purely a colour contrast and applies to small rays as well as to large. (e g. kauri and Queensland maple)

With gum canals. These can often be seen with a lens on the tangential surface as dark cavities or dots in the rays. Occasionally they can be seen on cross or radial surfaces as dark streaks. (e.g. radiata pine and pink poplar).

Soft tissue forms the main storage system of most trees. It runs vertically up and down the stem, and its cells, like those of the rays, are alive throughout the sapwood. It forms definite patterns when seen on the cross surface of the wood. It is distinguished from the main mass of the woody tissue by being formed of relatively thin-walled cells.

Soft tissue usually appears somewhat lighter in colour than the rest of the wood, but it may occasionally contain much resinous matter which makes it darker than the background.

Soft tissue absent or very difficult to see. (Figs. 2 and 8 of last article). If the soft tissue is extremely scanty and is difficult to see, even with a lens, it is said to be absent, even though a little might be seen in an examination with a microscope. (e g. myrtle beech).

In regularly spaced bands wider than the pores. (Fig. 10). (e.g. Moreton Bay fig).

In regularly spaced bands narrower than the pores. (Fig. 11). (e.g. Miva mahogany).

In irregularly spaced bands. (Fig. 12). In these three features the width of the bands is judged by comparison with the *radial* diameter of the pores. Regularity or irregularity refers solely to the *spacing* of the bands on the cross surface of the wood, and not to their width. (Figs. 10-12). (e.g. white birch and Queensland walnut)

Surrounding the pores. (Fig. 5 of last article.) (e.g. many of the eucalypts).

Winglike and confluent. This means that the soft tissue projects laterally from the pores and links them together. (Fig. 13, and Fig. 1 of last article). (e.g. black bean).

Diffuse. The soft tissue may be scattered irregularly through the wood, often occurring as single cells or short lines of a few tangentially linked cells. This feature is often a little difficult to see, but can be made out with the lens, if the surface is wetted. (Fig. 14). (e.g. red gum).

Reticulate. This arrangement of the soft tissue is an elaboration of the one above. The tangential linkage of the cells is more marked, the tissue forming fine, often broken, lines. These are usually only visible with a lens. Together with the rays they give a net-like appearance on the cross section. (Fig. 15). (e.g. mararie and brown alder).

Other useful features are the presence of *Vertical Gum* Canals which may be either scattered through the wood, or arranged in definite concentric bands. (Fig. 16). These canals may be of two types, (i) *normal*, in concentric bands or scattered, as in many of the Dipterocarps (e.g. red maranti and *Anisoptera* from New Guinea), and (ii) *traumatic* or the result of a breakdown of the tissues—commonly after injury—as in silver ash and the eucalypts. In these latter they are conspicuous because of their size and reddish-brown contents, and are commonly known as gum veins.

Ripple marks. These are faint vertical markings which can be seen on the tangential surface of some timbers. They resemble ripples on sand and are caused by a tiered arrangement of the rays and sometimes of the other elements of the wood. They are often more clearly seen with the naked eye than with a lens. (Fig. 9). (e.g. true mahogany and, to a less extent, in tulip oak).

These are the features which have been found to be most useful for purposes of identification of unknown timbers. How to prepare and use the different mechanical keys will be discussed in the next article.

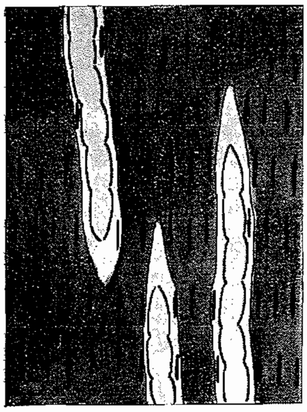


Fig. 9—Ripple marks due to tiered arrangement of the rays.

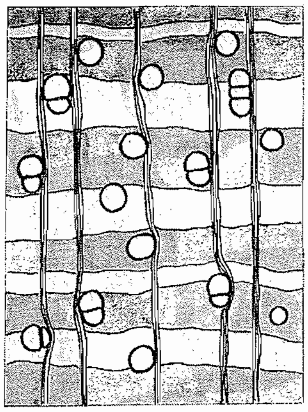


Fig. 10—Soft tissue in regularly spaced bands wider than the pores.

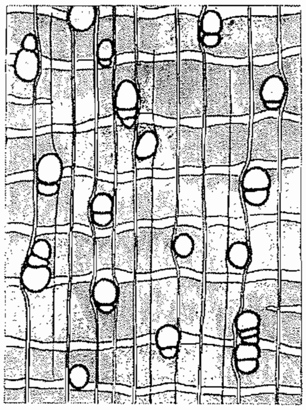


Fig. 11—Soft tissue in regularly spaced bands narrower than the pores.

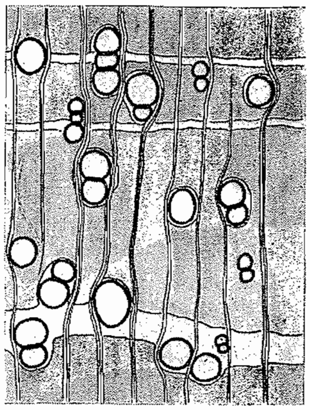


Fig. 12—Soft tissue in irregularly spaced bands, and also surrounding the pores.

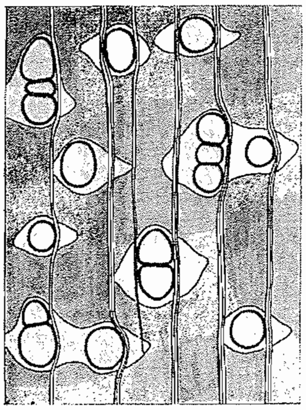


Fig. 13—Soft tissue wing-like and confluent.

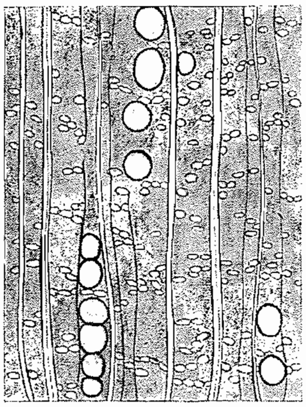


Fig. 14—Soft tissue diffuse.

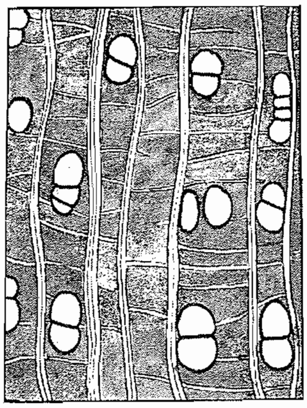


Fig. 15—Soft tissue reticulate.

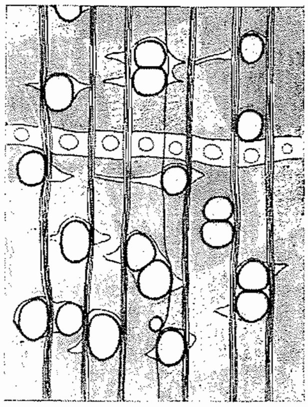


Fig. 16—Vertical gum canals in concentric bands. Soft tissue; soft tissue wing-like.

MOISTURE CONTENT AND THE PROPERTIES OF TIMBER—Part I

by K. E. Kelsey, Timber Physics Section

Most timber users realize that the moisture content of a piece of wood varies with changing atmospheric temperature and relative humidity. But the magnitude of the variation, and the far-reaching effect which it has on the properties of wood are probably not so well appreciated. The actual physical processes underlying the binding of water to the wood are not generally understood; indeed this is still the subject of a good deal of research. It is proposed to give a general account of the way research has thrown light on the problems associated with the binding of water to wood, and to show how this leads to an explanation of the effect of moisture content on the properties of timber.

1. How Water is Held by Wood

In order to understand the way in which water is held by wood, it is first necessary to have some knowledge of the structure of wood. This has already been discussed in two recent News Letters (No. 180, pp. 2-5 and No. 184, pp. 5-6) but it will be briefly outlined here, and more details will be given of the way water is associated with the wood substance.

The long thin cells of which wood is composed are mainly arranged with their length vertical in the standing tree. These cells possess a central cavity, or lumen, the surrounding cell wall consisting of cellulose and related material and lignin. Cellulose is the principal component and the cellulose molecule, the elementary cellulose unit, can be considered as a chain of indefinite length, possessing at regular and frequent intervals along its length hydroxyl groups. These are responsible for the hygroscopic nature of wood. They exert an attractive force towards water molecules, and also towards similar groups on adjacent cellulose molecules, so that they can be regarded as sites on which water can be held, and also as potential cross links between cellulose chains or chain molecules.

As the wood is formed in a living tree, the cellulose chains are laid down so that they tend to be arranged parallel to one another, and in certain parts of the cell wall the alignment is almost perfect and small crystalline regions of cellulose exist. In other parts, however, the alignment is imperfect, the spaces between adjacent chains are irregular and considerably greater, and the hydroxyl groups are freer to hold water.

When the cell is first formed, the minute spaces between the crystalline regions are all filled with water, or in other words the cell wall is saturated. The cell cavity, too contains a considerable amount of water. After the tree is cut the wood begins to dry out. The water held in the cell cavities evaporates first, as this is bound to the wood only in the way that water is held in very fine capillaries. This is often spoken of as "free" water, in contrast to the "bound" water which is held by much stronger forces by the cellulose itself. At atmospheric humidities approximating saturation, only the water in the cell cavities can evaporate, but at lower humidites some of the water held in the very fine spaces between the cellulose chains can escape. At still lower humidities, the water bound to the cellulose molecule itself is lost. Even on prolonged evacuation, or on oven drying at a temperature of about 217°F., some water remains chemically combined with the cellulose, so that the intimate relation between wood and water can thus be appreciated.

The process of adsorption, or picking up of water takes place in the reverse order to that of desorption, or drying, which has just been described. Due to the fact that direct binding between cellulose chains may have occurred on desorption, and some of the minute spaces between the molecules may have been closed, the moisture content under given conditions on adsorption is usually slightly lower than that on desorption.

The foregoing account should suffice to indicate the way in which water is held by wood, and it will now be shown how the observed effects of water on the properties of wood can be explained.

2. Equilibrium Moisture Content

The moisture content of timber is a much used term, but it is important that one should be clear as to the basis on which it is calculated. It has just been mentioned that even on prolonged drying at about 217°F. there is still some water left chemically combined with the wood. However, on drying the wood in a well-ventilated oven at this temperature, a constant weight can be attained, and it is this constant weight which is the basis of all moisture content calculations. The loss in weight on drying in this way is taken as the weight of water in the original wood, the loss in weight due to the evaporation of other volatile constitutents of the wood usually being negligible. Thus, the percentage moisture content of a given piece of wood is calculated as:

$$\frac{\text{weight at test—oven dry weight}}{\text{oven dry weight}} \cdot 100$$

In the green state, the moisture content may vary from over 300 per cent. for light woods, where the volume of the cell cavity is large, to less than 40 per cent. for some of the denser woods whose cells have thick walls and small cavities. The variation in green moisture content in any one species or even in one tree is considerable.

The object of timber seasoning is to dry wood from this green state to its equilibrium moisture content, or that which it would naturally attain in its conditions of use. This equilibrium moisture content varies with both humidity and temperature. Over the usual climatic ranges the effect of humidity is greater, and is as described in the preceding section. Increase in temperature tends to lower the moisture content for a given relative humidity. The variation of moisture content with humidity at 80°F. is shown in Figure 1. It is to be noted that, on drying, the wood is at a slightly higher moisture content than on wetting at the same humidity. Only an approximate figure can be given for the moisture content in equilibrium with any given conditions, for this varies considerably from species to species, and to a lesser extent within one species, and it also depends on the previous history of the timber. The variation between species will be appreciated when it is realized that at 60 per cent. relative

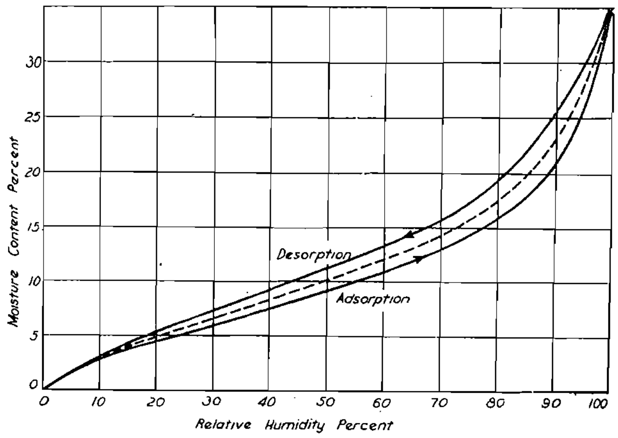


Figure 1.—Curves showing the dependence of moisture content on the relative humidity of the air at 80°F.

humidity and 80°F. the equilibrium moisture contents for jarrah and Douglas fir, as tested in this laboratory, were 14 per cent. and 10½ per cent. respectively. This difference is probably due to variations in the structure of the cell walls in the different species.

As a general rule the atmospheric conditions in any one place vary widely from day to day and season to season. As a result of this, the moisture content of timber in use, even in a sheltered position, will be constantly changing. It is possible, however, to determine the extreme moisture contents which the wood is likely to attain, and to season the wood to an intermediate moisture content, so that the variation in dimensions which accompanies changing moisture content may be as small as possible. This moisture content will vary from place to place, being higher in humid coastal climates than in dry inland ones.

In actual conditions of use, timber will seldom be found to be at exactly the moisture content corresponding to the atmospheric conditions prevailing at the moment. This is because of the time taken for the whole piece to come to the equilibrium moisture content; in any one piece the inner "core" will lag behind the outer "case."

(To be continued)

TIMBER FOR BATTERY SEPARATORS

Extensive tests on klinki pine have been carried out in this laboratory during the last three years to assess its value for use in the manufacture of battery separators. This timber grows in New Guinea and belongs to the same genus as hoop and bunya pines.

Many other species have been tried during the last five years but none has proved so completely satisfactory for the purpose as klinki pine and few have even shown promise.

It is therefore gratifying that klinki pine is now being sent to Australia to the extent of about 600,000 super feet per annum specifically for this purpose.

This should largely overcome the acute shortage of separator timbers which has been felt for some years, and has prevented battery manufacturers from building up sufficient stocks to carry them over delays in supply due to weather, transport stoppages, etc. At times, the shortage has even resulted in the shutting down of separator manufacturing plants.

The Standards Association of Australia has been asked to consider the approval of klinki pine as a separator timber for inclusion in the standard specification for wooden separators for storage batteries for all purposes.

THE HORNTAIL WOOD WASP

by N. Tamblyn and Nancye E. Kent, Preservation Section

The horntail wasp or wood wasp, recently discovered in large shipments of softwood timber from Europe, is a widespread forest insect which has been found on several occasions in the past in timber imports from oversea countries. Although various species of wood wasp occur naturally or have been introduced in England, Europe, Canada, America, New Zealand, Japan, parts of India, etc, there are as yet no records of native or introduced species in Australia.

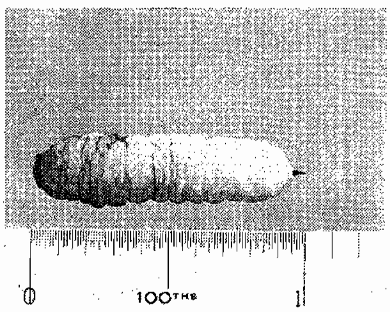
Wood wasps belong to the family *Siricidae*, of which *Sirex* is a well-known genus, and are typically stout-bodied insects without the slender-waisted appearance of the usual Australian hornets and wasps. Most of the important species are conspicuous insects up to about 1¾ inches in length including the long horntail, and are more or less strikingly coloured. The sexes usually differ, often to a marked degree, both in colour and size. The female of *Sirex* (*Urocerus*) *gigas*, one of the three species found in recent timber shipments, has a yellow and black banded abdomen, whilst in the male it is predominantly yellow. Both sexes have yellow antennae and a prominent yellow spot behind each eye. In the other two species found, the colour of the females ranges from the steel blue of *S. juvencus* to the metallic violet blue of *S. cyaneus*. The males of both these species have abdominal segments which are chiefly orange.

Wood wasps attack unhealthy trees or green logs and are said to be attracted by the odour of resin. The ovipositor or egg laying tube of the female, which is protected by the sheaths of the horntail, is sufficiently long to penetrate through the bark to some depth in the wood. The ovipositor itself is composed of three parts, two of which function as small saws to assist its insertion into wood. Observations made in England indicate that in each minute tunnel thus made the insect lays from 5 to 7 eggs and that these hatch out after about 4 weeks. The larva or grub then begins to bore in the wood making a circular tunnel which becomes very tightly packed with rather coarse fragments of chewed wood. Tunnels ¼ inch in diameter are frequently seen containing the soft bodied cream coloured grub which carries a sharp spine at the tail end. In cold climates the grub remains in the wood for periods up to about 3 years before pupating and emerging as the adult wasp. In emerging, the wasp cuts a circular hole in the surface of the wood, but otherwise the adult insect does no obvious boring as the puncture made during egg laying is relatively minute.

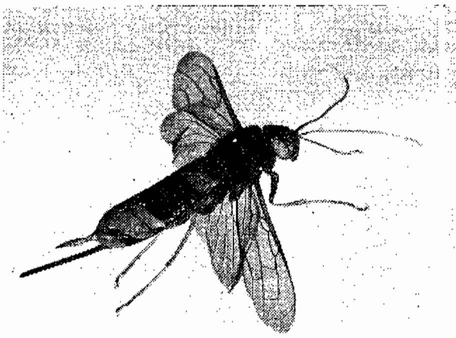
This long life cycle may be accelerated in warmer climates, and adults of the species introduced into New Zealand (*Sirex noctilio*), are reported to be emerging in as short a period as one year. The wasp has powerful wings and may fly for considerable distances. In European technical literature it is generally conceded that weak or sickly trees caused by underthinning, waterlogged soil, fungal disease, etc. are mainly attacked, and that as a rule healthy trees are practically immune. There is no evidence that wood wasps will infest seasoned timber, though they may emerge from timber infested in the tree or log for some time after air drying. However, for practical purposes it may be said that damage to the wood occurs before seasoning and the wasps are of no direct importance to builders, furniture manufacturers, etc. Even if wasps were found emerging from stocks of furniture timber they need occasion no alarm to the manufacturer because they represent the final stage of an infestation which commenced in the forest or in the mill log. Re-infestation of the timber will not take place.

It is interesting to record that two species of parasitic wasps which are natural enemies of *Sirex* in Europe were also collected during inspection of the infested shipments. These parasitic wasps, *Rhyssa* sp. and *Ibalia* sp., are believed to be responsible for controlling the severity of *Sirex* damage in Europe.

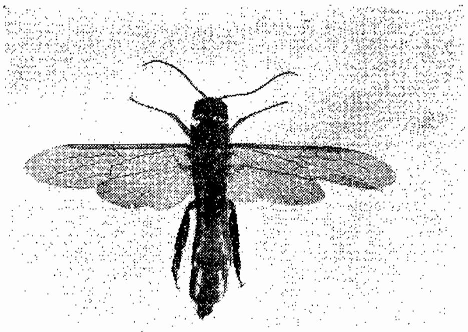
Heat treatment is the usual method recommended for the destruction of *Sirex* eggs and larvae in infested timber. Steaming or kiln treatment to attain a minimum temperature of about 130°F. inside the wood will kill all stages of the insect in a short period. Surface spray treatment of infested timber cannot be expected to kill the grubs below the surface and will not necessarily destroy the emerging wasps. Fumigation, if very thoroughly applied, would be more effective, but there are practical difficulties in this type of treatment where large quantities of timber are involved. However, in oversea countries where *Sirex* is already established, treatment of sawn timber is not normally given as the structural damage caused at this stage is usually unimportant. Heat treatments now being given to infested timber at Australian ports are essentially quarantine measures.



Larva of *Sirex* sp., approx. 1 inch in length.



Sirex (*Urocerus*) *gigas* female wasp.



Sirex juvencus male wasp.

Ramsay, Ware Publishing Pty. Ltd., 117-29 King St., Melbourne, C.1.

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FOREST PRODUCTS NEWS LETTER

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No. 186 1951##186 June-July, 1951.

MOISTURE CONTENT AND THE PROPERTIES OF TIMBER—Part 2

by K. E. Kelsey, Timber Physics Section

3. The Effect of Moisture Content on Dimensions

It is a fact too often experienced in practice not to be realized that shrinkage and swelling accompany changing moisture content. Checking and warping which result from shrinkage are often observed in wood which has been dried from the green condition, and even in seasoned timber used in joinery, swelling in humid weather can result in jammed doors and windows, buckled table tops, and many other undesirable effects. Much work has been done in an attempt to prevent shrinkage, but so far no entirely satisfactory solution to the problem has been attained, although the effect can be reduced by chemical seasoning and by careful design.

The shrinkage of the wood can be explained on the basis of the cell wall structure given earlier. As the water leaves the cell wall, the strong attraction of the cellulose molecules for each other causes them to draw together, and thus the total volume of the cell wall is reduced. The decrease in volume of the cell wall is approximately equal to the volume of the water lost, and this in turn causes the total volume of the wood to decrease by approximately the same amount. The fact that the radial shrinkage is usually about half that in the direction tangential to the growth rings has already been explained in News Letter 184. The same article also explains the variation in the very small longitudinal shrinkage by variations in cell wall structure. This unequal shrinkage in the different directions in the wood is the cause of much of the warping, checking, bowing, and diamonding which occurs on drying and this must be allowed for when the final dimensions of seasoned timber are important.

Differences in shrinkage between species are very considerable; for example, the tangential shrinkage from green to 12 per cent. moisture content of karri is about 10 per cent. of the green dimension while that of radiata pine is only about 4 per cent.

The shrinkage of wood in a given direction depends in a simple way on the moisture content. As mentioned earlier, shrinkage is caused by the water leaving the cell wall, and the cellulose molecules then being drawn nearer to each other. Under ideal conditions, no decrease in volume in the cell wall accompanies the removal of water from the cell cavity in green wood, and consequently, no shrinkage of the wood as a whole occurs. Shrinkage occurs on drying when a moisture content has been reached such that the cell walls begin to lose water and it will be recalled that most of the water has been removed from the cell cavity before this. On further drying, the shrinkage is approximately proportional to the loss in moisture content so that the significance of the point at which the cell walls begin to lose water can be appreciated. This moisture content below which under ideal conditions the shrinkage is proportional to the moisture content loss is known as "the shrinkage intersection point."

However, in practice, the shrinkage from one moisture content to another depends on the way in which wood is dried. If green stock is dried very rapidly, or if the dimensions of the timber are large, the moisture content near the outside may be fairly low, and well below the intersection point, while that at the inside may still be quite high. In such a case, an appreciable moisture gradient exists in the piece. The outer portion will have a tendency to shrink, but the inner portion has not yet reached such a low moisture content, and so cannot shrink to the same extent. A balance will be attained by the shrinkage of the outer portion being reduced while the inner portion is subjected to compression by the outer. When drying is finally complete and the whole piece has come to equilibrium moisture content, there will be a tendency for the inner portion to shrink but this will be restricted by the outer portion whose shrinkage occurred earlier, and thus the inner portion will be now under tension, and the final dimensions of the piece will be greater than if no moisture gradients had been present on drying.

Another type of degrade which can occur during drying is the occurrence of irregular regions of extraordinarily high shrinkage. Microscopic examination of the cross section shows that the cell cavities are no longer open, but have "collapsed." This can be seen in Figure 2 (a). This collapse occurs in the early stages of drying, and in contrast to normal shrinkage accompanies the removal of water from the cell cavity. During the removal of this water liquid tensions are set up which tend to draw the cell walls together. The wood being at a high moisture content, the rigidity of the cell walls is at a minimum and may be less than that required to resist the liquid tensions. In such a case, collapse will occur. It is unfortunate that many of the common Australian species, especially the lighter eucalypts, are subject to severe collapse on drying.

Fortunately, however, a treatment has been discovered which, provided the wood has not been dried to too low a moisture content, will not only relieve the stresses set up in drying when moisture gradients are present but will also restore the collapsed cells to their original form. This reconditioning treatment, as it is called, consists in exposing the wood to an atmosphere of steam for a period of a few hours. During this period the high temperature softens the cell walls while the high humidity keeps their moisture content high, and the natural elasticity of the cell walls causes them to return to their normal shape.

The effect of reconditioning on the cross section of Figure 2(a) is shown in Figure 2(b). Figure 3 shows a badly collapsed specimen of wood and a matched specimen after reconditioning and redrying.

For further information on the effect of moisture on shrinkage, and on collapse, the interested reader is referred to two trade circulars published by the Division, namely,

No. 20. Collapse and the Reconditioning of Collapsed Timber.

No. 23. The Shrinkage of Wood during Drying.

These are available at the Division on request.

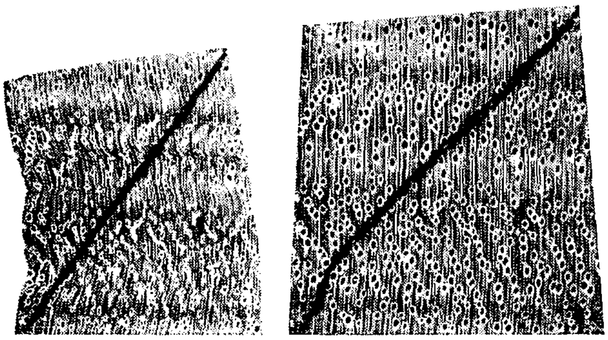

Figure 2.—(a) Cross section of a block of mountain ash, showing the distortion of the cells caused by collapse. (b) Same section as in (a), after reconditioning, showing the restoration of the cells to their normal shape. Note the distortion of the diagonal line due to this restoration.

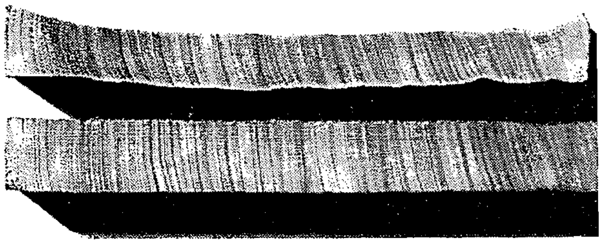

Figure 3.—Collapsed sample showing its characteristic distortion, paired with a matched piece which has been reconditioned and redried.

4. The Effect of Moisture Content on Density

The weight of unit volume of timber is of great importance to the trade, not only in the transport and handling of timber, but also as a means of assessing its properties, many of which are closely related to the density.

The preceding discussion has shown that a piece of wood consists of wood substance (mainly cellulose and lignin), water, and air. Since the weight of the air can be neglected, the density at any moisture content is given by

$$\frac{\text{weight of wood}}{\text{total volume}} = \frac{\text{weight of wood substance} + \text{weight of water}}{\text{total volume}}$$

It has already been mentioned that the moisture content of green wood may be as high as 300 per cent. The change in volume associated with this change in moisture content is small in comparison with change in weight, so the need for specifying the moisture content at which the density is determined is evident.

Since the volume is scarcely affected by moisture content above the intersection point, the green density of a given piece of timber is only affected by the actual weight of water it contains. This, as previously discussed, is extremely variable, so that any value for the green density of a species must be regarded as very approximate. The green density, however, cannot exceed the density of wood with all its cavities filled with water. This maximum green density can be calculated quite simply if the density of the wood substance itself is known.

The value of the density normally used in the timber industry is the air dry density, or the density at 12 per cent. moisture content. This includes allowance for the shrinkage from the green condition, and therefore may be affected by collapse and drying stresses. For this reason, values of the air dry density are usually determined both before and after reconditioning.

Just as the oven dry weight of wood is the only sound basis for any weight specifications, the green volume, the volume of the wood before any shrinkage has occurred, is the only sound basis for any volume specifications. It is from these two properties that the "basic density" is derived, the basic density being defined as the ratio of the oven dry weight to the maximum volume. Thus the basic density is independent of the moisture content and history of the sample. Of course the basic density does not represent the density of wood in any condition ever realized in practice, and so is not so valuable from the point of view of timber transport or use but is of value in the comparison of the density of different species as the effect of unequal shrinkage is eliminated.

The variation in air dry density from species to species is very great, ranging from 7 lb./cu.ft. for balsa to 70 lb./cu.ft. for red ironbark.

The density of the wood substance itself has been found to vary very little from species to species, so that the variations in density between species must be attributed almost entirely to differences in wood structure. The volume occupied by the wood substance can be determined by immersing the completely dry wood in a medium which will fill all the cell cavities, and all the spaces in the cell wall, and measuring the volume of liquid displaced. The result will vary slightly depending on the degree of swelling, but to a reasonably good approximation, the wood substance has a density of 93 lb./cu.ft., i.e. it is about half as dense again as water.

5. The Effect of Moisture Content on Other Properties

In addition to the way moisture content affects shrinkage and density, it also has a considerable effect on electrical, thermal and mechanical properties. The well-known resistance type moisture meter depends for its operation on the fact that over the range of equilibrium moisture contents normally encountered in practice, the electrical resistance of the timber varies tremendously, there being a simple relation between resistance and moisture content. This relation is similar for all species, but there are small differences between species, so that standard moisture meter readings have to be corrected according to the species used. For green timber, there is little variation in resistance with moisture content, so that for this property, as for shrinkage, an intersection point can be determined. The value of the electrical resistance intersection point may not, however, be identical with that for shrinkage. Because of the existence of this intersection point, the resistance type moisture meter is only useful for material which has been dried below the green condition.

The dielectric constant of a given piece of timber varies with moisture content, and this fact has been utilized in another type of moisture meter. The thermal insulating power is also affected, a considerable decrease in insulating power accompanying an increase in moisture content.

The various strength properties are usually decreased by an increase in moisture content. As the water enters the spaces between the cellulose crystals, they are forced apart, and become more and more independent of each other. The bonding force between the cellulose molecules is thus reduced, and this is usually accompanied by a decrease in the strength of the wood as a whole.

The strength-moisture content relations also possess intersection points, at moisture contents above which strength is independent of moisture content. These again may differ from the values for the intersection point for other properties. The reason for the variation in intersection point is not understood, particularly in the light of the fact that it was once thought that there was a definite moisture content at which the cell cavities become empty and the cell walls begin to lose water.

DECOMPOSITION OF SOME AUSTRALIAN WOODS TO YIELD AROMATIC ALDEHYDES

By D. E. Bland

Wood Chemistry Section

In studies of the chemical composition of Australian woods one technique employed at the Division of Forest Products is the chemical breakdown of the wood by treatment with nitrobenzene and alkali. This chemical treatment has been known and employed for several years. Its effect is to bring about almost complete destruction of the carbohydrate fraction of the wood but to give a controlled breakdown of the lignin into fairly high yields of aromatic aldehydes. The study of the nature and amount of the different aldehydes produced gives a valuable insight into the chemical constitution of the wood, more particularly of the lignin fraction about which less is known than about the carbohydrate fraction.

It has been shown in Germany that treatment of coniferous woods by this method yields an aldehyde called vanillin. Soon after this it was found by workers in U.S.A. that deciduous woods, treated in the same way, yield vanillin and another aldehyde named syringaldehyde. Some notes concerning the nature of these two substances may be of interest. Vanillin was discovered in 1858 when it was isolated from the pods of *Vanilla planifolia* from which it was named. It is from these pods that the popular food flavouring "essence of vanilla" is made. It was not many years after the recognition of vanillin as the principal flavouring material in essence of vanilla that it was made synthetically and from this it was a short step to artificial essence of vanilla. Vanillin is not used alone as the flavouring in the artificial essence but in combination with small amounts of other substances. It is claimed by many that the artificial essence is inferior to the "natural" product; nevertheless the artificial essence has to a considerable extent replaced it. Vanillin is now manufactured on a large scale as a by-product of the sulphite pulping of coniferous woods in U.S.A. and Canada.

As there is no sulphite pulping in Australia there is little possibility of obtaining vanillin as a by-product. It is unlikely that treatment of wood specially to obtain vanillin would be profitable because of the consumption of chemicals in the process. In any case it can be seen from results given later that the eucalypts show no promise as a source of vanillin.

Syringaldehyde is a substance chemically closely related to vanillin but it has not its flavouring properties. It was prepared as a synthetic product early in the present century and recorded as having an odour of vanilla. We now know that this was due to contamination with vanillin, properly purified syringaldehyde has no characteristic odour. No use has been found for syringaldehyde; it remains a substance of scientific interest only.

In view of the results obtained by nitrobenzene oxidation of coniferous and deciduous woods the products obtained from Australian woods, particularly the eucalypts, will be of interest. A number of eucalypts and two southern hemisphere conifers have been studied. It has been found that the eucalypts, like the deciduous woods, yield both vanillin and syringaldehyde, whereas the conifers yield only vanillin. Analysis of the crude aldehydes from these woods by delicate methods revealed that a small amount of a third aldehyde is produced. This has been isolated and shown to be p-hydroxybenzaldehyde. The amount of this substance is so small that for practical purposes it may be disregarded. The yields of aldehyde from various woods and the percentages of vanillin and syringaldehyde in the aldehyde mixture are shown in Table 1.

TABLE 1

Aldehydes from Australian Woods

Wood	Yield of Crude Aldehyde % of Wood	Pure Vanillin in Aldehyde %	Pure Syringaldehyde in Aldehyde %
Mountain ash	9	14	68
Messmate stringybark	9	16	78
Alpine ash	8	16	77
Jarrah	6	34	54
W. A. blackbutt ..	8	23	64
Blackbutt	7	23	64
Spotted gum	6	13	80
Marri	6	20	68
Red bloodwood	7	22	66
Red mahogany	8	19	65
Sydney blue gum ..	8	20	68
Karri	8	13	79
Hoop pine	5	84	0
Celery-top pine	5	75	0

Some features of these results are noteworthy. The high percentage of syringaldehyde yielded by the eucalypts shows that the chemical structure of their lignins resembles that of the deciduous woods. However, there is considerable variation among the eucalypts which shows that eucalypt lignin is not a chemical entity. The southern hemisphere conifers give vanillin as the principal product and in this respect are similar to the northern hemisphere conifers.

Details of this investigation will shortly be published in the Australian Journal of Scientific Research Series A, Vol. 3, No. 4.

THE PROPERTIES OF AUSTRALIAN TIMBERS

MARRI GUM

Marri is the standard trade common name for the timber known botanically as *Eucalyptus calophylla*, R.Br.; This timber is also called redgum in Western Australia.

Distribution: This species is found in Western Australia throughout the entire jarrah and karri forests, extending northwards to Dandaragan and eastwards to Harrismith in the Wandoo forest.

Habit: Marri is a tree of 70 to 140 feet in height with a bole of up to 50 feet and a trunk diameter up to 6 feet or more. The tallest specimens are in the southern portion of its range.

The bark is rough, persistent and flaky (not fibrous) and is light grey in colour in the younger trees and friable in small threads. It becomes more flaky in the mature tree and changes colour to a brownish-dark grey.

Quantities of a deep red kino 'gum' are commonly exuded from the bark and contained within large concentric gum veins in the wood.

Timber: The wood of marri is light brown in colour, with some pink tints. Gum veins are very common (in this respect marri is similar to the bloodwoods of the East). It is moderately heavy open textured, non fissile and has slightly interlocked grain.

Marri has a green density of 76 lb/cu. ft. and an air-dry density before reconditioning of 53.4 lb./cu. ft.; thus it is slightly heavier than jarrah (51.4 lb./cu. ft.) and lighter than karri (57.4 lb./cu. ft.).

In drying from the green condition to 12 per cent. moisture content, the average shrinkage of a backsawn board, including slight collapse, is 6.6 (tangential shrinkage) and the average shrinkage of a quartersawn board is 3.7 (radial shrinkage). Reconditioning reduces these averages to 5.6 and 3.4 respectively.

Seasoning: Very little information is available relative to the seasoning of marri except that it dries without undue shrinkage and twisting. The jarrah schedule may be adopted and this will possibly be found to be somewhat conservative.

Mechanical Properties: Marri is reported by Julius to have a modulus of rupture to 16,600 lb. when dry, and 11,400 when green; thus it is slightly stronger than jarrah in this respect. These figures are for selected timber free from gum veins and the general run of marri is likely to be less strong than the above figures would suggest.

General: The sapwood of marri is relatively susceptible to attack by the powder post borer (*Lyctus* spp.). The timber is not considered durable, being classed in durability classes 3 and 4, but this view may have arisen due to its use chiefly as round saplings. It has never been hewn due largely to the availability of jarrah and wandoo. Thus it may be said that marri heartwood has not had reasonable testing as to its durability.

Uses: Marri has been used for weatherboards and general building scantling, case manufacture, knees for small craft, general mill work and waggon stock.

The kino (gum) of marri is available in large quantities, but gathering is expensive and has never attracted collectors. The tree exudes large quantities of the red liquid kino which is largely absorbed by the bark. It is this kino-impregnated bark which could be used for extract making. The kino contains a high percentage of tans, but also possesses a bright red colour. It has been found that a good coloured extract may be prepared by extracting the bark at 60°C and subsequently treating the extract with sodium bisulphite.

Work carried out at this Division shows that the kino, which was previously considered homogeneous, contains at least 12 different components. The kino has been separated into a red pigment (25 per cent.) and a brown residue. Simple compounds have been separated from these, and it is hoped that future work will indicate a suitable method to remove the detrimental red colour of the kino.

PUBLICATIONS

The following Trade Circulars, which were out of print for some time, have been reissued in a revised form and are now available on application to the Chief, Division of Forest Products, C.S.I.R.O., 69-77 Yarra Bank Road, South Melbourne, S.C.4.

No. 12:—Combined Air and Kiln Seasoning: Handling by means of the Christensen truck

No. 17:—Types of Timber Seasoning Kilns

No. 19:—Gluing Practice, Part 2: Casein Glues

No. 22:—Timber Bending

No. 27:—The Preservation of Timber

No. 30:—The Chemical Utilization of Wood

No. 32:—Causes and Detection of Brittleness in Wood

No. 42:—Selection of Timber, Part 3: Plywood: Its use and grading

Plywood Research

Ten years of research on Australian timbers to augment supplies of hoop pine for veneer and plywood manufacture are described in C.S.I.R.O. Bulletin No. 260 issued recently.

Heavy inroads into hoop pine forests during and after the war have depleted the supplies of suitable logs of this timber, which was formerly the chief veneer and plywood timber in Australia. The researches undertaken by the Division of Forest Products of C.S.I.R.O. on more than 60 species indigenous to or extensively planted in Australia, have aided manufacturers in their search for substitute timbers.

The report provides, for each timber, information on the need for steam treatment or heating in water to soften the logs before veneer cutting, the thickness of veneer which may be cut, recomended drying conditions, the proportion of usable dry veneer which may be recovered, and the quality characteristics and potential uses of the resulting veneer.

Mention is also made of the treatment of veneers necessary to prevent staining by moulds and other fungi and to immunize sapwood against Lyctus borer attack.

Copies of Bulletin 260 are available on request either from the Secretary, C.S.I.R.O., 314 Albert Street, East Melbourne, or the Chief, Division of Forest Products, C.S.I.R.O., 69-77 Yarra Bank Rd., South Melbourne.

C. S. I. R. O.

FOREST PRODUCTS NEWS LETTER

This monthly bulletin is prepared for general circulation by the Division of Forest Products, C.S.I.R.O., 69-77 Yarra Bank Road, South Melbourne, S.C.4., and will be supplied free on request to members of the timber trade and timber users who wish to keep abreast with current developments in the field of forest products.

No. 187. 1951##187 August-October, 1951.

UTILIZATION OF SAWDUST

The problem of disposing of sawdust economically is a difficult one, despite its many and varied uses. Some of these make no special demands, but to be satisfactory for specialty purposes sawdust must conform with certain requirements of colour, particle size, moisture, resin or tannin content. For some special purposes trade custom is so firmly established that trials are very difficult to arrange for sawdust from species other than those already accepted.

The main use for crude sawdust at present is for fuel. Appreciable quantities are used for litter, packing and insulation. Some selected sawdusts are used for stuffing, food preservation, compost, ingredient in compositions, wood meal, wood flour and abrasives or absorbents. Notes on these uses are given below.

Fuel

The use of sawdust for fuel offers the greatest possibilities for absorbing large quantities of green or dry sawdust, but this is fundamentally dependent on local markets, as transport costs make its use uneconomic at even short distances from it source. For industrial heating, the ideal method is to burn it as fuel under boilers fitted with a suitably designed furnace, such as a step grate or a Dutch oven. For domestic purposes, it is again necessary to use special burning equipment. Such sawdust burning stoves and hot water heaters have been used in Europe, England and America for many years, and space heaters now have widespread usage in Australia.

An alternative to the burning of sawdust in loose form is to manufacture briquettes which can be burnt in ordinary fireplaces, stoves or furnaces. To do this successfully it is essential to have either a cheap binding material (which is at present unobtainable in Australia) to enable briquetting at low pressures, or to have expensive and elaborate machinery capable of briquetting without the addition of a binder by employing very high pressures. For the latter operations to be worth while it is essential to have a large output—at least 9 tons per day—to operate the smallest economic plant.

There are definite limits to the amounts that can be absorbed for uses other than fuel and plants favourably situated in or near centres of large population are the only ones that have the chance to contact potential users who will pay satisfactory prices for all types of sawdust. Consequently a survey of the potential local markets is generally desirable.

Litter

Dry sawdust is necessary for bedding cattle, protecting dance floors and covering domestic floors during re-decoration of walls and ceilings, but apart from dryness, no other particular restriction on sawdust seems necessary for purposes such as these. For butchers' floors and for sweeping compounds to prevent dust from rising, a damp sawdust is generally satisfactory.

Packing

Sawdust for packing goods for transit should be dry, free from injurious chemicals, and for many purposes should be odourless. As a substitute for granulated cork for packing grapes. it should be fairly coarse but free from splinters. Suitable sawdust can be cut with a special drum saw or may be obtained by sieving.

Insulation

Sawdust for packing ice-chests, refrigerators, cool stores, etc., should be dry, free of strong odours or volatiles which will contaminate goods placed therein.

Stuffing

For stuffing cushions, dolls' bodies, toys etc., sawdust should be dry and free from splinters or too much fine dust.

Food Preservation

Sawdust is a regular fuel for producing smoke for the curing of fish or meat. For this purpose it may be wet. It must give off a satisfactory volume of smoke of such a quality that it will not impart any undesirable odour or flavour to the foods.

Compost

Although sawdust has been used for this purpose for many years, it is only in recent times that careful study has been given to the role sawdust plays when mixed with soil. Rotted sawdust, or humus, is more important for its physical effect on the soil as a place for plant roots to grow than a source of plant food. Mixed with heavy soils, it tends to loosen them, increase the water holding capacity and lessen erosion.

Ingredients in Compositions

(a) **Floors:** Sawdust is an important ingredient in quite a number of flooring compounds. The mineral base of most of these substances is magnesium oxychloride. Probably the most common filler is wood, chiefly in the form of sawdust. There is considerable variation in the type, kind, grade, and proportion of sawdust used in making composite flooring. Chiefly, however, hardwood of 20 to 40 mesh is used. The proportions of sawdust in the mixture may vary from 4 per cent to 70 per cent and more. One type of flooring, in which 70 per cent sawdust is reported to be used, employs kiln-dried hardwood sawdust of 20 mesh for the top layers and coarse softwood sawdust for the base. Another type of composition flooring is said to contain 85 per cent sawdust.

Sawdust is often used in composition floors that are to be covered and to which it is desired to nail the covering. The sawdust makes the floor light and porous so that the nails can be readily driven into it.

(b) **Concrete Products:** Sawdust and shavings are used to some extent as fillers in various types of concrete-like products. Concrete of these types is light and porous, holds nails and screws well, and has fair insulating qualities. One concern uses mineralised sawdust (sawdust treated with iron compounds) in making a light weight concrete. About one-third to one-half of the weight of the material is sawdust. The product is said to be highly wear resistant, fire resistant, a non-conductor of sound, and more comfortable to walk on than concrete. It can be sawn, nailed, screwed, and polished. Sawdust-concrete floors are sometimes laid where it is desired to attach wooden construction by means of screws and nails.

The use of sawdust in place of sand in the making of cement barn floors has also been found, in at least one instance, to produce a floor which is warmer and less wearing on the hoofs of the cattle than ordinary cement, and the report states that after several years the floor was still in as good condition as when first laid. Reports of other similar concrete work, however, are not so satisfactory.

(c) **Cast Products:** The number of products made by casting mixtures containing sawdust is increasing. Cast products include tiles, fire bricks, shingles, plumbing ware and floor marble. One firm manufacturing the items noted uses 80 to 90 per cent sawdust in the mixture. The cast products are said to hold nails well and can be sawn. A very beautifully mottled wall and floor tile has a high percentage of shavings in its composition. It is used for bathroom and other interior purposes.

(d) **Stuccos and Plasters:** There are several composition stuccos and plasters sold commercially that use sawdust as fillers. The wood particles help to bind the mass together. The resulting mixtures are lighter and more porous than ordinary stuccos and plasters. They can be nailed without damage, and are said to have better insulating qualities than the ordinary product. One of these compounds, said to contain 80 per cent sawdust, is used for stuccoing, interior plastering, and, in a modified form, for floors. Another is sold as wood plaster. The filler of this compound is ground sawdust.

The use of sawdust plasters and stuccos is not increasing greatly, and the chances of any considerable development along these lines are not very promising.

(e) **Gypsum Compositions:** Sawdust is used with gypsum in the manufacture of a number of commodities. Sawdust decreases the weight of the products, makes them more porous, increases their insulating qualities, softens the material so that it can be nailed and sawn, and lessens the cost of the finished articles. The following are typical gypsum products in the manufacture of which some sawdust may be used: interior partitions, floor insulation, wall insulation, wall boards, cast products of a variety of kinds, and roofing material. The last-named product is a recent addition to the family of gypsum-sawdust products.

Sawdust and shavings used in mixtures with gypsum are usually light coloured, light weight, and of non-staining species.

(f) **Clay Products:** In the manufacture of porous clay bricks and tile, it is necessary to mix with the clay a substance which will be consumed during the burning and leave the finished product with a porous structure. For this purpose either sawdust or finely chopped straw is used. The sawdust should be dry and sifted to produce uniform results.

Hollow clay tile for partitions is made light and porous by adding 25 to 35 per cent sawdust. In the burning process the sawdust burns out, and the resulting product is soft and porous. When certain clays are used the product can be nailed and cut with ease. A semi-porous tile is made by adding 20 per cent sawdust. The use of sawdust in the manufacture of clay and gypsum products is probably decreasing, because of the rather general use of "bubbling" compounds for the purpose of expanding the mass to lighten its weight and increase porosity.

(g) **Building Boards:** Composition boards made from sawdust by the application of heat and pressure, with binders, appear to be a promising outlet for sawdust and shavings where a sufficient supply is available. New processes have been developed during the last few years both in this country and abroad. Under favourable economic conditions hard sheeting, either flat or moulded into forms, can now be made from sawdust by the addition of synthetic resin or blood binders.

To justify the expensive hydraulic press and other equipment that is necessary, a plant would need a fairly large production. Supply of dry waste must be assured.

Wood Meal and Wood Flour

(a) **Explosives:** Wood meal is used as an absorbent and a source of carbon in some explosives. A certain limited percentage of resin, volume/weight ratio, nitro-glycerine absorption, prescribed particle size and low moisture content appear to be the fundamentals. Whereas in the past explosives manufacturers were particular to specify "prepared from white pine sawdust or other similar softwood," it has recently been demonstrated that provided the woodmeal conforms with the fundamentals, numerous species or blends of species yield satisfactory woodmeal for explosives.

(b) **Linoleum and Plastics:** Wood flour for these purposes is usually prepared by grinding finely sawdust from non-resinous coniferous timbers although some of the medium and low density pored timbers are also used satisfactorily. It must be dry, and must be readily convertible into the requisite particle size and texture and the necessary volume/weight ratio. For many purposes the flour must be almost white and have a low resin content.

New types of plastics, in which 80 to 85 per cent by weight of the materials used is sawdust, are being developed. Ordinary dry sawdust, which in tests so far has been hardwood, is hydrolysed, after which it is dried and ground to the fineness of wood flour. To this dried mass certain chemicals are added and the whole thoroughly mixed. The resulting stock may be placed in heated moulds and consolidated under heavy pressure.

(c) **Moulding Compounds:** Sawdust ground to the proper fineness is utilized as an ingredient in many moulding compounds used for the manufacture of such articles as dolls' heads. Common binders are starch, flour, animal glue, resin, gutta-percha, gum arabic rubber latex, casein and blood.

(d) **Plastic wood:** Plastic wood for stopping holes or repairing cracks, etc., is made from wood flour, nitro-cellulose, ester gum and other materials dissolved in solvents.

Absorbent or Abrasive

Sawdust is frequently used as an absorbent for removing water or other liquids from pressed or shaped articles. It also finds use as an abrasive and buffer in rumblers for polishing small metal goods.

For both these purposes it must be dry and in special cases must be free from resins and tannins.

WHAT WOOD IS THIS?

Part 4.

By M. M. CHATTAWAY, Wood Structure Section

How to Make a Key for Identifying Timber:

The principles underlying all mechanical devices for identification, whether of plants or animals or timber, are fundamentally the same. The features to be used having been decided on, the specimens to be identified are examined for each feature in turn to find out whether it is present or not. At each examination separation into two groups occurs, the number of specimens in each getting fewer as more groups are formed. This subdivision is continued until only one specimen remains.

This type of key is relatively simple to prepare, and it is a common and useful exercise to give students a collection of timbers with which they will be working at some future date and to allow them to make their own keys. This type of key is usually referred to as a *dichotomous* key as it is based on the principle of two alternatives and sorts the woods into two groups at a time. Its great disadvantage is that the features are always considered in a definite order, so that a moment is liable to come when the less experienced user—and indeed sometimes the experienced one too—is faced with a decision he is unable to make: "Is such-and-such a feature present or not?"; "Do I call this size intermediate or small?" The user of the key must make a decision because the key demands it; he cannot do so because his lens isn't strong enough to allow him to see clearly, or because he hasn't enough knowledge or experience to make up his mind. The result is that he either gives up in disgust, or laboriously follows on through both groups in the hope of picking up some clue later on.

It was to resolve this quandary that the card-sorting system was first applied to the identification of wood. By using this system there is no arbitrary order in which the features must be taken, and obscure or doubtful features can be left till last, or even neglected altogether without prejudice to the final result. As with the dichotomous key, once the underlying principles are grasped it is quite easy to build up one's own key, and to add to it from time to time as sufficient details of new timbers come to hand. The cards can be kept in any order, so that the addition of new ones presents no problems of arrangement.

Multiple entry perforated cards are used for this key, each card representing one species, or a group of inseparable species. Each perforation on the card represents one anatomical feature that can be seen on the wood, or one other piece of information such as weight, hardness and so on, which helps to identify the timber.

Although the card-sorting key may be quite an elaborate affair, with printed cards on which each hole is well labelled according to the feature it represents (Fig. 17a and b), this is an elaboration that is not necessary for the amateur who is preparing his own key. Indeed, to learn the timbers and the values of the different features it is far better to prepare one's own key than to accept one ready made from someone else. Making your own cards may take time, but that time is well spent if it familiarises the maker with the different wood features, and increases his powers of observation with a lens.

A plain punched card on which the holes are numbered is all that is needed, and a feature list to correspond, in which each number on the card is that of one of the features on the list. This may at first make the work slow when the key is in use, but familiarity with the list is soon acquired and the most used numbers readily memorized. The great advantage for a beginner is that the features used are not so briefly listed as when they are printed on the card, and a short descriptive sentence may be added to the list.

The features enumerated in earlier parts of this article (see News Letters Nos. 182-3, 185), are the ones that have proved the most useful with both a *dichotomous* and a *card-sorting* key. When the list has been prepared and numbered and the cards with numbered holes are ready, the method of making a card-sorting key is as follows: Examine the specimens of a known timber and list all the features you can find, both those which you can see with the naked eye and those that can only be seen with the lens. Check this list if possible against several authentic specimens, as there is often a good deal of variation from sample to sample. When you are certain that you have checked every feature on the list, take a card and name it for the wood you are examining and notch out all the features you have found for it. If you are in doubt about a feature it is safer to notch the card, provided you indicate on the card that this is a doubtful feature, or difficult to observe, or that it occurs in some specimens and not in others. It is always better to end with too many cards than to eliminate one which may be the wood you want. Add to the back of the card any details about the wood that you may have found which are not among the listed features, and your card is then complete, ready to be used when a bit of wood with just those features comes to hand. Gradually your set of cards can be increased as more authentic samples of timber come your way, or it may be added to from descriptions and from data given by other wood anatomists.

When you come to use this key, the procedure is to check the features of the unknown timber against those on the list, noting their numbers, just as you did for the known timber when you were making the key. Then make sure that the cards are all facing the same way—i.e., that the cut-off corner is uppermost and to the right—and run a knitting needle or fine rod through the hole corresponding to one of the features. Experience will teach you which features prove most reliable and helpful, and these are the ones to take first. All the notched cards, representing woods in which this feature is present, will drop from the pack. Those without it remain on the needle and can be discarded. By repeating this process with other features fewer and fewer cards are retained, until only one or two remain. Sometimes only one card will drop on the final sorting, but even if two or three are left it is usually possible to distinguish the wood in question from details listed on the back of the card, or by a comparison of other notched features which have been neglected previously — those difficult or doubtful features that are so very troublesome in a dichotomous key, but which can by this system be left till last.

If photographic apparatus is available, small photos showing the wood at a low magnification can be affixed to the back of the card (Fig. 17b). These show the wood as it appears with a hand lens and are very useful for a final check against the actual timber specimen to confirm the identification. They can also be used

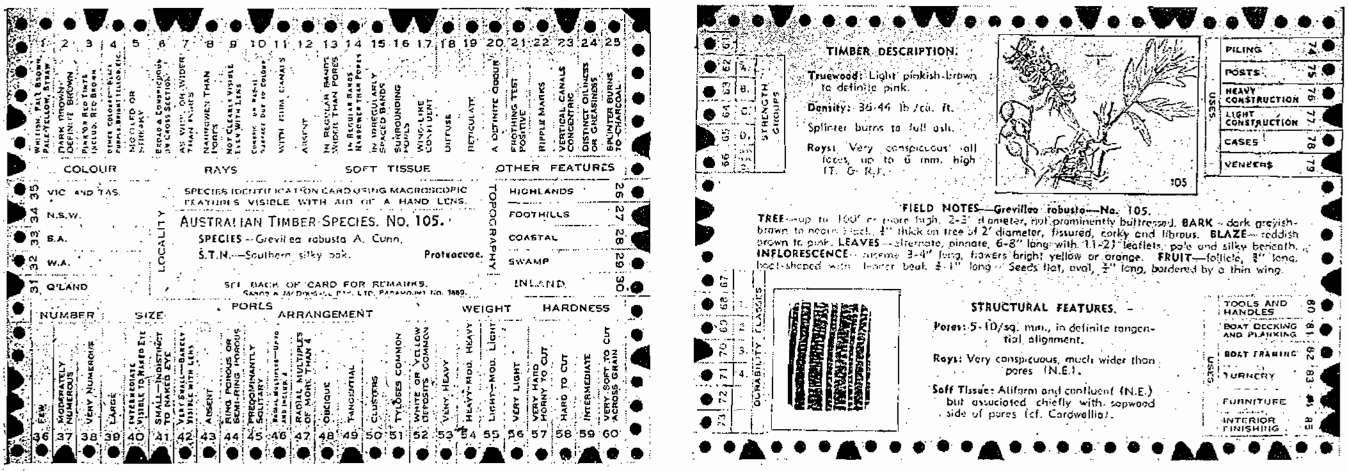

Figure 17.—Specimen card for use in a card-sorting key. Front and back of the card are shown.

for separating two woods which have dropped out together through having similar features notched, but which can be separated by subtle differences and tissue contrasts that are difficult to put into words, but which nevertheless show clearly in a photograph.

The card-sorting key gives a quick way of identifying far more timbers than can be carried in the memory, and though it will not give the answer in the case of a totally new or unknown wood for which there is no card, it can still help towards its identification. Timbers with similar structure often turn out to be related, belonging to the same family or genus. If a totally new timber is sorted on its most conspicuous features a nearly related timber may be among those which fall out, so that it may be possible to get an idea of its family, sometimes even of its genus. This can give the needed clue, and further reference to books may produce a description that will place its identity beyond doubt.

CASEIN GLUE SHORTAGES

Urea Formaldehyde Glues the Answer?

By ALAN GORDON, Officer-in-Charge, Veneer and Gluing Section

The winter of 1951 stands out as a period which plywood and furniture manufacturers and other glue users will remember well for the shortage of lactic casein, the basic component of the major part of the glue used in Australia. Casein production drops each winter and this year stocks were low partly because of the dry summer and low milk production but also because larger quantities of milk have been diverted for dried milk, for condensed milk or for cheese production, any of which is more profitable. The answer to the shortage of lactic casein and consequently of ready mixed casein glues appears to be the adoption of urea formaldehyde glues, which were introduced to Australia in the early war years. Although other materials such as soya bean, dried blood, dried buttermilk, peanut meal, cottonseed meal, saffron flour and starch have been investigated either as glue bases or as extenders for lactic casein glues, none of these is as easy to use as lactic casein. In addition, with the possible exception of soya bean, supplies are limited, of unsuitable quality or are more expensive.

In Europe and North America the use of casein glues has been largely superseded by synthetic resin and soya bean glues. With ample capacity for producing in Australia all the urea formaldehyde resins which would be needed to replace casein glues completely, it might seem surprising that a similar change has not occured here. What are the points for casein against urea glues in Australia? The lower cost of casein glues, the need for more careful control of gluing technique with urea glues, the necessity for importing urea supplies, and a natural inertia against change from established practices have held up rapid expansion of urea glue usage. However, the urea formaldehyde glue manufacturers are fully alive to the present possibilities of expanding their sales at the expense of casein glues and are vigorously seeking supplies of raw materials to increase production and sales.

Certain points concerning urea glues should not be overlooked. The glue is usually colourless and does not stain. The glue-line cost can be reduced by extending the syrup with a cheap extender such as wheat flour, and by applying thin spreads. The amount of water in urea formaldehyde glues is considerably less than in casein glues and redrying problems after gluing are considerably reduced or might be eliminated. They are more suitable for hot pressing and have better moisture resistance than casein glues. Some urea glue manufacturers claim that with hot pressing the glue-line cost with flour extended syrups is cheaper than casein glue-lines and that they can compete with casein glues for cold pressing plywood. It seems probable that casein prices will tend to rise, and if a large-scale demand for urea glues develops, their costs will tend to fall and a further expansion in use may be anticipated. Let us consider, therefore, the points to be observed carefully to get the best results and lowest costs with urea glues for plywood and assembly gluing.

(a) **Manufacturers' Instructions:** Follow carefully the manufacturers' instructions particularly in regard to storage, mixing, spreading and assembly and pressing times.

(b) **Moisture Content:** Careful control of moisture content of stock is necessary. For cold pressing 8-12 per cent moisture content is desirable. For hot pressing, lower moisture content may be required to ensure freedom from steam blisters.

(c) **Preparation of Surfaces:** Surfaces should be clean and freshly prepared and fit accurately so that intimate contact between the surfaces and glue is assured. Thick glue-lines will craze unless special gap-filling glues are used, and these are recommended for joinery and other assembly work where accuracy of fit is difficult to attain.

(d) **Storage of Glue:** Urea formaldehyde syrup has a limited shelf life which is reduced if exposed to high temperatures.

(e) **Mixing of Urea Formaldehyde Glues:** Mixing should follow manufacturers' instructions, and should be carried out in clean iron, tinplate, glass, enamel, earthenware or wooden vessels. Do not use copper, brass or aluminium.

(f) **Pot-life:** The period during which the glue remains usable depends largely on the temperature. High temperatures reduce pot life.

(g) **Spreading:** Thin spreads are necessary with close contact glues and are best attained with a finely grooved rubber roll spreader with plated doctor rolls. Brushes, scrapers or rollers may also be used.

(h) **Assembly Time:** Permissible open and closed assembly times are reduced under warm conditions. Follow the manufacturers' instructions.

(i) **Pressure:** For close contact glues pressures of about 100 p.s.i. for softwoods and 200 p.s.i. for hardwoods are desirable.

(j) **Pressing Time:** Low temperatures require very long pressing times. Temperatures of 70°F. or over are best. Gluing at temperatures below 60°F. is not recommended. High pressing temperatures may be obtained by hot pressing plywood or by providing suitably heated factories or rooms.

(k) **Cleanliness:** It is necessary that all glue mixing and spreading equipment be kept as clean as possible during operation and, with many glues, it should be cleaned thoroughly before ceasing operations for periods longer than 30 minutes. Personal cleanliness of operatives is desirable to minimize possible development of dermatitis. Some persons are very susceptible whereas others are relatively immune to this trouble.

The Division will be glad to advise specifically on points to be observed in changing to the use of urea formaldehyde glues or on problems encountered in using them.

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C.S.I.R.O.

FOREST PRODUCTS NEWSLETTER

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THE TANNING MATERIAL SITUATION

By W. E. HILLIS, Wood Chemistry Section

Tannins have been used from pre-historic times to convert hide into leather, probably in a manner similar to that used by the Australian aborigines who dissolved the kino (the brown gum) of the eucalypts, in water, which was carried inside the animal's skin during their nomadic wanderings. After such treatment with tannin the hide becomes resistant to decay and wear, will not swell in water, and remains flexible. Leather has become an essential part of our living, and it has been said that leather consumption is a rough indication of the standard of living. Leather was rated the seventh most critical material in the U.S.A. during World War II.

The controlling factor in the production of leather is the tanning agent. In order to reduce the time of the tanning process from the former 160 days to the present 30 days, various types of tanning agents are used. By suitable blending it is possible to produce different leathers to suit specific requirements.

Types of Tanning Materials

These may be considered as the inorganic, the synthetic and the vegetable tanning materials.

(a) **Inorganic.**— Chromium, iron, aluminium and zirconium salts have been used for tanning leather, but 'chrome-tanning' is the only process which is used extensively on a commercial scale. 'Chrome-tanning' can be carried out more rapidly than can vegetable tanning, and produces leather which finds its use where flexibility is more important than water-proofness, resistance to hard wear, and to fungal attack. Like other mineral tanning agents it does not impart the necessary solidity to leather. To make this leather suitable for heavy wear it must be impregnated with waxes and resins. As about 75 per cent. of the leather produced is heavy leather the use of inorganic tanning materials is unlikely to be used extensively. In 1947 one-tenth of the leather produced in the United Kingdom was made with chrome salts, and almost all of this was light leather.

(b) **Synthetic.**— In 1943, 50,000 tons of synthetic tanning materials (100 per cent. tannin) were manufactured in Germany to replace oversea vegetable tanning agents. Some of them are produced from phenols and some from naphthalene. Although they can be produced with a uniform quality or to suit specific requirements, it is unlikely that they will be used extensively for ordinary leather because their cost is prohibitive. At present-day prices the cost of one of the raw materials, viz., phenol, is alone at least three times the cost of imported wattle tannin. As it has been estimated that the cost of tanning material used represents at least 15 per cent. of the total cost of the finished leather, any increase would seriously affect consumer prices.

Other synthetic tanning materials are prepared from sulphited lignin (a waste product of certain wood pulp mills) and have found use as auxiliary agents. There are very large quantities of waste lignin of various types produced annually, and recently a new type, magnesium lignosulphonate, was found to produce a leather similar to that made with natural vegetable tannins, but in contrast with the latter it permitted a considerable amount of tryptic attack (an indication of resistance to rotting). It is possible that in the future lignin and its derivatives may be modified to suit the requirements of the leather industry, but that must wait the results of long term research because the concrete fundamental knowledge of lignin is, at the moment, rather scanty.

(c) **Vegetable.**— There are numerous materials of this type in use and they belong to one of three types, viz., catechol, pyrogallol or mixed. The first two types have specific properties which, in general present-day tanning practices, are complementary, although recently it was found that on altering certain conditions, tannins of the first type could be used in place of the second. These vegetable tanning materials are best considered individually in order of importance.

(i) **Quebracho :** This name has been given to several species of the genus *Aspidosperma* growing in the Argentine, Brazil and Paraguay, and producing trees rarely exceeding a height of 100 ft. or a girth of 8 ft. The heart wood yields more than 25 per cent. of catechol type tannin extract of high purity. Quebracho tannin can tan all types of leathers, but it is usually used in conjunction with other extracts which possess the necessary acidity for the manufacture of heavy leathers. This extract was formerly relatively cheap, but the scattered distribution of the trees in the remaining stands and their distance from the extraction plants, have increased transport costs and consequently the price of the extract. The tree does not reproduce by shoots and there is little natural regrowth. Because of this it has been estimated that the supplies will be cut out in the forseeable future unless better control of cutting is brought into operation. It is difficult to calculate a definite date owing to the lack of definite knowledge of the extent of the forests. The shortage of quebracho extract has already begun to appear, and eventually an annual replacement of at least 250,000 tons of tanning material (60 per cent. tannin content) must be found.

(ii) **Wattle :** The Australian wattle has been cultivated in South Africa for 60 years, and plantations now exceed half a million acres. On the basis of a harvest every ten years, five acres of wattle plantation produces one ton of wattle extract (catechol type) annually, so that at least 1950 square miles of wattle plantation would be required to produce enough extract to replace the quebracho extract. Wattle bark extract can replace quebracho entirely in the tan liquor and is regarded as the best substitute.

(iii) **Myrabolan :** This Indian tree *(Terminalia chebula)* takes twenty years to reach maturity, and the fruit which it bears for 50 to 100 years is collected from the forest undergrowth after it has fallen. Myrabolan extract (pyrogallol type) is an essential constituent for many tan liquors; it is not very astringent and produces a soft rather spongy leather, and is therefore complementary to the properties of wattle, quebracho and other astringent extracts. Almost 100,000 tons of dried myrabolan fruit (30 per cent. tannin content) were exported annually before World War II, but the amount has decreased since then owing to problems of collection and transport.

(iv) **Chestnut :** The wood of this tree has been the source of a considerable amount of tanning material in Northern America, France and Italy. It is a pyrogallol type and has been used chiefly for sole and other heavy leathers. A blight disease has seriously affected the trees in Europe and has killed the trees in North America, where the remaining dead trees will be cut out by 1960. As it will take many years to establish blight-resistant oriental chestnuts the United States will require a replacement for about 70,000 tons of 60 per cent. chestnut tannin per annum.

(v) **'Myrtan' extract :** With the exception of foliage the whole of the wandoo (*Eucalyptus redunca* var. *elata*) and powder bark wandoo (*E. accedens*) trees is used as raw material for this extract, which is an example of the mixed type. There is no reafforestation programme and the raw material is obtained from land being cleared for agricultural purposes in Western Australia. About 7,000 tons of extract are produced annually. It could replace chestnut to give a firmer and heavier leather, although the colour is darker than usual.

(vi) **Mangrove :** There are widespread areas of mangrove forests growing along tropical sea shores and swamps. From the bark of these trees a few thousand tons of extract are produced annually. Although it has been used extensively by the fishing industry it is not held in favour by the leather tanners because of the dark red colour it imparts.

(vii) **Others :** The barks of the oak, pine, larch and spruce are collected in Europe and used in the country of origin. It is unlikely that the volume of collection can increase appreciably without increasing the costs. Valonia (acorn cups and beard of Turkish oak) gives a tough firm leather; sumac (leaves, Sicily and Cyprus) gives a light leather; gambier (leaves and twigs of a climbing shrub, Malaya) is used as an auxiliary or preliminary tannin, and other tannins of minor importance are used in some cases for specific purposes. However, the possibility of large extension of production is remote.

The Situation

The world will require in the near future more than 300,000 tons of tanning materials per annum to replace the loss of chestnut and quebracho. If approximately the same price and quality of leather are to be maintained, new vegetable tanning agents must be found or the cultivation of suitable ones commenced. Because there is a spread of higher living standards, together with an increase in world population, a greater demand of leather and of tanning materials can be expected.

Oversea Investigations

These are concerned with four aspects :—

(a) the development of cultivated sources of vegetable tanning material
(b) the discovery and utilization of new sources of vegetable tannins
(c) the more efficient utilization of existing sources of tanning materials
(d) the development of synthetic tanning agents

Recently plantations of suitable materials, in particular wattle have been developed in Madagascar, Morocco, Tanganyika, India, California and Brazil, and there should be a total production of at least 50,000 tons of extract annually.

Sumac has been used in the United States to check soil erosion, and the leaf of this plant contains an appreciable amount of tannin. A recent investigation showed that in Virginia alone there is sufficient sumac growing wild to produce at least 20,000 tons of tanning agent annually (60 per cent. tannin). It is a pyrogallol type and produces soft, durable, pale-coloured light-weight leathers. However labour costs in producing the extract from the sumac leaf are higher than with the bark or wood.

There are more than 70,000 tons of tanning extract (60 per cent. tannin) potentially available annually from the bark of the western hemlock of the United States and Canada. This catechol type of tannin produces a firm good-wearing leather but with an undesirably deep colour. However the extract blends readily with others, so that the colour can be lightened. After a careful study in 1937 it was found that successful utilization of the bark hinged on a rather narrow working margin of profit. The situation has now improved as the cost of the major extracts has increased and suitable mechanical barkers have since been developed. A large portion of the western hemlock logs cut are transported in sea water and the bark takes up a certain amount of salt, which interferes with tanning. Recently Canadian workers showed that it is possible to remove the salt readily from the tanning extract. In any case over 70,000 tons of tannin extracts are used by the United States oil drilling industries to reduce the viscosity of drilling muds and to control water loss. Laboratory tests have shown that salt-containing hemlock extract is just as effective as other extracts for this purpose.

A recent examination in the U.S.A. has shown that Douglas fir bark is a good source of wax and tannin, and commercial exploitation has commenced. Pilot plant quantities of sodium palconate from redwood bark have been produced; this material is useful as a dispersing agent and for oil drilling industries. A tannery evaluation of redwood extracts gave encouraging results. The potentialities of the Californian tan-bark oak and the scrub oak of Florida are also being carefully investigated. Canaigre, a dock-like plant, grows in the arid region of the south-west of the United States and possesses a root which is a good source of tannin. The root extract requires special treatment to prepare a suitable tanning extract and this treatment is under investigation in the United States. There are numerous other sources of new tanning agents that have been reported recently, but the total amount of extract that they could potentially yield is not large.

An important discovery made by the British Leather Manufacturers Research Association during World War II will enable a wider utilization of existing tanning extracts. They found that addition of organic salts and acids to wattle extract enables it to be used as a replacement for chestnut. Consequently the latter material is no longer indispensable.

Australian Position

During 1947-48 Australia imported 3,500 tons of wattle bark and 12,500 tons of tannin extracts, to the total value of £1,064,000. Since that time the cost of these materials has risen sharply. During the same period at least 5,000 tons of extracts (mainly 'Myrtan' extract), valued at £205,000, were exported.

Can Australia become a large exporter of tanning materials? In answering this question several factors must be taken into account. Apart from the more vigorous growth of Australian wattles in South Africa that country possesses the economic advantage of cheap labour sources (more than seven times cheaper), whereas up to the present we have suffered from the disadvantage that the collection of the bark has been a minor occupation, with consequent irregularity of supply. The establishment of wattle plantations is governed by several conditions. They require suitable soil conditions, a certain minimum rainfall which depends on local conditions, they must have a lower priority than the requirements of a serious world food shortage, and the necessary long-term investment is not favoured in our present economic condition. Thus production of tanning extract by this means does not appear to be a particularly attractive venture.

Despite certain initial disadvantages an integrated industry would be a better means of producing tanning extracts in a suitable price range. It is possible with a development of silvicultural programmes in this country that a genetical study of our most suitable sources may produce variants with a high tannin content. Similar studies are producing encouraging results overseas.

There are two approaches to the problem of producing more tanning materials; firstly, the utilization of the existing source in the usual manner, and secondly, the development of little-exported materials.

In 1937 United States workers considered that the smallest practical tannin extract plant was one yielding 2,000 tons of extract (55 per cent. tannin) per year, that the tannin content of the raw material should be, as a rule, more than 7 per cent., and that the non-tannin extractables should be low. If the tannin content of a waste product were 7.5 per cent., 11,000 tons of bark would be required annually for the above extract plant, and it is obvious that the plant must be close to the forest areas in order that transport is reduced to a minimum. There has been no study of Australian conditions to determine the smallest economic unit.

A survey of the tannin content of Australian raw materials was made a number of years ago, but as a result of later investigations, some doubt has been placed on the accuracy of the earlier results, and they are at best regarded as minimum values. They did show, however, that there are a few valuable sources in this country.

At the moment no large cultivation of wattle is envisaged, although the tannin content of some varieties is being actively studied by the New South Wales Division of Wood Technology. The 10,000 tons of wattle bark now collected annually are from natural stands and this amount could be increased readily if sufficient labour were available.

Steps have already been taken by the Western Australian Forests Department to replace the brown mallet (*Eucalyptus astringens*) stands. The bark (45 to 55 per cent. tannin) of this tree is one of the richest tan-bearing materials in the world, and was extensively exploited at the turn of the century when supplies were seriously depleted. However a total area of 125,000 acres of potential mallet country has been reserved, and about 17,000 acres have been established. On the basis of a 35-year rotation and thinnings commencing at fifteen years, 8,500 tons per annum of 60 per cent. tannin extract should be available.

The use of mangrove bark has often been suggested because there are large areas of these forests in Queensland and New Guinea. However, the extract produces a dark coloured leather, which at present is unpopular on the British market. Because of this and because mangrove bark must be collected from unhealthy and unpleasant swamp areas, it is a doubtful possible source. There are large quantities of karri bark produced annually with a good average tannin content of 20 per cent.; however the non-tannin content is high, so that karri bark extract would need to be blended with other high tannin extracts in order to find wide use. Other barks such as that of cypress pine have been examined but the available bark is so scattered as to make utilization limited.

Recently, Dr. Anderson, of the New South Wales Department of Technical Education, found that the thick bark of the Monterey pine, taken from the lower part of the tree, contains more than 15 per cent. tannin. The tannin-bearing bark can be selected by its colour. The extract produces a very satisfactory leather, and although later investigations may show that care will have to be taken in the storage of the bark and during extraction on a large scale, the present work is encouraging. As there are approximately 200,000 acres of pine plantations in Australia, with the crop reaching maturity in 30 years, the importance of the project is recognized. The tree is a source of softwood timber and long fibre pulp, and tannin extraction could be integrated with these industries. Although pine bark contains waxes the amount present is hardly sufficient for economical recovery.

Another source which could be integrated with the wood pulp industry is that of eucalypts. The stringybarks contain about 5 per cent. tannin in the heartwood, and removal of tannin by water extraction prior to alkali pulping would reduce the alkali consumption without seriously affecting the strength of the pulp. The extract is a pyrogallol type and is very similar, and in some respects superior to, myrabolan extract. There is an estimated possible production of 4,500 tons per annum.

The disadvantage of the above source is the small amount of tannin present and the large amount of heat necessary to evaporate the dilute extract. There is a more attractive unexploited source in Australia in the form of the cellular kino of jarrah. Jarrah wood contains about 25 per cent. of this phenolic material, and as kinos from other eucalypts have been used as tanning agents, it would be expected that jarrah kino could also be used. However, jarrah kino is not removed from the wood by the usual water extraction, and an extensive examination of it has commenced in this Division. A method developed on a small scale successfully removed the kino as a brown solution and equipment is now being built to enable an assessment of this method. There are 10,000 tons of sawdust alone produced annually and this, together with the mill refuse, would supply an appreciable quantity of extract.

Future Research

The lack of reliable data makes it impossible to calculate just how far the possible replacements can meet the calculated loss of 300,000 tons of quebracho and chestnut extracts. With our present knowledge it does seem that they will not be able to meet the demand. The lack of accurate knowledge of the precise action of tanning materials hinders the production of tanning agents which could take the place of natural vegetable tannins. Further investigation of the chemical constitution of natural vegetable tannins is therefore desirable.

TOO GOOD TO BURN !

By N. H. KLOOT, Timber Mechanics Section

"Osage-orange, a thorny tree with large, yellow, somewhat orange-like fruit. The tree, which is the only species of its genus, belongs to the mulberry family (Moraceae). It is native to rich soils in the south-central United States, from Missouri and Kansas to Texas, but has been planted extensively in the Mississippi valley and occasionally in the eastern states, being hardy in New England. The very hard, strong, flexible, yellow wood, formerly used for bows and war-clubs by the Osage and other Indians west of the Mississippi, is utilized for railway ties and fence posts. Osage-orange is also known as bowwood and as Bois d'Arc. The wood yields a yellow dye principle." — *Encyclopaedia Brittanica*, 1948, Vol. 16, p. 947. This species, which is known botanically as *Toxylon pomiferum* Rafn. has been used in Australia mainly as a hedge-row tree. In Victoria, probably the largest volume is grown at Bacchus Marsh, but the distribution and volume grown in other States are not known with any certainty.

Many years ago, some samples of this timber were submitted to the Division of Forest Products for examination, but spiral grain was so prevalent in these samples that it was considered that the material was unlikely to be of much use for the purpose required, namely, tool handles. However, for some years now, archery clubs have been using osage-orange for bows, reputedly with a great deal of satisfaction.

Arising out of an enquiry from the Victorian Archery Club, this Division conducted some mechanical tests on a number of clear straight-grained samples supplied by the Club. The results of these tests are given in the following table :—

Properties of Small Clear Specimens of Osage-orange at 12% Moisture Content

Property	Unit	Mean value	No. of specimens
Density	lb./cub.ft.	58.7	17
Static bending			
Stress at L. P.	lb./sq.in.	13,100	15
Modulus of rupture	lb./sq.in.	25,700	15
Modulus of elasticity	10^6lb./sq.in.	1.89	15
Compression strength parallel to grain	lb./sq.in.	12,400	15
Toughness (tangential)	in.lb.	422	5

The number of specimens given in the final column actually corresponded to the number of trees represented by the samples except in the case of toughness, where the five samples represented only three trees. Of the seventeen samples tested in bending, two failed with a cross-grain fracture, their results as a consequence being rejected.

The bending fracture of this species is interesting. The tension failure which gradually spreads over practically the whole cross-section is laminated, the early-wood bands being more or less brittlish and the late wood bands failing with very fine fibrous fractures indicative of great toughness.

As far as is known, the only other data available on the mechanical properties of osage-orange are some American figures for the timber in a green condition, but as the results are based on tests on only one tree the information is of little value even for comparative purposes.

When the archer draws a bow, he performs a certain amount of work which is temporarily absorbed by the bow itself. When the bow is suddenly released this stored energy is practically all used up in driving the arrow through the air. The capacity to store and release energy in this way is known as resilience. An analysis of the figures given in the above table indicates that osage-orange has a particularly high resilience. Hickory, well-known as an axe and bow timber, also has a high resilience although not as high as that of osage-orange.

Toughness, as distinct from resilience, is a measure of the total capacity of a timber to absorb energy. In other words, the toughness value is a measure of the work done under impact loading, in completely fracturing the specimen. In general, however, tough timbers have a high resilience and vice versa.

The results of these tests on osage-orange confirm the opinions of those archery experts who have held this species in high regard for a long time. When one considers the constant search for substitutes for hickory in Australia, it can only be assumed that a lack of knowledge of the potentialities of osage-orange is behind the reported use of this species as firewood. It must however be stressed that, as with any other timber, only by the careful selection of straight-grained sound wood can the user expect to obtain the advantages of the superior shock-resistance properties of osage-orange.

The Properties of Australian Timbers

CELERY-TOP PINE

Celery-top pine is the standard common name given to the timber botanically known as *Phyllocladus rhomboidalis* L.C. Rich.

Habit

The genus *Phyllocladus* is confined to the Southern Hemisphere, chiefly New Zealand, Tasmania, the Philippines, Moluccas and New Guinea. *Phyllocladus rhomboidalis* is indigenous to Tasmania, where it is found chiefly in the western third of the island. On most sites the commercial trees have a diameter of about 2 feet at breast height, with a total height of about 65 feet of which the millable length is usually about 35 feet.

Timber

The timber is a pale straw colour to pale brown, usually straight grained with fairly distinctly marked growth rings. It is moderately heavy for a non-pored timber, having a mean weight of 40 lb./cu. ft., with a range of 32-50 lb./cu. ft. when dried to 12 per cent. moisture content.

Seasoning

In drying from the green condition to 12 per cent moisture content little shrinkage takes place, back-sawn boards shrinking only 3.2 per cent and quarter-sawn only 1.6 per cent. This attribute has been well known in Tasmania as also the fact that it possesses a very high longitudinal shrinkage. This is due to the presence of abnormal tissue or compression wood, confirmed by scientific tests, which militates against its successful use under certain conditions.

General

This timber has a high resistance to fungal attack and is durable when in contact with the ground; one of its uses in Tasmania has been in tennis courts. It works moderately easily with hand or machine tools and is an excellent bending timber, being used for coach building and for railway carriage construction.

Uses

It may be used for all classes of joinery, flooring, external and internal fittings, and for kitchen furniture. This timber has been found most useful where it is subject to adverse conditions of wet and dry or of heat and cold, such as in vats and in doors for reconditioning chambers. It is recognized to be resistant to acids and to chemical liquors and is used extensively in containers for these. Celery-top pine can be used for the manufacture of wooden separators for all types of lead-acid accumulators, after suitable chemical treatment. It is not now normally used because it is difficult to obtain the required clear material, free from birds' eyes and compression wood, in the necessary sizes. In boat building the timber is used for decking and to a lesser extent for planking.

Additional information on this timber can be obtained from the Forestry Department, Tasmania, and from the Chief, Division of Forest Products, 69 Yarra Bank Road, South Melbourne.