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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. 180 1950##180 January, 1950

CONTROL OF BORER ATTACK IN PLYWOOD BY USE OF PRESERVATIVES IN THE GLUE

By

N. TAMBLYN, Officer-in-Charge
Wood Preservation Section

and

A. GORDON, Officer-in-Charge
Veneer and Gluing Section

Introduction

During 1945-46 the Division of Forest Products gave careful consideration to various methods of treating veneer and plywood to prevent damage by the Lyctus or "powder post" borer. Although the hot tank boric acid veneer process (1) then practised in Australia was reasonably satisfactory, the rapidly increasing use of Lyctus-susceptible veneer timbers was a sufficient reason to investigate any new or improved method which might result in greater simplicity or economy of treatment. Two methods which appeared promising were selected finally for test.*

In the first new method tested, the green veneer was immersed momentarily in cold boric acid solution, and then block stacked to permit diffusion of the chemical into the wood. This process proved highly successful and, following its release in February, 1949 (2), it has been widely adopted in commercial veneer plants.

The second method tested involved the addition of toxic chemicals to cold setting glues used in plywood manufacture and hence avoided preparation of treating solutions and provision of dipping equipment and additional handling. Although in this respect it offered a further simplification with the minor advantage of being more applicable to dry veneer, the success of the momentary dip process had the immediate effect of limiting its possible application. *However testing has been continued and the complete control obtained with both benzene hexachloride ("Gammexane") and D.D.T. is now considered sufficiently promising to warrant publication of results and recommendation of the method for certain special purposes.*

Method of Test

Tests were commenced in 1946 when 1440 sheets of 3-ply (8½ in. square) were prepared from 3 different timbers using 1/16 in. and 1/8 in. veneer, with both casein and urea glues. Six chemicals were selected for incorporation in the glue over a range of concentrations, the actual compound used being varied to avoid using an acid material with casein glue or an alkaline one with urea. There were 6 replications of every treatment.

The timbers used were white birch (*Schizomeria ovata*), yellow carabeen (*Sloanea woollsii*), and yellow walnut (*Beilschmiedia bancroftii*)—commercial species selected for their high susceptibility to Lyctus damage. The preservatives and concentrations used are set out in Table 1.

The chemicals used were of "technical grade" of 90 per cent. or higher purity. The D.D.T. and benzene hexachloride ("Gammexane") were reputed to contain 95-98 per cent. of the para para isomer and 10-12 per cent. of the gamma isomer respectively. Where it was necessary to vary the compound according to its compatibility with the glue, the weights were adjusted so that equal amounts of the toxic constituent were used. Thus with borax and boric acid the amounts used were calculated to give the same boron content with both glues.

TABLE 1

Chemicals and Concentrations Used

Toxic chemical	Glue	Weight of chemical used as lb./1000 sq. ft. single glue line			
		Controls	Low	Medium	High
D.D.T. ...	Casein & urea	Nil	0.20	0.40	0.80
Benzene hexachloride	" "	"	0.22	0.44	0.88
Borax ...	Casein only	"	0.52	1.04	1.08
Boric acid	Urea only	"	0.34	0.67	1.34
Sodium pentachlorphenate	Casein only	"	0.52	1.04	2.08
Pentachlorphenol	Urea only	"	0.48	0.96	1.92
Microfine sulphur	Casein & urea	"	—	—	2.08
Sodium fluosilicate	" "	"	—	—	2.08

After redrying to remove moisture added with the glue, the faces of all panels were sanded and edges were trimmed with a saw to remove excess glue. They were installed in 40 insect-proof cages. Each cage contained 36 panels of 3/16 and 3/8 in. plywood separated by strips into 12 single and 12 double panel components. In the double panel components 2 sheets of plywood were in contact, face to face, to simulate plywood in a stack. This arrangement offered maximum chance of infestation as it presented two veneer thicknesses without an intervening glue line. In any one cage only one chemical at one concentration was represented.

Inoculation with Lyctus beetles commenced in December 1946, and has continued until at present a total of almost 9000 beetles have been liberated in the cages. During the first 2 years of test, cages were stored at room temperature, but have since been housed in a controlled temperature-humidity room maintained at approximately 80°F.

Results of Test

All panels were inspected in 1948 and 1949 for signs of Lyctus damage with the following results (Table 2).

* It should be recorded that this second method was listed by the Division for investigation before the last war, but could not then be proceeded with. Its commencement was hastened at the request of the Queensland Plywood Board, who independently suggested the method in 1946.

TABLE 2

Results of Test (December, 1946–December, 1949)

Toxic chemical	Concentration	Extent of Lyctus damage 1948	Extent of Lyctus damage 1949
D.D.T.	Low	Very slight	Very slight
	Medium	Nil	Nil
	High	Nil	Nil
Benzene hexachloride	Low	Nil	Nil
	Medium	Nil	Nil
	High	Nil	Nil
Borax and Boric acid	Low	Slight	Slight
	Medium	Slight	Slight
	High	Nil	Slight
Sodium pentachlorphenate & pentachlorphenol	Low	Severe	Severe
	Medium	Severe	Severe
	High	Severe	Severe
Microfine sulphur	High	Moderate	Severe
Sodium fluosilicate	High	Severe	Severe

At the present stage of the test these results are most promising for both D.D.T. and benzene hexachloride, with the balance in favour of the latter because of its lower chemical cost* and slightly better performance. However, in any application of the results, careful account should be taken of the fact that both substances are slowly volatile and are also liable to loss of toxicity through gradual chemical breakdown. There is thus no guarantee that their effectiveness will continue beyond the present duration of the test, though it is reasonable to expect that failure at the high loading will not occur until some years after the lower concentrations are attacked. Unfortunately, however, there appears to be no easy method of determining the maximum period of protection, except by long continuance of the test.

* Current (Jan. 1950) prices in Melbourne of D.D.T. and benzene hexachloride are approximately as follows in cwt. lots —D.D.T. (9[illegible]-98 per cent. para para isomer) 8/– per lb. benzene hexachloride (10-12 per cent. gamma isomer) 2/9 per lb.

Recommendations

In formulating the following recommendations, it was considered that for the present, application of this method should be restricted to plywood to be used only for temporary purposes, or to plywood which, within a few years of manufacture, will be effectively sealed on all surfaces with paint, polish or other permanent sealing coat. When protection is required for not longer than 3 years, the lowest concentration of benzene hexachloride (approx. ¼ lb./1000 sq. ft. of single glue line) is recommended. Where service in excess of this period is required the highest concentration (approx. ¾-1 lb.) should be used, though it is at present impossible to predict the period of safe control which may be expected.

Both D.D.T. and benzene hexachloride may be mixed with cold setting casein or urea glues and do not appear to affect significantly either the working life or the bond strength. This aspect will be further investigated by the Division when semi-commercial trials of both preservatives are commenced shortly. Before mixing either chemical with the glue it should be examined to ensure it is in fine powder form.

Cost of Treatment

Based on the current price of crude benzene hexachloride the chemical cost of treatment is extremely low. Using the lowest concentrations, it is equivalent to a cost of approximately 1.6 pence per 100 sq. ft. of 3-ply, and of approximately 6 pence at the highest concentration.

Acknowledgements

Grateful acknowledgement is made to officers of the Division of Entomology, Canberra, who assisted in the supply of Lyctus beetles used in inoculation of the cages.

References

(1) Cummins, J. E.—The Preservation of Timber Against the Attacks of the Powder Post Borer (*Lyctus brunneus* Steph.) by Impregnation with Boric Acid. J. Coun. Sci. Ind. Res. (Aust.) 12 : 30-49 (1939).

(2) Tamblyn, N.—A Momentary Dip Treatment for Green Veneers. For. Prod. News Letter 171 (Feb., 1949).

FIBRE STRUCTURE AND THE PROPERTIES OF WOOD

The scientists Schleiden and Schwann first stated as a general principle that all living things are composed of small structural units called cells. Groups of cells of the same kind are known as tissues. Each living cell consists of a minute amount of living substance called protoplasm which is limited by an enveloping wall. In plants the cell wall is much more developed than in animals, and it is this fact that makes the tissues of plants so much more rigid than the tissues of animals. In trees there are many different kinds of cells, each adapted in its own particular way to the function it serves. In this article, however, it is proposed to consider the structure of only one type of cell—the fibres—which for the most part constitute the tissue known as xylem or wood.

The fibres of pored timbers (hardwoods) differ slightly from the corresponding cells of non-pored timbers (softwoods), but since their structure is essentially similar, in this discussion they will all be referred to simply as wood fibres. The fibres are elongated in form, ranging up to about 1/4 in. in length, but are only about 1/50 to 1/100 this size in diameter. The fibres are arranged in the tree with their length parallel to the trunk. In fact the direction in which the fibres are arranged is called the grain of the timber. If a cross section of a tree trunk is examined by means of the microscope, the fibres have the appearance of a series of cylinders cut across their length, but in a section cut parallel to the stem (*i.e.*, along the grain) their tapering ends and considerable length can be seen. It is in cross sections of the fibres however that the structure of their walls can be most easily investigated. In Figure 1, which is a cross section of the non-pored timber radiata pine, the cells marked " f " are the fibres which give the wood its great strength. Those labelled " r " are ray cells which serve to store food materials and also to conduct nutrients from the bark into the wood. The fibres are similarly labelled in the section cut parallel to the trunk shown in Figure 2. Except for a narrow band of cells under the bark the fibres for the most part are dead. In these dead cells the protoplasm is absorbed so the spaces in the cells originally occupied by the protoplasm appear empty. The ray cells however, may remain alive for considerable periods.

The cell wall consists mainly of a substance called cellulose together with lesser amounts of other substances : hemicellulose and lignin. The cellulose however, is the most important because it is the skeleton substance of the wall. This is known to be so, because if the hemicelluloses and lignin are removed, the wall retains its original form, but if the cellulose is removed, the wall loses its strength and crumbles. Between the wood cells is a thin layer of lignin which cements the cells together. This layer of lignin can be made visible by staining a thin cross section of wood with a dye, which stains the lignin but leaves the cellulose unaffected. The section in Fig. 1 was treated in this way. In paper making it is necessary to isolate the individual wood fibres which form the pulp for paper manufacture. This is done by treating the wood with chemical reagents which attack the cementing lignin between the cells and so allow the fibres to separate. Fibres isolated in this way are shown in Figure 3. Not all the lignin however, is located between the cells. Some of it is within the fibre wall itself. This can be shown by treating thin cross sections of wood with chemical reagents which dissolve the cellulose from the cell wall but do not affect the lignin. When this is done, the lignin is left behind as a fine residue from which the location of lignin in the wall can be deduced. Figure 4 shows the cross section of the wood fibres from a tropical species (*Tetramerista glabra*) treated in this way, where the lignin is seen to exist in a series of concentric bands in the cell wall.

Now although the study of the chemical nature of the fibre wall is important for industries such as pulp and paper production, these studies do not tell much of what the factors are which determine the properties of wood ; for example why wood from the centre of the tree is weaker in strength properties than wood from near the bark, or why of two pieces of wood from the same tree one has a large shrinkage parallel to the grain and the other has not, or again, why it is that heat is conducted more rapidly along the grain than across it. To find answers to questions such as these it is necessary to investigate the finest details of structure of the fibre wall itself, and when this is done, it is found that, to a large extent, the properties of wood depend upon the arrangement of the cellulose.

To understand this last statement it is necessary to know that cellulose, like all pure chemical substances, is composed of ultimate structural units called molecules. Molecules of different substances have different size and form. A cellulose molecule for example, is very large compared with a molecule of water, and whereas a cellulose molecule is long and threadlike in form, a water molecule is shaped rather like a boomerang.

In the fibre wall these long, threadlike molecules of cellulose are arranged in a particular way so that over limited regions of their length they are perfectly parallel to one another in a manner which is probably like that illustrated in Figure 5. Between these regions of perfect alignment the molecules possess no particular arrangement with respect to each other, and other cell wall substances (hemicellulose and lignin) are present. Now when molecules have a perfectly ordered arrangement such as those of cellulose in the region marked "M" in Figure 5, the existence of these regions can be detected by appropriate scientific techniques ; for example they behave in a characteristic manner when examined by X-rays and substances which behave in this way are said to be crystalline. It can thus be said that cellulose molecules are for part of their length arranged to form crystalline regions. The size of these crystalline regions can be estimated from X-ray examination to be about two and a half millionths of an inch in length, but are only about one tenth this size in diameter, from which it can be deduced that each crystalline region consists of a bundle of some 100 cellulose molecules. (For simplicity the crystalline regions illustrated in Figure 5 are shown as consisting of only four or five molecules).

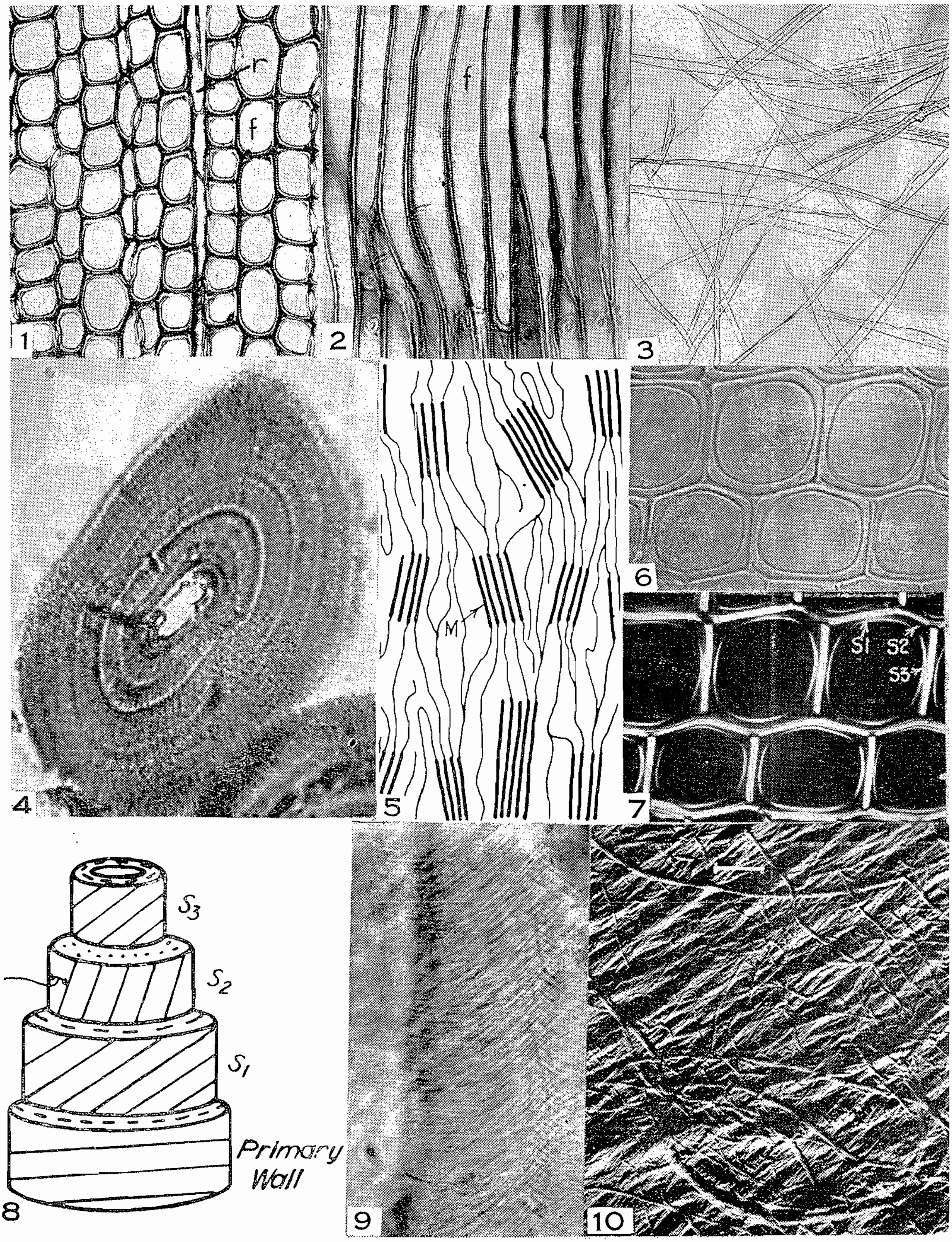
In studying the way in which these crystalline regions are arranged in the cell wall, an instrument known as the polarizing microscope is used. Its use in studying the structure of the fibre wall is illustrated in Figures 6 and 7. In Figure 6 is a group of fibre cells from radiata pine magnified 450 times in which the cell walls appear quite uniform. In Figure 7 the same cells are shown as they appear when examined by means of the polarizing microscope. In this second photograph the fibre wall can be seen to consist of three layers ; an outer (S_1 Figure 7) and an inner layer (S_3 Figure 7) which appear bright and which are separated by a broader dark layer (S_2 Figure 7). This behaviour of the fibre wall in the polarizing microscope can be shown to mean that in the bright outer and inner layers the minute crystalline regions illustrated in Figure 5 are arranged in a flat spiral so that their lengths are more or less in the plane of the wood section, but in the dark layer they are arranged in a steep spiral so that their lengths stand out of the plane of the section. Actually enclosing the three layers described above there is a very tenuous layer called the primary wall, in which the crystalline regions are arranged at right angles to the cell length, but this layer is so thin that it cannot be detected in Figure 7, and can be seen only in specially prepared sections. In view of the above description, if a single fibre is now imagined, for simplicity, as a hollow cylinder, and that part of each successive layer is imagined to be peeled off, the arrangement of the crystalline regions of cellulose in each successive layer can be represented as shown in Figure 8. The layers S_1, S_2 and S, of Figure 7 correspond with those layers similarly labelled in Figure 8. Thus the cell wall which by ordinary microscopic examination appears as a uniform structure (Figure 6) actually consists of four layers in each of which the minute crystalline regions of cellulose are arranged in spirals of different pitch. By suitably treating the fibre wall it is possible to show the presence of at least some of the layers shown in Figure 8. In Figure 9 which is part of a single fibre wall, the fine striations indicate the directions in which the crystalline regions are aligned in the layers S_1 and S_2 of Figure 8. Further information concerning the nature of the fibre wall can be obtained using the electron microscope which has a power of magnification several hundred times greater than that of ordinary microscopes. Figure 10 is part of the layer S_1 magnified 30,000 times. A line 1/100,000 of an inch long, magnified the same amount is shown on the top of the photograph. The finest fibrils in this photograph most probably correspond to the crystalline regions of cellulose described above, but further work is needed to decide this point.

It remains to describe the way in which the remarkable structure of the cell wall summarized in Figure 8 determines firstly the properties of the fibre and secondly those of the wood as a whole. Of the cell wall layers shown in Figure 8, the layer marked S_2 is the most important in influencing fibre properties ; firstly, because it contains more cellulose than the other layers and secondly, it is usually thicker. A further point of great importance is the fact that the pitch of the spirals made up of the minute crystalline regions depends upon the length of the fibres. This is illustrated in Figure 11 where the way in which spiral arrangement in the most important layer, S_2, depends on fibre length, is shown. It will be noted that in the short fibre on the left the spiral is flat (Figure 11 (*a*)) while in the long fibre on the right it is steep (Figure 11 (*b*)). The spiral arrangement in the layers S_1 and S_3 of Figure 8 depend upon the cell length in a similar way.

If this fibre structure is now considered in relation to some property such as breaking load, then it will be clear that if an individual fibre is imagined to be weighted, then the force acting along its length will, in the case of the long fibre with the steep spiral structure, act more or less along the direction in which the cellulose molecules in the layer S_2 of Figure 8 are arranged. On the other hand, in a short fibre with a flat spiral structure the force will be exerted more or less across the direction in which the cellulose molecules are aligned. Now since cellulose molecules are much stronger than the forces which hold them together laterally, it can thus be expected that the longer fibre would be stronger than the shorter one. For this reason the wood near the centre of a log where the cells are short is weaker than the wood near the bark where the cells are longer.

Shrinkage during drying is another property of wood which seems to depend upon the structure of its fibres. It will be recalled that between the crystalline regions of cellulose are located other substances making up the cell wall—particularly lignin and hemicellulose—as well as the loose cellulose molecules connecting the crystalline regions. These substances differ from the crystalline cellulose in that they possess a large capacity to absorb water and in so doing they become swollen in much the same way that gelatine swells on soaking in water.

In growing trees the wood is quite wet and those substances between the crystalline regions of cellulose are in a highly swollen condition, with the smaller molecules of water held in the interstices of the loose cellulose molecules together with those of the lignin and hemicelluloses. When this water is removed from the substances between the crystalline cellulose, they decrease in volume, so that the crystalline regions of cellulose are drawn closer together, which results in an overall shrinkage of the fibre wall. However, this shrinkage is not the same in all directions and is greatest perpendicular to the length of the crystalline regions. Thus in a long fibre with a steep spiral structure in its layer S_2 (Figure 11 (*b*)), the shrinkage will be greatest perpendicular to its length, and wood composed of such fibres would be expected to posses high shrinkage perpendicular to the grain, but relatively low shrinkage along the grain. In a similar way wood composed of short cells with a flat spiral structure such as those in Figure 11 (*a*) would


1
r
f
2
f
3
4
5
M
6
7
S1 S2
S3
8
S3
S2
S1
Primary Wall
9
10

be expected to possess a relatively higher shrinkage parallel to the grain, but relatively smaller shrinkage perpendicular to the grain. In general, these conclusions agree with experiment.

Although in this article emphasis has been placed primarily on fibre structure in determining the properties of wood, it is not the only factor involved, since the nature of the cementing material between the cells, and the proportion of the different kinds of cells present are also of importance. As to the relative extent to which each of these factors is involved it remains for future research work to decide. Investigations such as have been described here on fibre structure, have also been carried out for other types of cells and although much of the information is of purely botanical interest, it is nevertheless of great value in studying problems of practical importance. It is often the case that investigations of a purely scientific nature lead to results which are capable of considerable practical application. For this reason both the applied and theoretical aspects of problems—of which the present account is an example—are studied in this, and many other laboratories throughout the world.—A.B.W.

Fig. 1 Section of wood from radiata pine cut across the grain. This section is stained to show the regions between the fibres which contain a large amount of lignin. Magnification = 175x

Fig. 2 Section of wood from radiata pine cut radially parallel to the grain. Magnification = 175x

Fig. 3 Wood fibres of mountain ash isolated by removing the cementing lignin from between them. Note their elongated form and tapering ends. Magnification = 75x

Fig. 4 A transverse section of a single fibre from the wood of *Tetramerista glabra*. The section has been treated with a reagent to remove cellulose, leaving a residue of lignin. In this process the cell wall is swollen greatly and so appears considerably thicker than in sections not treated in this way. Magnification = 1,000x

Fig. 5 A diagrammatic representation of the way in which cellulose molecules are aggregated in the cell wall to form crystalline regions here labelled M. In the cell wall the lignin and hemicelluloses are located between the crystalline regions (after Alfrey, Mechanical Behaviour of High Polymers, Interscience Publishers, New York, 1948).

Fig. 6 A section of radiata pine cut across the grain viewed in ordinary light. Magnification = 450x

Fig. 7 The same section as shown in Figure 6 viewed in polarized light. Magnification = 450x

Fig. 8 A diagrammatic representation of the way in which the crystalline regions of cellulose are arranged in the different layers of the cell wall. Only part of a fibre is drawn and the cell wall layers are imagined to be successively peeled off to show the structure of those beneath.

Fig. 9 Part of a single longitudinal cell wall of a fibre which has been crushed. The striations visible indicate the directions in which the crystalline regions of cellulose are arranged in the layers S_1 and S_2 of Figure 8. Magnification = 450x

Fig. 10 A photograph of portion of the cell wall of wood from the layer S_1 magnified 30,000 times, taken using the electron misroscop e.

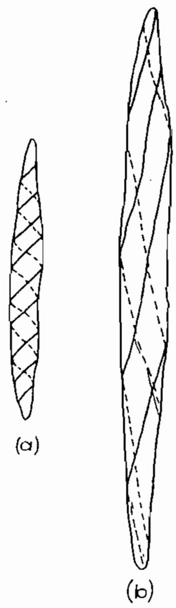


Fig. 11 A diagram representing the way in which the arrangement of the crystalline regions of cellulose in the layer S_2 of the cell wall of fibres depends upon the fibre length. The spiral lines represent the direction in which the crystalline regions are arranged : the full line being on the front wall and broken line on the back wall of the fibre. Note that in the longer fibre (*b*) the spiral is steeper than in the shorter fibre (*a*).

PERSONAL

Dr. W. E. Cohen, Officer-in-Charge of the Wood Chemistry Section returned to Australia in November after an oversea visit of five month's duration. In addition to technical liaison in the United Kingdom, Finland, Sweden, Norway, Belgium, Holland and Germany, he attended several international meetings. These included the Third World Forestry Congress, the First International Congress on Biochemistry, a meeting of the European group of the F.A.O. committee on Wood Chemistry, the International Colloquium on Macromolecules and the International Union of Chemistry.

For the purpose of technical liaison, Dr. Cohen visited the principal research institutions devoted to wood chemistry, cellulose, pulp and paper in the various countries mentioned above, as well as many pulp and paper mills together with their associated research laboratories. These visits emphasized the importance which the pulp and paper industry places on research, more especially in the Scandinavian countries, whose laboratories are well-housed, elaborately equipped and bear evidence that they are not stinted in their pursuit of knowledge.

At the Third World Forestry Congress, Dr. Cohen was elected "Rapporteur" of Section V—Forest Industries, and consequently served on the drafting committee for the general report of the Congress. At the meeting of the F.A.O. Wood Chemistry Committee, he presented papers submitted by the Division of Forest Products on "Integrated wood-using industries," "Sampling of forests, trees and wood for pulping studies," "Methanol lignin from eucalypt woods," "Acid-sensitive links in eucalypt cellulose" and "The need for a co-ordinated effort." The last paper stressed the importance of closer co-operation between the laboratories in different countries in the way of exchange of information, reports and publications, and there is already evidence that delegates from the various European countries are acting on the suggestions put forward in that a steady flow of reports and publications from these countries is now reaching the Division of Forest Products.

Some Notes on the Holding Power of Nails in Boxes

By *J. J. MACK*, **Timber Mechanics Section**

It is a well recognized fact that the capability of a nailed wooden box to withstand rough handling depends to a large extent on the efficiency of the nailing. Failure of the nailing may occur by the nails pulling from the wood, by the nail heads pulling through the sides, tops or bottoms, by the wood splitting and releasing the nails, or by the failure of the nails themselves. The latter type of failure, which when it occurs is usually due to the head of the nail pulling off, is a far less frequent cause of box failure than any of the others mentioned.

In pines and other softwoods the most common method of failure of boxes is through withdrawal of the nails. With hardwood cases, this type of failure is not so common due to the greater holding power of these timbers. Failure of these cases is more often due to the wood splitting when the nails are driven or subsequently when the timber dries or is roughly handled.

The holding power of a nail depends on a number of factors including the density, grain direction and moisture content of the wood into which it is driven, the depth of penetration, the diameter of the nail (so long as splitting does not occur) and the condition of the nail surface. Greater density, moisture content, depth of penetration or nail diameter usually means a higher holding power. Nails driven into side grain have a greater resistance to withdrawal than nails in end grain.

It has been observed that nails driven into green timber and pulled immediately have a somewhat higher resistance than those driven into dry wood. On the other hand, a considerable reduction in holding power occurs if a nail is driven into green wood which is then allowed to dry. If rusting of the nail occurs it usually more than compensates for this reduction.

As regards the effects of diameter and depth of penetration, no tests have been carried out on Australian timber and nails, but the Forest Products Laboratory of the United States Department of Agriculture has evolved the following general formula for the load required to withdraw common wire nails soon after driving into the side grain of seasoned wood :—

$$P = 6900G^{2\frac{1}{2}}D$$

in which P represents the ultimate load in pounds per lineal inch of penetration, G the specific gravity of the wood and D the diameter of the nail in inches. This formula is only an average one applicable to American species and assumes that no splitting takes place.

The tendency for nails to pull out may be reduced by increasing the size or number of the nails but this is not always feasible because of spacing and tendency of the wood to split. It may also be uneconomical. In the past, the practice has been, in order to obtain the maximum service, particularly from softwood containers, to use special high holding power nails. Many designs have been tried out in various countries with and without some measure of success.

The methods tried have been :—(*a*) to increase the area of contact of the nail with the wood, e.g., oval, square and fluted nails,

(*b*) to increase the coefficient of friction between the nail and the wood, e.g., by coating with resinous coatings, or roughening by chemical treatment or sand rumbling,

(*c*) to provide a mechanical resistance in addition to the frictional hold, e.g., barbed and twisted nails. Special nails of the types mentioned above are well-nigh impossible to procure to-day, but prior to the war, the following classes were the most popular in Australia :—

(*a*) Barbed or jagged nails
(*b*) Twisted or spiral nails
(*c*) Cement-coated nails (resinous coating)
(*d*) Rusted and sand-rumbled nails

Some manufacturers supplied nails with different combinations of the above varieties.

Various tests have been carried out over a period of some years at this Division on all these types of nails, but using only radiata pine, bunya pine and imported western hemlock as the test timbers. While it is possible that the relative efficiencies of the various types of nail will be similar in all species of timber, this is not known for certain. Also the lack of knowledge of the holding power of various Australian case timbers prevents advantage being taken of the superior holding powers of some species when specifying the number and size of nails for box construction. It is proposed to carry out in the near future a comprehensive series of tests to determine the relative nail withdrawal resistance of various Australian case timbers.

Comparisons between nails of different types have been made on the basis of static (slow) and impact (fast) nail-withdrawal tests in the laboratory. In addition the procedure adopted for this study provides for tests to be carried out immediately after driving of the nails and 3 months after driving. It is believed that the results obtained, when suitably weighted and combined, give a reliable indication of the relative merits of the different types of nail under service conditions.

The results of tests carried out on the various types of nail mentioned above have shown that twisted and rusted nails rank highest in static and impact holding power. Twisted nails had a 40 to 70 per cent. greater holding power than plain nails, and rusted nails 50 per cent. greater. More recent tests, in which a comparison was made between cement-coated and plain nails, indicated a falling off in the holding power of the plain nail which has been attributed to improved methods of wire drawing. The smoother wire being manufactured has resulted in reduced friction between nail and wood and consequently less holding power.

It is interesting to note that nails which rely on mechanical as well as frictional resistance, for example barbed and twisted nails, retain their holding power over a period much better than those which rely on friction only, and also maintain their holding power until withdrawal is practically complete.

Little experimental work has been carried out in the Division of Forest Products on the splitting of timber. The problem is particularly serious with pored species such as the eucalypts and may be tackled in several ways. Predrilling can overcome splitting tendencies and may also slightly increase the withdrawal resistance of the nails. However, the practice is inconvenient and usually uneconomic when speed of production is important. Another method sometimes used is to prepunch a hole, but this also has similar drawbacks to predrilling.

The shape of the nail point is of considerable importance in the promotion of splitting and several types have been suggested to reduce splitting. The most popular types are blunt, blunt tapered, and bifurcated. The latter has a slightly concave end, the periphery of which cuts the wood fibres when driven. Although these types tend to reduce splitting, a small amount of holding power is sacrificed.

This article is only intended to give an outline of the factors governing the holding power of nails and the ways in which it may be increased. The interested reader is referred to C.S.I.R. Pamphlet No. 46, "The Holding Power of Special Nails," by Ian Langlands, and to D.F.P. Reprint No. 85 (J. Coun. Sci. Ind. Res. (Aust.) 17 : 1944)—"Tests on the Holding Power of Titan Plain and Processed Cement-coated Nails," by N. H. Kloot, both of which may be obtained on application to the Chief, Division of Forest Products, Yarra Bank Road, South Melbourne.

BUILDING BOARDS FROM SAWDUST

Investigations in progress at the Division of Forest Products C.S.I.R.O., are indicating interesting possibilities for heat coagulated blood as a binder for sawdust. Mixtures of sawdust with about 10% of blood (on dry weight basis) have been pressed into boards that compare favourably in puncture resistance and surface hardness with commercial hard-pressed building boards. As both sawdust and blood are by-product or waste materials, there appears to be scope for both technical and economic studies.

In preliminary trials high pressures and high temperatures were applied to mixtures of dry sawdust and blood. Further work showed moisture content is not critical, but that pressing period is extended as moisture content increases. Low pressures and moderate temperatures are being examined to ascertain whether the range commonly used in the plywood industry can be relied on to produce boards of satisfactory quality.

Considerable work has yet to be done to establish the optimum conditions for producing boards with desirable properties. Sufficient progress has not yet been made for technical information to be released.

FOREST PRODUCTS NEWS LETTER

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to Forest Products News Letters—Nos. 170-179 (1949)

Technical Index

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THE PROPERTIES OF AUSTRALIAN TIMBERS
RIVER RED GUM

(*This species has been previously described in News Letter No.* 81, *but in the light of more complete information the description has been modified and enlarged*—Ed.)

River red gum is the standard trade common name for the timber of the tree known botanically as *Eucalyptus camaldulensis* Dehn. (Syn. *E. rostrata* Schlocht.) Other common names for this timber are blue gum (Queensland), Murray red gum (N.S.W and Vic.), and red gum (N.S.W., S.A. and Vic.).

Distribution

This species has a fairly wide distribution throughout the eastern half of Australia reaching its best development when growing on river flats and is found in great abundance along the course of the Murray river and its tributaries. Red gum is found not only on river flats in Victoria, New South Wales, South Australia and Queensland, but also in areas where periodical droughts are experienced, but where soil water is available at depth. It is a tree capable of withstanding both floods and rainless spells.

Habit

River red gum is not a tall tree, seldom attaining a height of 150 feet and frequently has a short massive trunk and wide spreading crown. At the butt it is covered with a persistent corky bark but, higher up, the bark is of the gum type which tends to flake off in strips and become somewhat scaly.

Timber

The timber is red in colour. Its grain is interlocked and often wavy. Its texture is close and it may exhibit a pleasing figure. Gum veins and pockets are relatively prevalent.

It is one of the heavier eucalypts, its density at 12 per cent. moisture content before reconditioning being 56.4 lb./cu. ft. and after reconditioning 52.5 lb./cu. ft. Its green density is approximately 70.4 lb./cu. ft. In drying from the green condition to 12 per cent. moisture content, backsawn boards shrink 8.7 per cent. (tangential shrinkage), and quartersawn boards 4.1 per cent. (radial shrinkage), these being reduced to 4.5 and 2.6 per cent. respectively after reconditioning.

Seasoning

In thicknesses up to 1 in. at least, red gum from mature trees can be air-dried or kiln-dried from the green condition free from checks, even when backsawn, if reasonable care is taken. Stock from immature trees tends to check fairly freely if backsawn, and it is doubtful whether satisfactory results can be obtained by kiln-drying the latter material from the green state. The timber is somewhat prone to warp, kinking along the edges of the boards, in particular, and close spacing of stacking strips (½ in. strips spaced at 15 in. centres) is recommended for commercial use to reduce trouble from this cause. Stacks should also be weighted to reduce warping in the upper layers of the stacks. A final steaming treatment (obtainable during reconditioning) is fairly effective in reducing warp. The extent to which collapse occurs in this species seems to vary with locality. Generally speaking sufficient collapse occurs to warrant a reconditioning treatment of some 6 to 8 hours duration towards the conclusion of drying. Approximately 20 days are required to kiln-dry green 1 in. mixed sawn stock, and about 9 days are required to kiln-dry stock which has been air-dried to a moisture content of 30 per cent. Recommended schedule will be supplied on application to the Division of Forest Products.

Mechanical Properties

Red gum is hard and strong in compression parallel to the grain but on account of the heavily interlocked grain is not well regarded for beams. It falls into strength group D for bending stresses but group B for other stresses together with such timbers as maiden's gum, southern blue gum, karri and turpentine.

General

This timber is not difficult to saw and, apart from a tendency for the grain to rise in dressing, it works well under machine and hand tools. It can take a high polish. Specially selected timber bends quite well at 6 in. radius and fair at 4 in., but only a very small percentage is suitable for bending. The sapwood of river red gum is classed as moderately susceptible to attack by the Lyctus (Powder Post) beetle.

Uses

It is most suitable for structural purposes, especially where durability and availability are the main factors. It is used extensively in wharf, bridge, and other structures, in the pili g and superstructures. It is the most common sleeper timber in Victoria and is also used in other States for this purpose. It has also been used for paving blocks, intensively for fence posts, and commonly for soles, struts, and posts of suburban fences. In dwellings it is used in positions near the ground such as sole plates, stumps, bearers, and in exposed positions like steps and window-sills.

Certain wearing parts of agricultural machinery are also specified in red gum. It is the most favoured timber for felloes for wagon wheels. With the development of satisfactory kiln drying schedules red gum is now being manufactured into flooring and weatherboards.

Availability

It is available in round, hewn, or sawn form. Sawmill supplies are chiefly scantlings and squares. Large widths and thicknesses are fairly readily obtained, but there are limitations to lengths. Approximate annual cut is 10 million s. ft. sawn.

Additional information on this timber is available from the forestry authorities in New South Wales, Queensland, South Australia, Victoria, and from the Chief, Division of Forest Products, 69-77 Yarra Bank Road, South Melbourne.

V.R. Print. 584—50.

C. S. I. R. O.

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No. 181 — 1950##181 — February—March, 1950

THE CHRISTENSEN AND CROZIER LOG EDGER SAWMILL

By

J. W. Gottstein and H. D. Roberts, Seasoning Section

In much of the forest of the Delatite area of Victoria, considerable quantities of relatively small girth timber occur. Mr. William Christensen, son of Mr. P. V. Christensen, was impressed with the potential value of this material, but early recognised the inefficiencies which would result from milling small girth logs in a sawmill of orthodox design. He, therefore, determined to design a portable mill especially for this work, and in association with Mr. R. Crozier, his mill engineer, completed the construction of a log edger in mid-1948.

During December, 1949, at the request of Mr. W. Christensen production and time studies were carried out on the mill by officers of the Division of Forest Products, C.S.I.R.O. The results from this investigation demonstrated that high performance is obtainable, and that a further considerable contribution to the timber industry has been made by the Christensen family, who were earlier responsible for the development of the well-known Christensen lifting truck. A provisional specification covering special features of the design of the portable log edger was lodged with the Commonwealth Patents Department late in 1949.

Description of the Mill

The heart of the mill design is a log edger consisting of a pair of 44 in. diameter circular saws which are aligned on a common horizontal axis, but are mounted on separate spindles and carriers. The spacing between the saws can be adjusted rapidly, irrespective of whether they are rotating or not, provided, of course, that a log or flitch is not actually in transit through the saws. Special features of the log edger assembly are (*a*) the use of an I-beam as a log carriage, mounted on ball bearings and arranged to move centrally between the saws, forward and reverse movement being provided mechanically, and (*b*) a high speed set and locking mechanism which operates through a pinion rack to each arbor carrier. The movement is calibrated, and the high speed set arrangement provides for setting the saws for every cut. The racks ensure that the saws are maintained at equal distances on either side of the I-beam carriage, so that two sawn sections of like depth are moved from the log at each cut. The adjustable width between the saws is variable from 6 in. as a minimum, to 20 in. as a maximum.

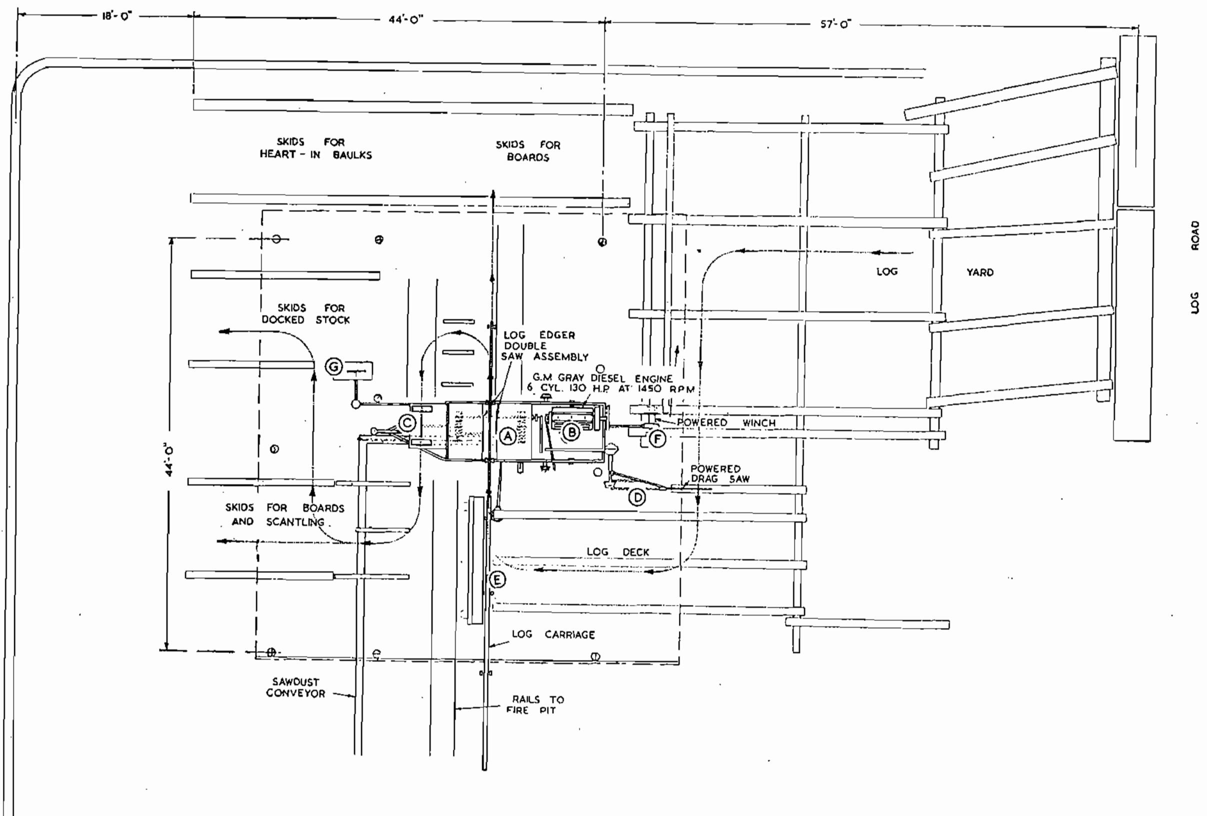

FIG 1 SCHEMATIC LAYOUT OF PORTABLE LOG EDGER MILL, SHOWING GENERAL PATTERN OF TIMBER FLOW

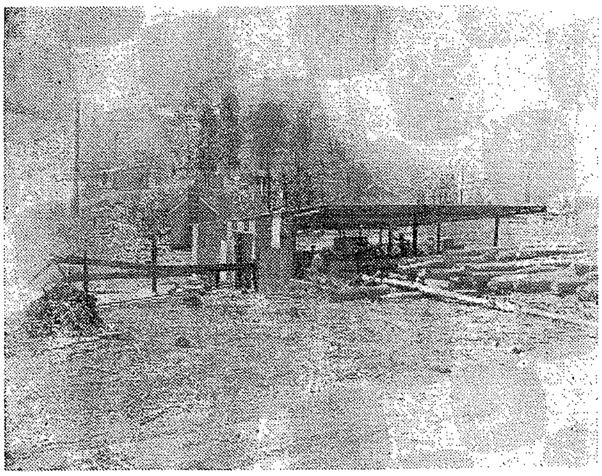

Figure 2. A general view of the portable log edger mill

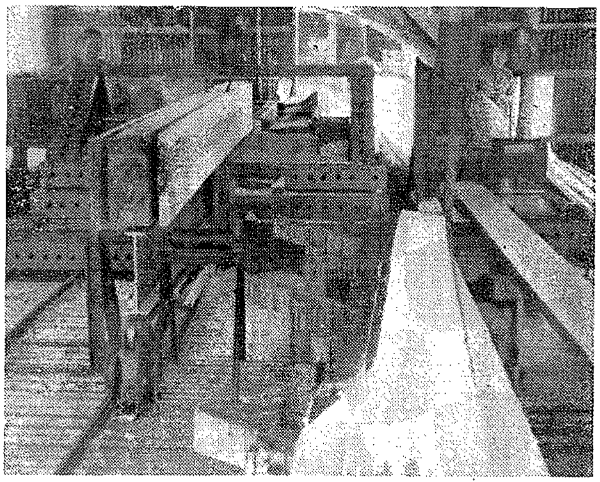

Figure 4. The log edger from the discharge side. The small edging-and-dimension bench is shown at the right

The log edger is mounted on a sturdy fabricated steel chassis, 17 ft. long and 6 ft. wide and based on 7 in. by 3 in. channel sections. A triangular towing piece is provided at one end of the main frame. The general layout of the mill is shown in Figures 1 and 2, which show the location of the log edger (A), and the engine (B) within the main frame. A breast bench (C) which is mounted on the triangular towing piece of the chassis, is also an essential feature of the layout, and is used for any edging or dimensional sawing required on material from the log edger. Docker and reciprocating cross cut saws are also included in the layout, and these, too, are driven from the engine (B), which also powers a screw conveyor removing sawdust from the edger and breast bench.

An axle and stubs are provided for transport purposes, but on any location the wheels are removed, and a special frame to support the I-beam carriage is installed. Ancillaries including log input and sawn discharge skids, and log winch are installed separately on site. A roof is provided.

The power unit, a G.M. Marine type Diesel is operating at a rating of 130 B.H.P. at 1450 R.P.M. and handles the mill and ancillaries comfortably.

General views of the input and discharge of the log edger are shown in Figures 3 and 4, and the breast bench in Figure 5.

Mill Operation

The timber flow pattern through this mill is as shown in Figure 1. Saw logs from 8 ft. to 16 ft. long are passed from the drag saw across skids to the I-beam log carriage where, after a "spotting" cut, planks are sawn simultaneously from each side of the log, and usually to a thickness of 1½ in. These cuts are then repeated until the saws are only 6 in. or 7 in. apart. The sections produced are passed to the breast bench for final edging or dimensioning. The remaining portion of the log is turned at right angles on the I-beam carriage and sawing on the log edger is resumed until only a 6 in. width remains. Production at this stage may be discharged from the mill as finished sawn product, or be transferred to the breast bench should further dimension sawing be needed. The 6 in. by 7 in. heart section may be utilized as junk sizes for case stock if the quality is suitable, or otherwise disposed of. Docking is carried out after resawing, as required.

Mill Performance

In a mill study which was carried out continuously over a period of 5 days, a mill crew of 8 produced 36,027 super feet of sawn timber from 47,704 super feet (Hoppus) of logs. The average percentage recovery was, therefore, approximately 76 per cent. on Hoppus log basis. The 283 logs which were sawn during the production study ranged from 24 in. to 69 in. in mid-girth, the average being 49 in. The principal material sawn was 1½ in. thick stock from squares up to 16 in. widths, and 4 in. x ½ in. and 6 in. x ½ in. palings : the 7 in. x 6 in. heart sections were disposed of for recutting.

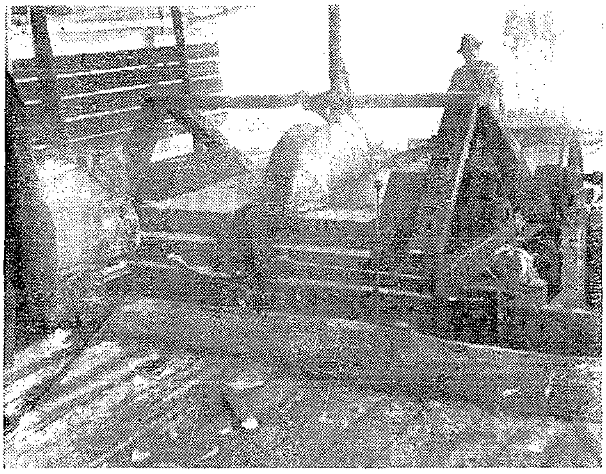

Figure 3. The log edger from the infeed side. The end of a log feeding into the saws is shown at the left centre

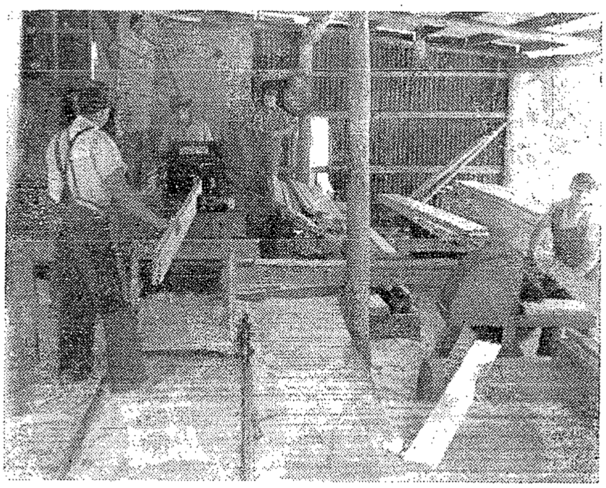

Figure 5. A view showing the edging-and-small-dimension bench, the mill discharge skids, and the docking saw

Allowing that the small "ash" eucalypt logs are of comparatively good quality, the output is regarded as being particularly good in that a production rate of 112 super feet sawn per man-hour was obtained. This may be compared with a rate of 56 super feet sawn per man-hour as the average obtained at a number of orthodox type mills cutting "ash" eucalypts to the same approximate sawn sizes, but from logs which were, in general, much larger. It may be of interest to note that from even the best of these latter mills, an average production rate of only 65 super feet sawn per man-hour was obtained.

General

A special feature of the double edging cut carried out during the breaking down of the log is that any tendency to "spring" in the log during sawing is, for all practical purposes, eliminated because a reasonably well balanced cut is given simultaneously on each side of the log. This ensures that there is no tendency for the log to move on the narrow I-beam log carriage.

It should be remembered, however, that the production of an edger mill of this type, is predominantly backsawn.

Further details will be supplied on request, by the Chief Division of Forest Products, 69–77 Yarra Bank Road, South Melbourne, S.C.4.

A NEW TESTING MACHINE TO HELP IN THE GROWING OF BETTER GRADE TIMBER

By *N. H. Kloot, Timber Mechanics Section*

Reafforestation of native species and plantation growing of non-indigenous pines are of great importance to the economy of Australia, but considerable difficulties are involved in planning and controlling these man-made forests to obtain the optimum amount and quality of timber. The time factor is probably the most difficult to overcome as it usually takes 12 years for the fast-growing pines to reach a diameter large enough to warrant conversion, even into case timber, and for eucalypts and other hard woods to grow large enough to allow light structural sizes to be cut takes 20 years or more. In the absence of some method of determining the strength properties of the timber as it grows, it would not be known until the trees were harvested whether the control and silvicultural treatment exercised by the forester had resulted in timber of the best quality for the species being grown. That the trees had been grown as fast as possible would not necessarily mean that the timber would have similar properties to that of the same species growing in a virgin stand. Indeed information already available suggests that timber from young fast-growing trees in some species is considerably weaker than from older slow-growing trees from the forest.

For a number of years the research worker has been trying to assist the forester to overcome this difficulty of lack of knowledge of the effect of his treatment on the properties of the timber; one of the research projects of the Division of Forests Products being concerned with the relationship between silvicultural treatment and strength properties of plantation grown trees. A first approach to the problem was made some years ago by the mechanical testing of thinnings of various species. This material, which became available from the operations of the State Forest Services in thinning out timber stands at regular intervals to leave the better developed stems with adequate opportunity for further development, represented trees which had been subjected to various silvicultural treatments, and it was thought that

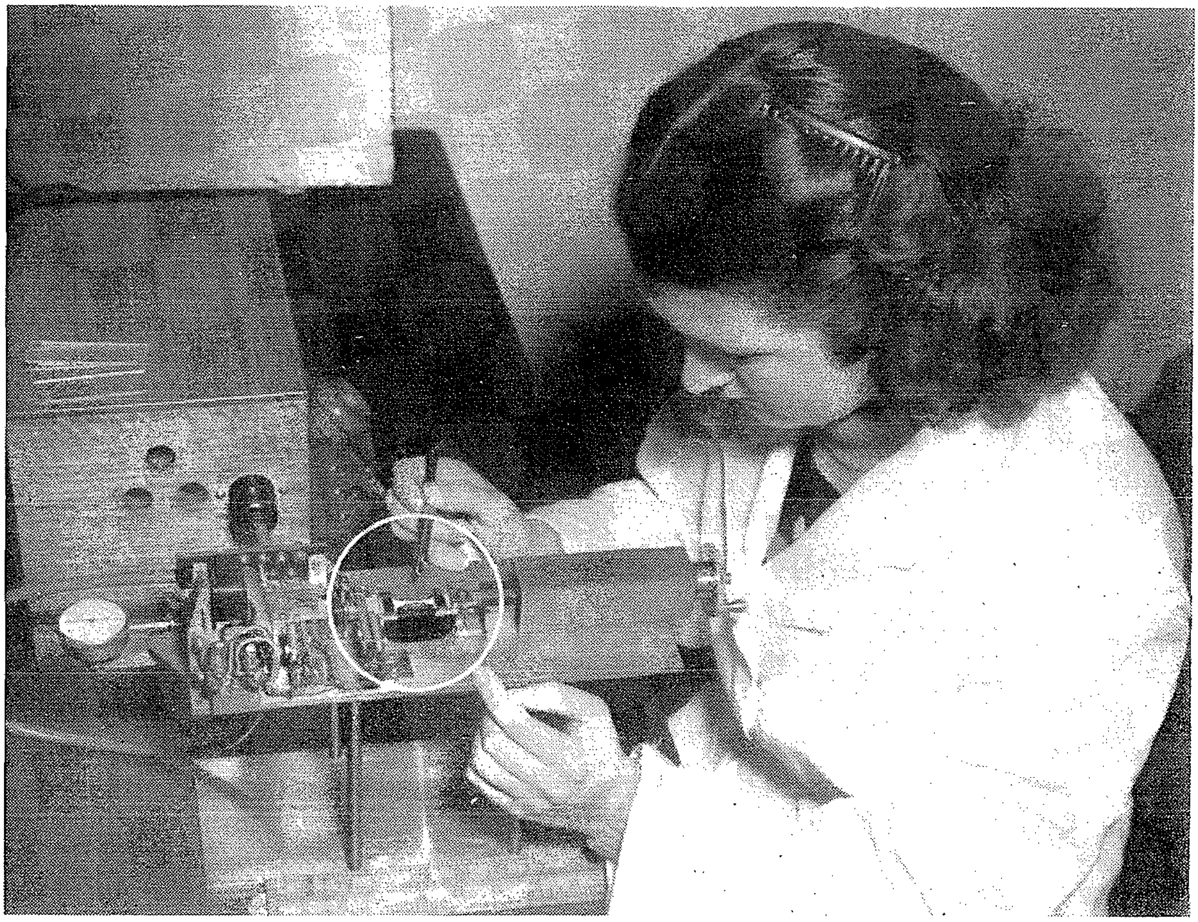

Figure 1. A general view of the micro-tensile testing machine. A specimen is shown fitted in the machine grips at the centre of the circle

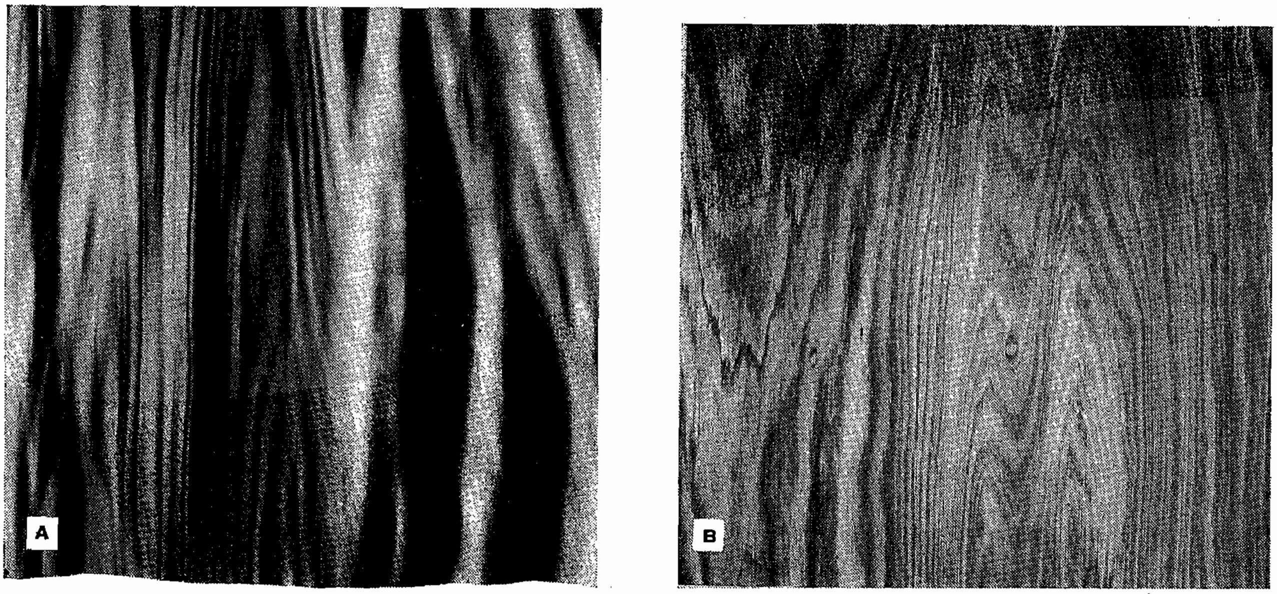

Figure 2. (A) Sheet of 1/16 in. "ash" veneer after drying; (B) Sheet of 1/16 in. "ash" veneer after drying and reconditioning.

cedure the veneer can be maintained under a large kiln wet bulb depression until it approximates to 40 per cent. moisture content, after which drying conditions do not appear to be critical.

A study of the value of reconditioning once the veneer had reached a moisture content of 17-18 per cent. was also made. The veneer was reconditioned using several methods of stacking, including separation on drying trays, between spacing strips, and on a slope in the reconditioner. By reconditioning* for 30 minutes the resultant effects were (i) to increase the width of the veneer sheet by an amount equivalent to 6 to 12 per cent. of the green width, i.e. from 2½ in. to 5 in. recovery on a sheet 40 in. wide ; (ii) to remove buckling and wrinkling ; (iii) to close face checks and splits ; (iv) to render the veneer more amenable to handling without splitting. (See Fig. 2).

Stacking the veneer on a slope in the reconditioner produced the most satisfactory results, as this method ensures a good circulation of steam and lessens the possibility of air pockets remaining between the veneer sheets. In the laboratory the flattest sheets were obtained from veneer (samples 3 ft. square) which was stacked on a slope between spacing strips placed across the grain at the ends of the sheets. The veneer, tending to sag under its own weight between its supported ends, caused a stress to act across the width of the sheets. This tends to pull the buckles flat.

It was also found that the final net width of the veneer, after reconditioning, was approximately the same for veneer dried at wet bulb temperatures between 55 °F. and 140°F. At temperatures above this, a proportion of the collapse developed during drying became non-removable.

It is understood that one commercial firm operating on rotary peeled "ash" eucalypt veneer has applied, in part, the principles enumerated above, with the result that an additional 10,000 square feet of veneer per day is recovered from previously wasted stock : this is equivalent to a gain of 10 to 15 per cent. of plant production. Also the quality of the veneer generally has improved to such an extent that where formerly it was difficult to find veneer of suitably high quality for faces, production is now almost uniformly 50 per cent. suitable for 'faces' and 50 per cent. suitable for 'backs'. Secondary advantages gained include far less trouble from glue staining because drying checks are closed by the treatment, and less difficulties from breakage as the reconditioned material is made much more 'mild' and flexible than unreconditioned stock.

* A steaming treatment carried out at 212°F.

BLEACHING OF WOOD

The following procedure has been found to be suitable for bleaching a wide range of timbers. Dark coloured woods can be made several shades lighter and light coloured woods can be bleached to a "blond" finish. There is no record of the bleaching reagents interfering with subsequent polishing operations.

The bleaching should be carried out on wood which has been cut and dressed and is ready for assembly or, alternatively, it may be applied to the assembled article. The bleaching is effected by one or more applications of aqueous ammonia followed by hydrogen peroxide. The details are as follows :—

Solution A. Aqueous ammonia—Made by diluting one part of 0.880 ammonia with 5 parts of water.

Solution B. Hydrogen peroxide—This may be used in the concentrated form (100 volumes) or if the material is bleached readily it may be diluted up to 5 times with water. Solution A is applied to the wood by means of a swab or mop and is immediately followed by solution B applied in a similar manner. The article is allowed to dry thoroughly and the above process repeated, if necessary. If these two treatments have not produced a marked reduction in the colour intensity the colouring agent is of a type which does not bleach readily and further treatment will have little effect. If the treatment has been effective, further applications of solutions A and B may reduce still further the colour of the wood.

After the article is thoroughly dry it should be *lightly* sanded to remove any roughness due to the water "lifting the grain" of the wood and then polished in the usual manner.

Ammonia and hydrogen peroxide may be purchased at most retailers of industrial chemicals. Both chemicals should be stored in a cool place when not in use and as hydrogen peroxide deteriorates on standing it is inadvisable to buy larger quantities than are required for any particular job.

The ammonia fumes make it advisable that the bleaching be done in the open or in a well ventilated room. Care should be taken to avoid undue contact between either of these chemicals and the skin.

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No. 182 1950##182 April—May, 1950

THE KILN DRYING AND RECONDITIONING OF ROTARY PEELED "ASH" EUCALYPT VENEER

by *E. L. ELLWOOD*, **Seasoning Section**

The decreasing supplies of Queensland veneer species, which pre-war constituted the main Australian source of supply, has directed attention to the possibility of other Australian timbers being suitable for this purpose. In south-east Australia the " ash " eucalypts appear suitable for rotary veneer production, considering the quantity available, the size and form of the logs, and the quality of the timber. These species can, in general, be peeled satisfactorily, but with the current commercial drying procedures used severe degrade frequently develops in the veneer during drying. As a result, the growth of the plywood industry in south-east Australia has been handicapped.

An investigation of the problem of drying " ash " veneers was commenced in the Division of Forest Products during 1948. The principal factors studied were (i) kiln schedule, (ii) drying tray design, (iii) reconditioning, (iv) heating and peeling treatment, (v) effect of salt seasoning, and (vi) variation in quality between and within trees. The work was carried out chiefly on mountain ash (*Euc. regnans* F.v.M.). This species exhibits the greatest collapse of the " ash " group and it was thought that it would present the greatest drying problems.

The most prevalent types of degrade which were found to occur in 1/16 in. thick mountain ash veneer during drying were extensive buckling, face checking, through checking and end splitting. Laboratory studies revealed that the primary cause of these troubles was collapse, and that the collapse was acting differentially between the early wood and late wood zones of the growth rings in the veneer. The early wood zones collapsed 2½ times as much as the late wood zones, and the uneven nature of this collapse gave rise to the development of severe stresses at each growth ring, resulting in buckling and checking in the comparatively thin veneer. Also, the checking which developed during drying originated on the tight face of the veneer (i.e. the side away from the peeling knife as the veneer comes off the lathe). Drying checks did not originate on the loose face of the veneer (i.e. the side touching the peeling knife as the veneer comes off the lathe) as this side had, in effect, been divided up into small sections by the development at the lathe of very small peeling cracks (see Fig. 1). As a result, the drying stress on the loose side of the sheet was accommodated by slight relief at the many small peeling cracks.

Furthermore, the seasoning defects were found to develop while the veneer dried from the green condition to an average moisture content of 35-40 per cent. ; after this critical stage was reached no further checking, splitting or buckling occured. In fact, there was a slight flattening of the veneer sheets on further drying below 40 per cent. moisture content, which was determined as being due to the difference in collapse of the early wood and late wood zones being balanced (to a certain extent) by the higher normal shrinkage of the late wood.

It was found that during the critical period of drying (i.e. from the green condition to an average moisture content of 40 per cent.), the veneer temperature approximated to the kiln wet bulb temperature, after which it rose rapidly towards the kiln dry bulb temperature. The kiln conditions during this latter stage of drying (i.e. from 35-40 per cent. moisture content) did not appear to influence the degrade developed during any kiln run. This study proves an important point, namely, that the temperature of the veneer is unlike that of solid stock and is dependent upon the kiln wet bulb temperature

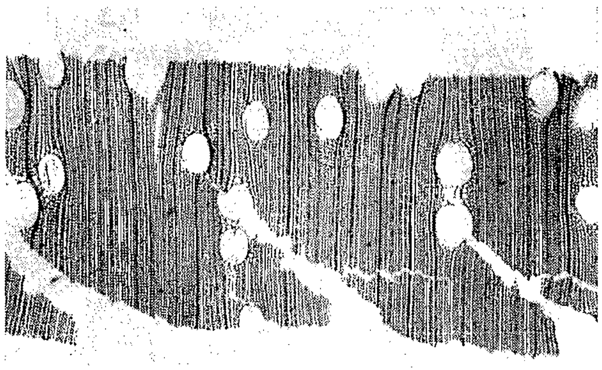


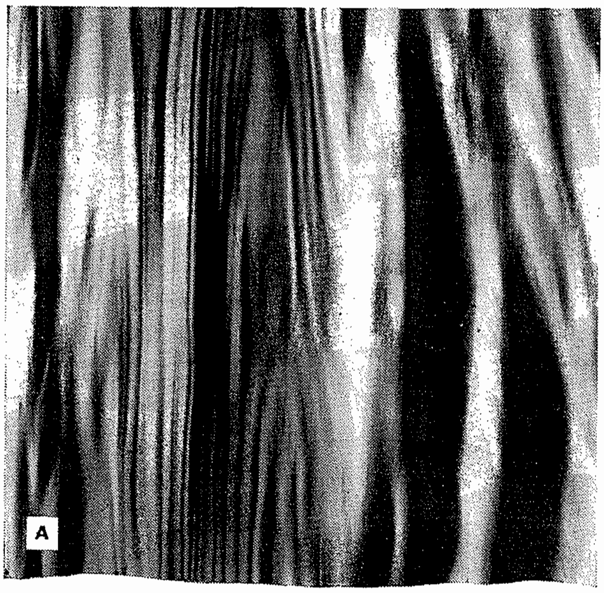
Figure 1. Magnified cross section of rotary peeled 1/16 in. *E. regnans* **veneer showing peeling cracks on loose (bottom) side.**

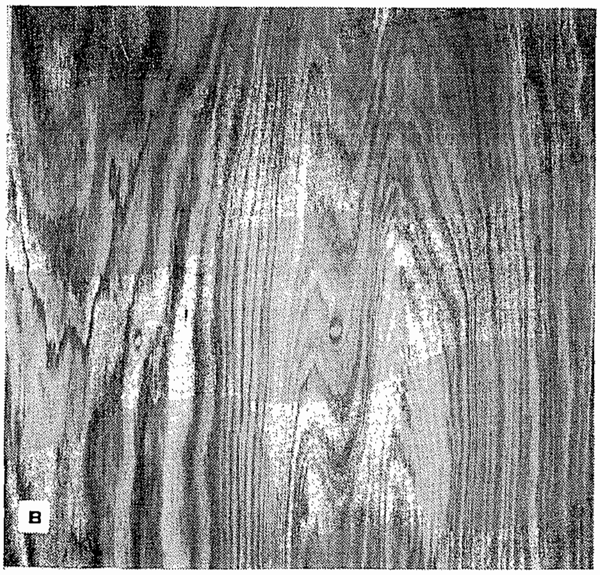
rather than dry bulb temperature during the early stages of drying, when collapse occurs.

Trials using matched sheets of veneer from five different trees which were dried under a wide range of kiln conditions, indicated that mimimum collapse occured when the kiln wet bulb temperature was held below 95°F. Above this temperature, collapse increased uniformly with increase in wet bulb temperature to a value of 150°F., after which the intensity of collapse increased rapidly with further increase in temperature. This led to the conclusion that, from the point of view of reduced collapse commensurate with a short drying time, the optimum kiln wet bulb temperature for " ash " type veneers is 95°F. In addition, however, it was found that, unlike the behaviour of thick stock, the quality of the veneer sheets progressively improved with increasing kiln wet bulb depression during the critical stage of drying. In other words, the amount of collapse developed was also a function of the drying time, and the shorter the drying time at a given veneer temperature, the better the quality of the resultant veneer. Thus high dry bulb temperatures are necessary to reduce the time over which the drying stresses act and also to reduce the magnitude of collapse.

This directed attention to an examination of kiln design, length of air travel through the stock, and tray spacing, because a comparatively large kiln wet bulb depression must be maintained across the veneer stack during the critical stages of drying. It was found that even for the relatively short air path of 3 ft. 6 in., and using 1½ in. spacing between veneer sheets, there was a temperature drop of some 25°F. across a stack of " green " veneer when an air velocity of 480 ft. per minute was used, and further, that after 40 minutes drying, the veneer on the leaving-air-side of the stack was as much as 40 per cent. higher in moisture content than that on the entering-air-side. This indicates that air velocities considerably higher than those normally used in dry kilns are desirable, and that the most suitable type of kiln for this class of material is the compartment type with a small distance of air travel.

Should progressive kilns be used, it would be necessary to reduce the number of stacks and to feed the veneer into the " dry end " of the kiln and remove it from the " green end," i.e. the reversal of the usual feeding procedure. By this pro-





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After the article is thoroughly dry it should be *lightly* sanded to remove any roughness due to the water " lifting the grain " of the wood and then polished in the usual manner.

Ammonia and hydrogen peroxide may be purchased at most retailers of industrial chemicals. Both chemicals should be stored in a cool place when not in use and as hydrogen peroxide deteriorates on standing it is inadvisable to buy larger quantities than are required for any particular job.

The ammonia fumes make it advisable that the bleaching be done in the open or in a well ventilated room. Care should be taken to avoid undue contact between either of these chemicals and the skin.

WHAT WOOD IS THIS?

Part 1

By *M. MARGARET CHATTAWAY*, **Wood Structure Section**

Introductory

People who handle timber regularly become able, in the course of time, to recognize various woods by their feel and look, by the way they cut, and their effect on tools, and come to know and recognize a vast range of species. But this is the result of experience and constant association with the timbers in question, and even these people are at a loss when they meet a timber they have never seen before, a piece of wood from overseas, or a new species that has only recently come on the market.

The present shortage of timber has brought many new woods onto the market, both by the utilization of a greater number of home grown species and by the import of woods hitherto little used in Australia. As more woods appear on the market, the task of memorising them becomes more difficult, especially as some of them are not often encountered. Many people who are constantly working with woods are now asking how they can record in a handy form, the main features on which recognition rests. In order to assist with the identification of some of these unfamilar woods it is proposed to publish a series of short articles in this and later New Letters, giving the fundamental principles on which the correct identification of timbers depends, lists of the features that have proved of value in identification and diagrams and line drawings which will explain clearly the terms in commonest use.

This need to identify something unknown and to relate it to a photograph or a published description occurs in many branches of biology, and has led to the preparation of keys which reduce this rather complicated process of identification to as mechanical an operation as possible. These mechanical keys all depend on the selection of various features from the unknown specimen, and, by choice of alternatives, they eliminate inapplicable ones and lead to a final correct determination. Experience will show that some features in a wood vary from sample to sample, and sometimes even within a single sample, while others remain relatively constant ; and that some—such as colour—change with the age of the sample or with the amount of moisture it contains. Some groups of features may tend to occur together and may quickly give a pointer to the woods of a particular botanical group ; others may be relatively widespread and occur commonly among woods of quite unrelated groups. Sometimes the pattern of the wood is so characteristic—as in the silky oaks and many trees of the pea family—that even if you are looking at a totally unknown wood, you can say at once " This wood belongs to the Proteaceae or the Leguminosae ". Sometimes you can even say in which genus it should be placed, but more often there are several alternatives and only a careful examination of the pattern on the three different surfaces will give the correct identification. After a little practice it is easy to know which are proving to be straight forward and obvious features, and therefore the ones to be used first, and which are the ones calling for an exercise of judgement ; these are the ones to leave till the end, and, with a little luck, the identification may be made without having to use them at all.

When an unknown timber has come to hand the first thing to do is to note all the things about it which can be seen with the naked eye, by feel or smell, together with such details as where it comes from, what type of country it grows in, and so on. The next thing to do is to prepare a clean cut cross surface, using a sharp knife, or a razor blade. Radial (quarter sawn) and tangential (back sawn) surfaces should be split and then smoothed. It is on these surfaces of the wood that the anatomical details can be seen, and it is on these anatomical features that the ultimate determination of genus and species will be made.

Physical Features

These are the things that can been seen with the naked eye or tested by the other senses, feel, smell, and even taste. While they are seldom sufficient in themselves for the identification of an unknown timber, they are useful as additional aids when the final assessment of the features is made.

A definite odour may be present as in sandalwood, cedar and rose mahogany, but it must be remembered that odour varies considerably with the age and previous history of the timber. Green timber often has a characteristic odour which disappears on drying or exposure to the air. Sometimes this odour may be recaptured by exposing a fresh surface of the timber.

Colour may vary considerably, depending on :—

(*a*) *the surface examined*—the end surface may appear different in colour from the longitudinal surfaces.

(*b*) *the moisture content of the wood*—wood from freshly felled logs usually appears darker than the same wood when dry.

(*c*) *whether it is sapwood or heartwood*—in some timbers there is little difference between the colour of sapwood and heartwood, in others the difference is very marked, the sapwood being almost without colour whatever the colour of the heartwood may be. Colour decisions should always be made on heartwood, or, in the case of sapwood trees, on the colour of the mature wood.

(*d*) *the age of the tree*—timber from saplings is generally paler than timber from older trees of the same species.

(*e*) *the age of the specimen*—the surfaces of any piece of dry timber soon darken when they are exposed to the air ; the true color is revealed by making a fresh cut and exposing an underlying surface of the wood.

(*f*) *decay and sapstain* alter the colour of any timber.

Colour may range from whitish or straw-coloured to almost black. It is a useful aid to identification, as long as it is remembered that, in addition to the points mentioned above, there may be a wide range of colour within a single species. By using five main colour groups many timbers may be sorted out from one another.

1. *The pale colours*, white, straw-coloured etc.
2. *The browns*, woods with definite brown heartwood.
3. *The reds*, all those timbers with a distinct reddish or pink tinge.
4. *Other colours*, black (e.g. ebony), purple (e.g. purpleheart), bright yellow or orange (e.g. yellow walnut) ; these are so distinctive that they form very useful features for identification.
5. *Mottled or streaky*, as in blackwood or Queensland walnut.

The Frothing Test. Shavings from certain timbers produce a soapy lather or froth when shaken up in a test-tube of water. This is a constant and reliable test, depending on the presence of saponins in the timber.

Feel. A distinct soapiness or greasiness is apparent in some woods—e.g. tallow wood or cheesewood.

The Burning Splinter Test. Match size dry splinters of truewood are burnt. This test is of limited application, but is particularly useful when identifying the eucalypts and other pairs of timbers ; e.g. turpentine and brush box, the silky oaks, rose and miva mahogany.

Weight and Hardness.—Weight is based on the weight of air dried specimens at 12 per cent. moisture content ; hardness is, of course, correlated with weight, but for purposes of identification it is used to indicate the difficulty encountered in cutting dry wood across the grain with a sharp knife. Hardness varies with the moisture content of the timber.

The classes used are as follows :—

Very heavy—above 62.5 lb./cu. ft. A.D.
Moderately heavy to heavy—50-62.5 lb./cu. ft. A.D.
Light to moderately light—30-50 lb./cu. ft. A.D.
Very light—less than 30 lb./cu. ft. A.D.
Very hard and horny to cut—as ironbark.
Hard to cut—as satinay or blackbutt.
Intermediate to cut—as silky oak.
Soft to cut—as kurrajong.

There are other general features, such as habitat, strength, uses etc., that can be added to this list, but however many are added they seldom serve for a complete and *certain* identification of an unknown or unfamiliar timber. For such woods recourse must be made to features which are less easily visible, or even not visible at all, to the naked eye, but which can be seen readily with the help of a hand lens giving a x 10 magnification. With this aid the *pattern* of the wood can be seen ; this is formed by the different arrangements of the various types of cell of which the timber is composed. There are not many of these different cells, but they can be arranged in a great variety of ways, and after a short study of them it is often possible to place a timber quickly and accurately among a group of closely related woods. Just as criminologists have found that the whorls of the human thumb or finger can give an infinite variety of " prints," so the wood anatomist comes to find a great variety of patterns appearing on the surface of the wood, and giving to each timber a characteristic " finger print " by which it can be recognized. The anatomical features that can be seen with a hand lens will be listed and explained in later articles of this series.

GLUES FROM HYDROCHLORIC ACID CASEIN

By *ALAN GORDON and H. G. HIGGINS,*
Veneer and Gluing Section

Casein glue has been widely used in Australia for many years, particularly in the production of cold-pressed plywood. The basic material for this type of glue has almost invariably been " lactic " casein, which is precipitated from skim milk by a natural souring process involving fermentation of lactose (sugar-of-milk) to lactic acid. Casein precipitated by the action of the enzyme, rennet, has also been produced in Australia to a considerable extent but has been used principally as the raw material of the casein plastics industry rather than for glue manufacture. Where " rennet " casein has been used as a glue base it has generally been conceded that it is less desirable than lactic casein. Rennet casein gives rise to glues with a very much shorter working life than those made from lactic casein, apparently as a consequence of its much higher ash content. To obviate this disadvantage an additional step, washing with acid solution, is often recommended for its use as a wood adhesive.

A mineral acid such as hydrochloric or sulphuric may also be used as an agent for precipitating casein from skim milk. From the point of view of the dairy producer the use of either rennet or a mineral acid as a precipitant for casein has two distinct advantages over the natural souring process :—

(1) The precipitation can be effected rapidly. Less than an hour is sufficient, whereas in the natural souring process the vats are usually left overnight to allow the lactic acid to develop in sufficient concentration to precipitate the casein.

(2) The lactose, or sugar-of-milk, can be recovered from the whey. In the natural souring process it is used up in the production of the lactic acid.

Apart from its use as a baby food, lactose has now been found to be especially suitable as an ingredient of culture media for the production of penicillin. Since cows' milk contains about 5 per cent. of lactose and 3 per cent. of casein the recovery of lactose is of considerable economic importance.

These circumstances, as well as other economic factors, underlie the occasional inability of lactic casein production to meet the full demand from plywood manufacturers and other users of casein glue.

During 1949 it was proposed that " acid " casein might be produced in Australia and used as a glue base. An investigation was therefore made to test the suitability of casein precipitated by hydrochloric acid for adhesive purposes, and arrangements were made with a well-known dairying company for samples from their daily production to be supplied for testing. It was hoped that acid casein might combine the advantages which lactic casein offers to the glue or plywood manufacturer, with those which rennet casein offers to the dairy producer. Attention was also given to modification of lactic casein formulations as required for best commercial applications for acid casein and to determining the best conditions for acid casein manufacture.

These investigations and the conclusions reached are described in detail in a paper by Higgins, Hayes, Barrie, Plomley, and Gordon, which is to be published elsewhere, but the following information is given here for the benefit of those interested in the industrial applications of this work.

It was shown that hydrochloric acid casein could be used in glues with full confidence. Glues made from acid casein have a rather longer working life than those from lactic casein. Modification of Formulae 1 and 2 of the Division of Forest Products Trade Circular No. 19 on casein glue is therefore recommended. The amount of sodium silicate in these formulae should be reduced from 70 parts, as given, to 50 parts, when acid casein is used. Failure to observe this recommendation may mean that the working life of the glue will be excessively long and that under cold, moist atmospheric conditions the glue may not be set satisfactorily within the normal clamping period. Such weather conditions quite frequently occur in the Australian winter in the regions where plywood is produced.

No modification is required to Formula 3 of the Trade Circular ; this is, however, seldom used in industry.

PRESERVATIVE TREATMENT OF PALING FENCES

Quite often the householder erects a paling fence and wishes to treat it in some way so as to ensure maximum life for the timber. Usually he chooses sump oil or some other oil such as fuel oil for the brush or spray treatment of his fence. He may also dip the butt ends of the posts in the oil or perhaps in tar. Contrary to general opinion, however, neither fuel oil nor tar have any marked toxicity to decay or termites (the most common causes of deterioration of such fences).

Although oil will improve the resistance of timber to water and weathering, and improve the fence's appearance, it cannot be classified as having all the desirable properties of a good timber preservative. However, the addition of a small amount of creosote oil to the original oil will produce a good general preservative. Depending on conditions, a mixture consisting of 1 part creosote to 3 or 4 parts of oil by volume is recommended. By varying the dilution, different shades of brown can be obtained. If other colours are desired, it is also possible to obtain coloured creosotes in various shades of green.

Other suitable preservatives which may be added to the oil are copper naphthenate (green) or pentachlorphenol (colourless). Both of these chemicals may be obtained in mineral turpentine or kerosene solutions ready for application directly to the wood. It will be found more economical however, to add these solutions to the oil ; an effective mixture is one part of the solution to 2 parts of oil. For the treatment of fences which are subsequently painted, these solutions should be used as bought. (Creosote should not be used where wood is to be subsequently painted.) Where brush or spray treatment is used, careful attention should be paid to all places where water is likely to collect, e.g., between palings, posts, tops of rails, etc.

Probably the best method of preventing decay in the sawn posts is to puddle in about $\frac{1}{4}$ to $\frac{1}{2}$ gallon of creosote oil (undiluted) around the butt of each post. A small amount of creosote should be poured into the bottom of the post hole before placing the post, and the remaining creosote mixed with the soil as it is back-filled. If vegetation is to be planted near the fence, it is usually best to leave the top 1 or 2 inches of soil untreated.

All the preservatives mentioned above are freely available in Melbourne, and at the present time their approximate costs per gallon (in 4 gallon lots) are as follows :—

Creosote oil : about 3/– (Coloured creosotes up to 13/–).
Copper naphthenate (20 per cent. solution) : from 6/–.
Pentachlorphenol (5 per cent. solution) : from 6/–.

It must be emphasized that superficial application of these preservatives will not be permanently effective. From time to time the householder should re-treat the palings with the preservative mixture and, if necessary, re-puddle the soil around the butts of the posts.

V.R. Print. 2243—50

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. 183 1950##183 June—December, 1950.

VAPOUR DRYING AUSTRALIAN GROWN TIMBERS

By E. L. Ellwood, J. W. Gottstein and G. W. Wright, **Timber Seasoning Section**

In Forest Products News Letter No. 177 the principles of the vapour drying process were briefly explained and the small experimental unit at the Division of Forest Products was described.

Since then, further laboratory investigations have been carried out to determine the suitability of the process for drying Australian hardwoods (pored timbers) of both the collapse susceptible and non-collapse susceptible types, and softwoods (non-pored timbers).

These studies have shown that the structural characteristics of species influence their behaviour very markedly when dried by the vapour process. Because of the scope of this work, comprehensive studies have so far been possible only on the collapsing "ash" type eucalypts, alpine ash (*E. gigantea*), myrtle beech (*Nothofagus cunninghamii*) and radiata pine (*Pinus radiata*), but limited trials have been carried out on a number of other species.

Some of the results obtained, and interim conclusions reached are given hereunder.

Hardwoods (Pored Timbers)

Tasmanian alpine ash and myrtle beech are generally regarded as refractory timbers not easily seasoned free from degrade. For example, because of their impervious nature, from two to three weeks are normally required for kiln drying 1 in. thick stock from the green condition to a moisture content of about 12 per cent. in modern cross shaft internal fan kilns.

Process variables examined in relation to the drying behaviour of these timbers were (a) working fluid, (b) working pressure, and (c) heat input.

Working fluid and working pressure. Three different working fluids have been used, namely Stanvac K9 solvent (boiling point 395°F.); mineral turpentine (boiling point 350°F.); and perchlorethylene (boiling point, 260°F.). With each of these working fluids, studies were made with the drying cylinder maintained under four different pressures, namely, atmospheric, 6 to 8 lb. per sq. in., a vacuum of 15 in. of mercury, and a vacuum of 25 to 27 in. of mercury.

At atmospheric pressure pronounced checking and collapse occurred with all three working fluids (see Figure 1). Under these conditions drying times for 1 in. thick boards, from the green state to a moisture content of approximately 12 per cent., ranged from 4 to 5 hours with Stanvac K9 solvent to 10 to 12 hours with perchlorethylene.

With drying cylinder and charge held under a pressure of 6 to 8 lb. per sq. in. no improvement was obtained. Vacuum conditions, however, gave a slight improvement in drying quality, this being more readily apparent with the highest vacuum used. This trend was similar with all the working fluids.

Heat Input Control. Several runs were carried out in which the wood sample temperatures were held at the comparatively low values of 180°F., 150°F. and 130°F. by regulating the heat input into the evaporator. These experiments were carried out under a vacuum

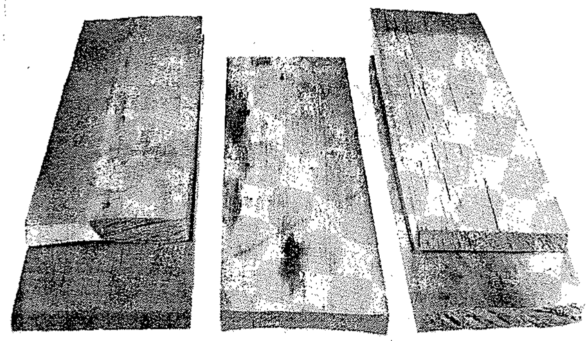

Fig. 1—Backsawn and quartersawn myrtle beech and alpine ash vapour dried in 5 hours UNDER ATMOSPHERIC PRESSURE showing poor quality of drying. (Note difference in drying quality between sapwood and truewood.)

of 28 in. of mercury with Stanvac K9 solvent and perchlorethylene as the working fluids. The drying quality of the samples improved progressively with reduction of wood temperature, quality suitable for joinery stock being produced at temperatures of 150°F. and 130°F. with perchlorethylene and Stanvac K9 solvent respectively (see Figure 2). The drying times for the 1 in. thick stock from the green condition to 12 per cent. moisture content were 5 days (24 hours per day) for the run at 150°F. and 12 days for the run at 130°F.

Discussion

With these relatively impervious and collapse susceptible species, two inherent features of vapour drying, namely, high temperature and rapid surface drying, are factors which accentuate degrade. The former favours collapse and the latter leads to the development of pronounced moisture gradients and unsatisfactory stress conditions in the wood during drying. Further, great difficulty is experienced in removing collapse produced in this manner.

The collapse susceptible "ash" eucalypts (which comprise about one quarter of the total sawn timber production of Australia), and myrtle beech, therefore, cannot be satisfactorily seasoned at the normally highly elevated temperatures used in vapour drying. Nevertheless, it has been established that by reducing the wood temperature considerably, and by applying a high vacuum, this class of timber may be vapour dried with little degrade. Under the reduced temperature collapse is minimized, loss in strength is less, and the collapse which occurs in largely removable; the high vacuum facilitates low temperature drying.

It is interesting to note that when matched samples of these species were dried in orthodox laboratory kilns at similar wood temperatures to those which gave good drying quality in the vapour drier, severe degrade developed in the samples. Alter-

Fig. 2—Backsawn and quartersawn myrtle beech and alpine ash vapour dried in 110 hours UNDER VACUUM with wood temperature control, showing satisfactory drying quality.

natively when the kiln conditions were adjusted to give a drying time of 5 days (to bring the drying time to a value comparable with that obtained with perchlorethylene under vacuum) the quality of drying was poor.

From these laboratory studies, which are somewhat limited in scope, it appears that vapour drying may offer some appreciable advantage in drying time and still maintain drying quality, even for the refractory pored timbers, when certain critical drying requirements are fulfilled. Optimum drying conditions are not readily determinable without appreciable study.

It should be stressed that the work at this Division is being conducted on a pilot scale, and that the studies have been confined to an examination of process variables as affecting the behaviour of the wood during drying, and the determination of conditions necessary to give good seasoning quality. It has not been possible to study the many problems in plant engineering, control and operation which result from a transition to large scale operation. Furthermore, this laboratory's present data are insufficient to show whether or not the process can economically compete with other methods of drying in current use.

The necessity for modifying vapour drying conditions for impervious timbers by reverting to comparatively low temperatures obviously tends to eliminate one of the chief advantages of vapour drying. In addition, such process difficulties to be solved for these species include (i) the prevention of working fluid retention in the wood when high vacuum is an integral part of the drying process and (ii) the maintenance of uniform temperature distribution within the drying cylinder. Also the production and maintenance of a high vacuum in commercial equipment is likely to be fairly expensive.

With the impervious hardwoods which do not show marked collapse, such as tallowwood, turpentine and spotted gum, critical drying conditions similar to those required for the collapsing species will probably be needed to achieve high drying quality. The critical vapour drying conditions of each of these species will need to be determined individually.

Several vapour drying scout runs with species such as ramin (*Gonostylus sp.*), which may be regarded as reasonably pervious hardwoods, indicated that these are more tolerant of vapour drying conditions than the types previously discussed and may be fairly easily dried at elevated temperatures.

Softwoods (Non-pored Species)

A study of the drying characteristics of radiata pine in 1 in. and 2 in. thicknesses, and in railway sleeper cross sections (nominally 9 in. x 6 in.) is in progress.

Work on 1 in. thick radiata pine shows that, in the experimental unit, this material can be dried readily without degrade from the green condition to a moisture content of about 12 per cent. under atmospheric pressure in about 5 hours. This material appears to be tolerant of a wood temperature as high as 350°F. towards the later stages of drying. Again, however, difficulties attendant upon operation in large size units under commercial processing conditions have not been studied and these could well involve many problems which would need solution before transition to commercial operation could be made. Also no examination of the economy of vapour drying seasoning quality radiata pine has yet been made, but the position should be more favourable than with collapse susceptible species.

Half length radiata pine sleepers were dried for periods ranging from 5 to 14 hours with a view to examining the suitability of vapour drying to give partial drying as a preliminary to a preservative treatment. Mineral turpentine at atmospheric pressure was used as the working fluid. In the times referred to, drying, of course, was not completed but various degrees of surface drying were obtained.

Subsequent pressure impregnations with creosote, designed to test quantities absorbed and depth of penetration in relation to amount of drying and moisture distribution obtained, were carried out with empty and full cell processes. Promising results were obtained with the empty cell process with a schedule of 25 lb. per square inch initial air pressure for 30 minutes, 150 lb. per square inch creosote pressure for 1 hour (or 100 lb. per square inch for 2 hours) followed by a vacuum of 25 inches of mercury for 30 minutes. Creosote retention under these conditions was from 6 to 8 lb. per cubic foot, and penetration was generally good.

During drying, little surface degrade occurred when considered in terms of the size of the sections involved and the end use. The most frequent form of degrade was the development of one or two long fairly fine checks up to 1 in. deep along the length of the backsawn face(s). This work is in progress and incomplete but present indications are that a drying time of 5 to 6 hours may be sufficient to give enough for a subsequent satisfactory preservative treatment.

Softwoods of a more impervious nature than radiata pine, such as the Australian cypress pine (*Callitris glauca*), would appear to be far less tolerant of the vapour drying process than the true pines. Work has not yet proceeded sufficiently for specific conclusions to have been reached concerning such species.

WHAT WOOD IS THIS?

Part 2.

By M. M. CHATTAWAY, Wood Structure Section

Anatomical Features

Wood is not a simple homogeneous material, but is made up of individual cells, which may occur as isolated units among other cells, or as a *tissue* composed of many similar units. These tissues form the vertical or radial conducting systems, the storage system and the ground mass which gives the tree trunk its strength to stay erect and provides us with the constructional material we call wood.

The main elements of which the wood is composed are the *pores* (the vessels), *rays, soft tissue* (parenchyma and tracheids) and the *fibres*. The details of the individual cells of which these tissues are composed can be seen when sections of wood are examined underneath a microscope, but a great deal of identification is done without recourse to sections or to high power magnification, and the details given in this series of articles are only those which can be seen with the naked eye, or with the help of a X10 hand lens. Particular care must be taken to make a clean

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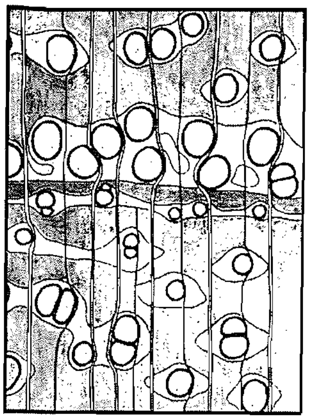

Fig. 1—Ring porous. Soft tissue aliform and confluent.

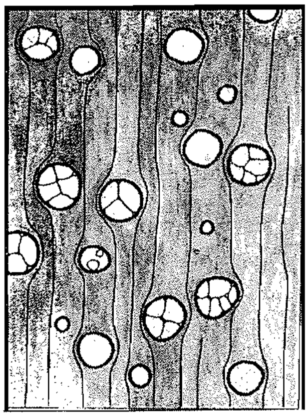

Fig. 2—Pores solitary and containing tyloses.

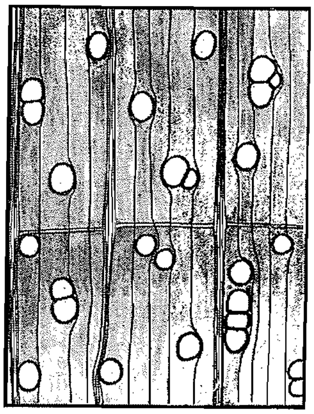

Fig. 3—Rays of two distinct widths.

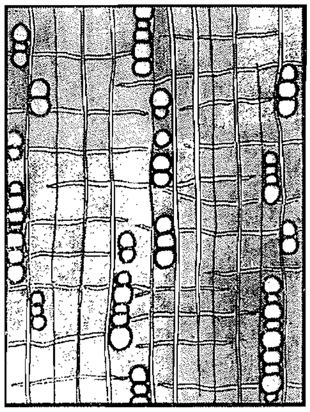

Fig. 4—Pores in radial multiples and in radial alignment.

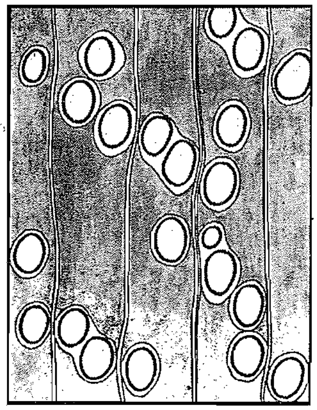

Fig. 5—Pores in oblique arrangement. Soft tissue surrounding the pores.

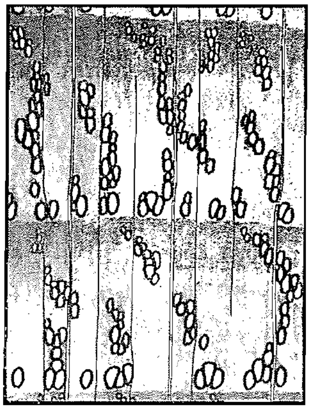

Fig. 6—Pores in flame-like arrangement.

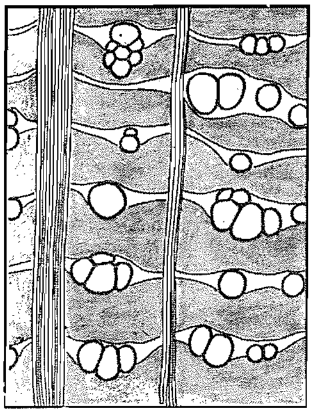

Fig. 7—Pores in clusters and in tangential lines. Rays wider than the pores.

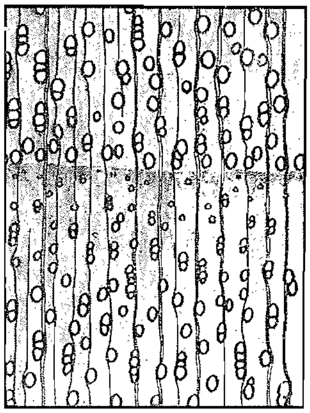

Fig. 8—Pores small and evenly distributed.

cut on the cross surface of the wood, otherwise the pattern will be blurred instead of showing up clearly and sharply. The best way to secure this is to use a razor blade; if a knife is used, it must be kept very sharp indeed.

For purposes of identification the tissues are examined in two ways, first for details of their individual structure, (e.g. size, number in a given area of the wood, etc.) and secondly for their arrangement in the wood and for the *pattern* which this arrangement gives on the cross surface of the timber. The patterns formed by different combinations of these tissues are very numerous and varied, and in many cases they are so distinctive that they tell at once to what botanical family a wood belongs. Woods of the pea family (blackwood, acacias) and the mahogany family (cedar, mahogany) have a very characteristic "family" pattern, and anyone who has come across them much, quickly comes to recognise them. In other families the patterns may be more commonplace and less distinctive, and in some woods the only thing that can be said of them is that they appear on first sight to be without any distinctive pattern, and a careful examination is needed to establish sufficient features to identify the wood.

Figures 1-8 show what is meant by the patterns that may be found in woods; the terms applied to them will be explained as they occur in the text.

Pores. On the cross surface of the wood the pores appear as circular or oval holes which may be empty of contents, or filled with deposits or tyloses. They are the cut ends of the vessels through which the nutrient solutions which form the food of the tree are carried vertically up the tree trunk. There is great variation in different species in number, size and arrangement of the pores.

Pore arrangement. The pattern that is formed by the pores on a cross surface of the wood is a useful diagnostic feature, and although minor variations occur, it remains fairly constant for any one species. Different arrangements are shown in the accompanying figures.

Pores absent. Some timbers are without pores; they are the true pines, douglas fir, spruce, hemlock and other timbers known as "softwoods" in the trade. It should be understood however that many softwoods have pores and many non-pored timbers are hard, and it is for this reason that the terms "pored" and "non-pored" timbers are preferred to the older ones

Ring-porous or semi ring-porous. This is a feature which only occurs rarely in Australian timbers, though it is extremely common among those of the Northern hemisphere, where it is connected with the deciduous habit and the alternation of the cold winter season and the sudden burst of growth which occurs in the spring. A ring of larger pores may be formed at the beginning of each growing season and from these there is a marked diminution in size or number (or both) throughout each growth ring. (Figure 1).

Pores predominantly solitary. (Figure 2). This term is used when at least 90 per cent of the pores are solitary, as in most of the eucalypts.

Radial multiples. When pores are grouped together they are often radially aligned, either with the common wall flattened (Figure 3) and the whole outline of the pore multiple somewhat similar to that of the solitary pores, or preserving the outline of the individual pores to give a chain-like appearance (Figure 4). It has been found that while many woods have short radial pore multiples of up to and including 4 pores (e.g. Queensland maple) there are relatively fewer woods with the longer radial pore multiples (e.g. yellow boxwood).

Pores in oblique arrangement. Pores are sometimes distributed with a definite oblique arrangement at an angle to the direction of the rays (Figure 5). This arrangement may occur with solitary pores or with pore multiples (e.g. eucalypts, oak, satin box). A variant of this which may occur when the pores are in multiples is described as "flame-like" (Figure 6).

Pores tangentially arranged. (Figure 7). Pores may show a tangential instead of a radial pairing or multiplication; this feature is very characteristic of the silky oaks.

Pore clusters are irregular groups of contiguous pores which may be tangentially arranged but are not necessarily so (e.g. silky ash).

Pore number is determined by pressing a cock borer or other metal tube of known area on to the clearly cut surface of the wood and counting the number of pores within it. Counts should be made on at least four widely separated areas and the mean obtained. On counting, the individual pores of a pore multiple or pore group must be counted separately. The classes commonly in use are as follows:—

Few—Four or less per sq. mm. (e.g. mountain ash).

Moderately numerous—Between five and eleven per sq. mm. (e.g. grey persimmon, Queensland walnut).

Numerous—More than eleven per sq. mm. (e.g. myrtle beech).

It will be appreciated that where two woods are being compared, the variation that may occur in number must be taken into account. Thus a difference between 3 per sq. mm. and 5 per sq. mm. would not be, of itself, sufficient to distinguish the woods, but a difference of say 8 per sq. mm. and 20 per sq. mm. would readily do so.

Pore size. Like pore number, pore size will vary, not only between different species of timber, but between different specimens of the same species, and sometimes even between different parts of the same tree. This has to be allowed for in assessing the value of the feature in each wood examined. No attempt to give actual measurements is made but the classes are based on the visibility of the largest pores.

Large—Pores individually distinct to the naked eye (e.g. mountain ash, messmate).

Intermediate—Pores visible to the naked eye, but not individually distinct (e.g. tallowwood, blackbutt, spotted gum).

Small—Pores indistinct to the naked eye, but clearly visible with a lens (e.g. yellow carabeen).

Very small—Pores indistinct, even with a lens (e.g. sandalwood, leatherwood).

Tyloses common. (Figure 2) Tyloses are ingrowths into the vessel cavity, they are commonly formed when sapwood starts to change into heartwood, but they may also be produced in the sapwood as a result of injury. Owing to their sporadic occurrence the fact that they are absent from a wood has no significance, but when they are very conspicuous either because of the thickness of their walls, or because of their abundance, they become a useful diagnostic feature of the wood. They usually glisten on the cross surface (e.g. many of the eucalypts).

White or yellow deposits common. Deposits may fill every pore, but usually they are sporadic in occurrence (e.g. saffron heart, turpentine, red silky oak).

REMOVAL OF STAINS FROM TIMBER

Black stains are frequently observed on various wooden structures when they are exposed to the weather or are subjected to frequent wetting with water. These stains generally originate from the heads of nails used in the construction and take the form of narrow lines extending downwards from the nail. Softwood timbers rarely show this type of stain but it occurs to a greater or lesser extent with most of the common hardwood timbers. The stains are due to the tannins in the wood reacting with the iron in the nail to produce the black iron tannate. These tannins are readily leached from the surface of the wood by water, and as they run down over the nail head they react with the iron to give the typical black stain. While these stains are of no consequence in frame work or rough constructions such as paling fences, they may leave marks on weatherboards or window frames which prevent the wood being finished in natural colours. Flooring also may be affected in a similar manner if wetting occurs.

The obvious way to prevent such stains developing in hardwood timber is by sheltering the wood from the elements until it is painted and by promptly punching all nails and sealing the holes with putty. However, if iron stains have developed on the wood they may be removed by the following procedure.

Make a saturated solution of oxalic acid in water (about two teaspoons full to a cup of water) and apply to the stain with a cloth. Allow the wood to dry and repeat if necessary. The solution should be confined to the stained area as it has a mild bleaching action on the unstained wood. It might be necessary to wash the entire area over with a very dilute solution of the oxalic acid after removal of the stain to ensure that the colour of the finished surface is uniform. Finally, the treated area should be rinsed several times with water to remove any oxalic acid remaining as this may interfere with the subsequent finish.

(*Warning.* Oxalic acid is extremely poisonous if taken internally and care must be taken to ensure that neither crystals nor the solution can come into the hands of children or of others unaware of its poisonous nature.)

Brown stains sometimes occur on timber which is in contact with concrete or mortar. They may also be caused when water which has run over a concrete or brick structure comes in contact with wood. These stains usually occur in newly constructed buildings or those in the course of construction. They are caused by alkaline materials being leached from the surface of the concrete or mortar and reacting with the tannins in the wood. While these stains are not nearly as prominent as the black iron stains referred to earlier, they may be sufficient to interfere with subsequent finishing operations.

Once again prevention is better than the cure, but if stains have developed and need to be removed the following procedure will generally be found satisfactory.

Wash the surface of the wood thoroughly with water to remove any alkaline material and follow this by a wash with dilute hydrochloric acid (about 1 egg cup of the concentrated acid to a pint of water). This concentration will not harm the hands providing they are thoroughly washed with soap after the work has been completed. More than one application may be necessary to remove the stain. The treatment is completed by washing several times with water to remove any remaining acid.

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