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DIVISION OF FOREST PRODUCTS, CSIRO, P.O. BOX 310, SOUTH MELBOURNE, VICTORIA 3205

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A Simplified Approach to Mechanical Grading

The Grading Device

AS MENTIONED in the first part of this article (Newsletter No. 356), the Division is in the process of developing a relatively cheap and simple device for the mechanical grading of timber elements such as scaffold planks, studs for wall framing, cross-arms, and other end-uses of timber where

(*a*) the piece of timber is subject principally to loading as a beam and (*b*) the high throughput and high capital cost of a mechanical grading machine would not be warranted.

Basically the device employs the same principle as the grading machine, but whereas timber feeds continuously through the latter in normal operation, it is stationary at the time of testing in the grading device.

Essentially the procedure involves supporting the piece of timber to be tested as a beam over a set span, applying a known weight to it, and using an indicator to determine whether the deflection of the piece of timber is within an acceptable limit in relation to the strength required. A pneumatic or hydraulic jack or even a simple hand-operated lever system may be used for lowering the weight and subsequently raising it after the test is completed.

It is essential that the measurement of the deflection under the applied load be free of

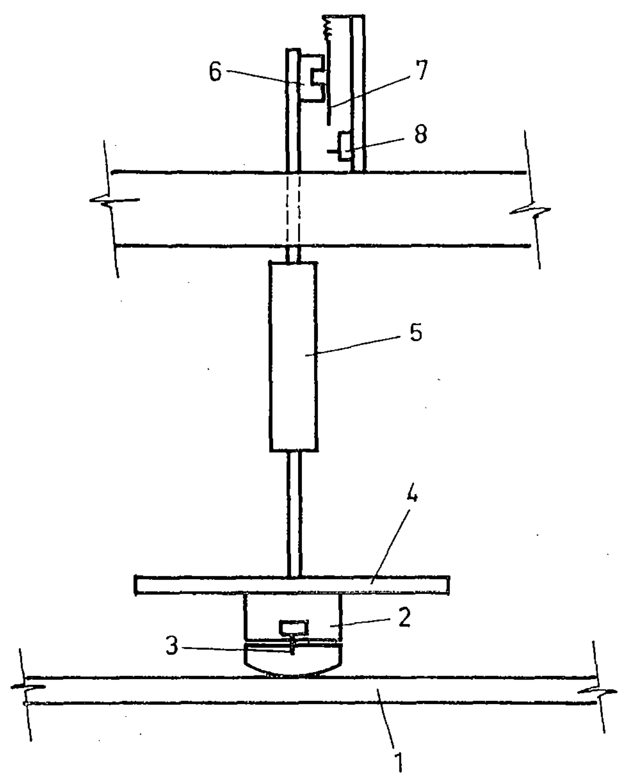

Fig. 1.—Diagrammatic representation of the grading device. 1, Test piece; 2, loading head; 3, plunger; 4, loading weight; 5, pneumatic or hydraulic cylinder; 6, electromagnet; 7, deflection measuring rod; 8, limit switch.

significant errors which could arise from any slight warp in the piece of timber in the unloaded state. Satisfactory measurement may be achieved in several ways; one method is shown in Figure 1. Immediately the loading head makes good contact with the surface of the beam, a small plunger in the head closes an electric circuit energizing an electromagnet. This causes a firm attachment between the magnet and a deflection-measuring rod and establishes a datum position from which the subsequent deflection of the beam can be measured. As the load is applied, the deflection-measuring rod moves through a distance exactly equivalent to the deflection of the beam at its mid point.

If the deflection of the beam under load exceeds the acceptable amount, a pre-set limit switch is actuated by the rod. This causes a second circuit to energize a pilot globe, buzzer, or other suitable indicator to inform the operator that the piece of timber is too flexible and should be rejected. If its deflection under load is less than would cause the limit indicator to operate, the piece of timber is deemed, because of the correlation between bending strength and stiffness, to be of satisfactory strength. This system can be made more sophisticated by providing a means for automatically marking the beam to indicate that it has successfully passed the test.

Generally, it is not practicable to use this simplified mechanical grader to grade continuously a piece along most of its length as does the more elaborate grading machine. It is essentially a "spot tester" and, if used intelligently in combination with visual grading, it should provide an efficient means of grading for some end-uses of timber.

With data already obtained from the machine grading of scaffold planks by the Division of Wood Technology, New South Wales Forestry Commission, there should be little difficulty in using the simple equipment described here to grade Douglas fir scaffold planks. Other softwood and hardwood planks may be graded similarly, but some investigational work may be necessary to check on the appropriate deflection limits for these.

Recently a more refined prototype grading device has been constructed (Fig. 2) to replace the original apparatus improvised to study the possibilities of this simplified approach. This is being used to establish correlations between strength and stiffness to enable sound procedures to be developed for the use of the equipment in the grading of studs, cross-arms, and timbers for other specific end-uses. These procedures will be described in subsequent articles as sufficient test data become available.

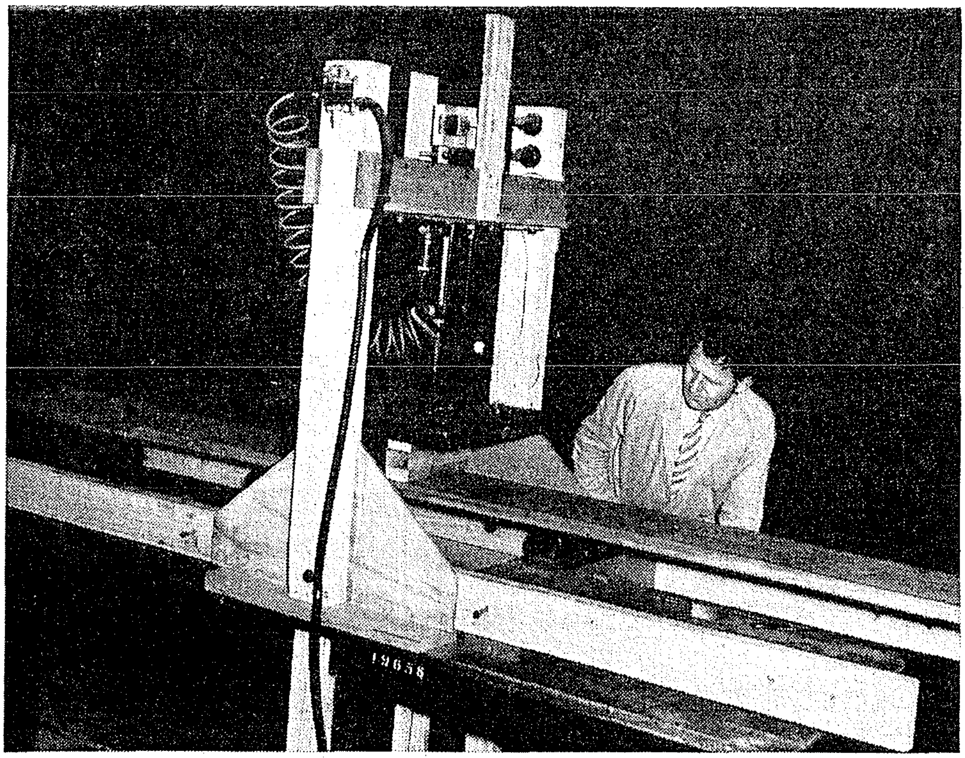

Fig. 2.—Scaffold plank under test in prototype mechanical grading device.

The Division and Standards

IN A RECENT ISSUE of the Standards Association of Australia Monthly Information Sheet, it was reported that there are currently more projects in hand that relate to timber standards than at any earlier time. In all, there are 18 technical committees actively engaged in timber industry work with a further 6 working on related topics such as containers, preservatives, safety, etc.

The extent of the Division's commitment to standards work is not widely known, but with one officer or his deputy allocated to each of the 24 committees and many more of the staff supplying data and opinions, it is obvious that the total work load is considerable. However, the production of Australian standards provides the opportunity to incorporate practice in accordance with our research and in this way ensures its application to industry.

The Division's role on a technical committee is normally to provide the detailed specialist knowledge relating to timber, timber products, and their application. In addition, most of the officers are able to make significant contributions to the drafting and presentation of a standard because of their considerable experience in this type of work.

Some of the standards currently in preparation are referred to as codes of practice, and as such will have wide ramifications in their fields. Two in the structural sphere relate to light timber framing and the use of timber as an engineering material. Because both topics are very broad, the amount of detailed information that will be contained in these codes is substantial. The final publications will be the end-product of several years' work by the appropriate committees.

The range of standards relating to timber is wide and, in addition to those mentioned previously, covers items such as plywood, scaffold planks, preservation, paper products, tool handles, poles, and piles. For this reason nearly all sections of the Division become involved in one way or another in standards work.

Research Projects

Seasoning Degrade

The importance of reducing degrade in timber to a minimum during seasoning cannot be over-emphasized, when it is realized that on an overall industry basis each 1% loss of production due to drying degrade represents a material loss of perhaps three million super ft per annum and a monetary loss of at least $300,000 per annum. Surface checking is one of the main forms of seasoning degrade, and recent research has been aimed at controlling this checking to enable 1 in. back-sawn stock of the ash-type eucalypts to be satisfactorily processed and to reduce the incidence of edge checking in the thicker joinery sizes.

Surface coatings of the microcrystalline wax emulsion type have already demonstrated their effectiveness in controlling face checking in joinery sizes of non-collapsing species such as kapur and ramin, but these have not produced consistently satisfactory results with the collapse-susceptible hardwoods, especially if back-sawn. However, good results are being obtained at one Victorian plant where stacks of 1½- and 2-in.-thick quarter-sawn material are being sprayed on the ends, sides, and top of each stack with a timber dressing compound diluted with kerosene. This practice reduces the effect of weathering, and checking has been considerably reduced.

Chemical seasoning is producing encouraging results with back-sawn eucalypts, and present investigations are concerned with the soaking of the timber for several hours in solutions of either sodium chloride or calcium chloride prior to normal air- or kiln-drying.

Penetration of Liquids into Wood

An understanding of the way in which liquids penetrate wood is of considerable importance in chemical wood pulping and wood preservation. In hardwood, the vessels or pores are the primary conducting elements through which liquids penetrate in the first place. From the vessels they then move into other wood tissues.

Earlier it was found that vessels in messmate (*Eucalyptus obliqua*) could be as long as 5 ft although most were in the range 7–27 in.

More recently a study of serial sections of spotted gum (*E. maculata*) showed that vessels are widely interconnected in the wood structure so as to form conducting networks. For instance, out of 149 vessels in one sample, 56 were in direct contact for an average of 28% of their length. Many more were connected via other wood elements, and when these indirect connections were taken into account, 110 of the 149 vessels were found to be in contact along 75% of their length.

Effect of Thinning and Fertilizer Treatment on Wood Characteristics

Thinning and application of fertilizer can have a marked effect on the rate of tree growth, but it is of equal importance to ascertain the effect of these operations on the quality of wood produced. In collaboration with the Western Australian Department of Forests, an investigation has been commenced on 25-yr-old *Pinus pinaster*. Stems were thinned from 1000 to between 400 and 100 per acre, and comparisons made with unthinned controls.

In this species, spiral grain and tracheid length are important properties for the utilization of the timber, and the forester aims to minimize the former and maximize the latter. This present work showed that neither thinning nor fertilizers influenced spiral grain angles which are probably largely genetically determined. On the other hand, the tracheid length was reduced 2 years after thinning treatment, and application of fertilizer 3½ years later caused a further reduction. This reduction was observed in the wood laid down during the year immediately after fertilizing and after this time tracheid length returned to normal.

Thinning and fertilizing treatment are thus seen to affect growth rate favourably although they can cause reductions in fibre length.

ABSTRACTS

Control of Shrinkage in Australian Timbers by E. R. Pankevicius. I. The influence of certain bulking agents at various concentrations. Div. For. Prod. Technol. Pap. No. 54.

A considerable amount of research has been carried out in an effort to improve the dimensional stability of wood under varying atmospheric humidity conditions. Although many methods have been devised, none have been acceptable to the wood industry, either for economic reasons or because of their adverse effect on properties.

This paper is the first of a series that will deal with the Division's research on dimensional stabilization of eucalypts and other species. The species covered in this paper are radiata pine, brown tulip oak, coachwood, alpine ash, and karri, all in the form of 1-in. cubes. Experiments with material of commercial size will be the subject of a subsequent paper.

DONATIONS

The following donations have been gratefully received by the Division over recent months:

Sapfor Timber Mills, Mt. Gambier, S.A.	$100.00
Britton and Grey, Smithton, Tas.	$30.00
Bright Pine Mills Pty. Ltd., Vic.	$200.00
Bowater Scott (Aust.) Ltd.	$100.00
Australian Timber Journal	$30.00
Perfectus Airscrew Pty. Ltd., Vic.	$30.00

Materials

Radiata Pine Association — Timber for experimental purposes	$180.00
Automated Building Components (Aust.) Pty. Ltd., Springvale, Vic. — Hydraulic press	$1200.00
Gang nails	$20.00
G. N. Raymond Pty. Ltd., Dandenong, Vic. — Round fence posts for preservative testing	$25.00
H. Beecham & Co. Ltd., Melbourne — Radiata slats for experimental purposes	$10.00

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Wood-inhabiting Bacteria: General Considerations

By H. Greaves, Preservation Section

DECAY of wood is usually taken to imply an attack by the higher fungi, such as basidiomycetes (typified by mushrooms, toadstools, and bracket fungi). Very rarely have the lower forms, such as bacteria, been known to destroy woody cell walls. Yet these micro-organisms are an extremely widespread group, representatives being found in almost all environments known to man. Wood can be attacked in many situations, and conditions that would be unfavourable to most fungi, such as waterlogging and low oxygen content, may be conducive to bacterial attack. They occur time and again in isolations from rotting wood and must surely play a role in the destructive processes.

Bacterial Development in the Living Tree and in Stored Wood

Not only are bacteria present in "dead" wood but also they occur in the living tree. It has been well established that certain bacteria cause diseases of trees, e.g. the water-mark disease of the cricket bat willow, and the bacterial cankers of numerous tree species. In addition to the water-mark disease, or wilt, in willows, bacteria have often been associated with wilts and discoloured zones of other tree species such as elms, poplars, aspens, oaks, etc. Similar bacterial effects have also been noted in softwoods as well as in the hardwoods, pines and firs being most frequently reported.

There is little doubt that certain storage conditions promote the growth of bacteria in areas of cells. Occasionally, larger areas of the wood may be affected. This effect is not uncommon in wood obtained from logs which have been ponded, or decked under water sprays. Bacteria can establish themselves at the bark–wood interface of logs, and then move with relative rapidity along their lengths. From this vantage point, the organisms are thus able to penetrate the ends of the rays. The fact that the ray cells contain so much nutrient is an obvious reason for bacterial (and fungal) preference for such cells. From the ray cells many organisms are able to move into the other wood elements, and once established there they are capable of rapid longitudinal spread throughout the wood. Infection of stored wood occurs mainly from the immediate environment, but where timber has been colonized in the standing tree, via a wound or branch drop, further bacterial growth may be enhanced by felling and subsequent storage.

Although the decay rate of bacteria is generally much slower than that of higher microorganisms such as basidiomycete fungi, cell growth is far more rapid; under optimum conditions a bacterium may reproduce by simple cell division every 20 minutes. This continual division means that a bacterial colony can grow at a considerable rate. Thus even when the individual bacterial cells are non-motile, they can still theoretically penetrate the wood by their rapid division and re-division. In addition, many groups of bacteria possess flagella, with which they are able to propel themselves from place to place. This means of movement is far more rapid than that achieved by wood-destroying fungi. Water movements within a piece of wood, e.g. partial drying and rewetting, during storage or service will also assist in bacterial movement throughout the wood.

Attack of Wood in Service

Having so far established that various groups of bacteria may infect wood either as the living tree or in the converted form, the questions arise as to whether bacteria are capable of causing any real damage to wood and whether they represent a serious threat to preservation of wood.

It is known that under certain environmental conditions wood will not be attacked by the higher groups of wood-destroying fungi. However, a small amount of surface softening of the wood caused by lower forms of fungi will occur. An environment typical of this situation is found in water-cooling towers. Under these conditions bacteria also grow quite readily in the wood.

In a preliminary survey of preservative-treated radiata pine slats in a number of cooling towers throughout Australia, it was found that though fungal attack had been largely prevented there was a considerable amount of bacterial penetration and some associated damage to the wood. The bacteria were isolated and found to be highly tolerant of such preservatives as copper–chrome–arsenic (CCA), creosote, pentachlorphenol (PCP), and tributyl tin oxide. Relatively high concentrations representing loadings of 4 lb/cu ft for CCA and 16·0 lb/cu ft for PCP in heavy oil (5% solution) were not sufficient to inhibit growth of many of these bacteria. Tests showed that relatively few of the organisms were able to attack wood cell walls alone, but certain bacteria in association with other bacteria, and probably with certain fungi, can accelerate the decay of treated cooling tower slats, resulting in premature replacement of the wood.

Examination of mining timbers has revealed a similar situation to that observed in cooling towers. With regard to wood in ground contact, where basidiomycete fungi are an added hazard, little work on the bacterial factor in decay has been done. It is intended to remedy this situation in the near future.

There are few reports on the loss in strength of wood due to bacterial attack. In cooling towers, measurements have shown as little as 5% loss in many slats, while in other slats about 45% of the bending-stiffness strength has been reduced primarily by bacteria. Using other measurements of strength such as compression strength and modulus of elasticity, piles of Scots pine and Norway spruce have been shown to lose about 30% of their strength during bacterial attack.

Bacteria in a Beneficent Role

The attack on stored timber, especially under water as discussed earlier, may lead to increases in the permeability of the wood. Experiments have shown that certain species of bacteria are able to increase wood permeability without affecting the gross strength properties of the material. They do this by decaying the pits (interconnections between the cells), with the result that liquids can move relatively freely from cell to cell. Ray cells are also attacked by the bacteria, giving rise to greater radial penetration in some wood species. Overall increases in permeability using small test specimens of *Pinus radiata* heartwood have been encouraging. There is hope therefore that refractory wood species may be made more treatable by a controlled bacterial attack.

Controlled delignification is another goal now being sought, by harnessing the action of certain species of bacteria; a number of species seem able to preferentially attack the lignin in wood. The increase in ease and yield of pulping processes that would result from a controlled attack by these micro-organisms is an obvious advantage, and would be a significant contribution to the pulp and paper industry.

Bacteria are well-known producers of antibiotic substances. Screening tests of isolates from cooling towers have indicated that diffusible compounds are produced by certain bacteria which are toxic to a large number of fungi. It is therefore conceivable that bacteria growing in wood in service may directly inhibit invasion by wood-destroying fungi. Bacteria are also well known for their metabolic products of value to man, such as vitamins, amino acids, alcoholic beverages, etc., and although no satisfactory process for the disposal of wood wastes has yet been outlined, it is not beyond the realms of possibility that bacterial fermentation can be beneficently employed.

It can therefore be seen that bacteria have an important role to play in wood utilization. Their deteriorative effects, especially in wet environments, are also being recognized, and the overall consideration of bacteria and wood products is rapidly gaining momentum.

Research Projects

Mechanical Properties of Building Scantling

The mechanical properties of scantling-size timber under various conditions of use are the subject of current study. One such project is concerned with the influence of gum veins on the strength and stiffness of marri, a Western Australian species. By grading each piece visually and mechanically and then testing it to destruction in the laboratory, it is hoped to obtain data that will permit the economic utilization of hitherto rejected material of this species.

A number of 4 in. × 2 in. scantlings of plantation-grown softwood have been tested in tension to determine the species' working stress for this property. Indications are that a suitable working stress will probably be rather less than 80% of the working stress in bending, which is the present recommendation for hardwoods.

Structural Timber Design

The development of new designs involving timber as a structural material is a project which receives constant attention from the Division's engineers. Recently two novel designs have been produced to meet special situations. The first of these is for a 60-ft span timber foot-bridge suitable for pedestrian overpasses. Considerable interest in this bridge has been shown by various authorities. The second is for a trussed roof beam to provide adequate roof support over large spans in house construction. This may be assembled on site using normal framing timbers and nailed gusset plates.

Several committees of the Standards Association of Australia rely on the Division for the provision of strength data and design tables. For example, information has been supplied to enable the Code of Practice for Light Timber Framing to cater for additional stress grades, two classes of construction instead of one, the use of seasoned timber, and a variety of tolerances on timber sizes. Assistance is being provided in drafting two other important codes that relate to machine grading and timber engineering design.

Glued Laminated Construction

Glued laminated construction provides a convenient stepping-stone for timber to enter the field of heavy construction. This fact has been recognized for some time, but now with increasing interest in "glulam" in Australia there is a need for basic design data. The first move has been the production of span-load tables of a type of beam that will have wide structural application. As is normal in laminated construction, maximum economy and utilization have been achieved by placing low-grade boards near the core with outer laminations of higher-quality material. Although these tables were prepared with radiata pine in mind they may readily be adapted for other species.

Thick Veneer

The use of thicker veneer in certain plywood constructions would effect savings in production and glue costs, but the most promising application may be in the production of high-quality laminated beams using low-quality logs as raw material.

In veneer peeling and slicing, thickness uniformity, surface smoothness, and knife checking become increasingly difficult to control as the thickness of the cut is increased. These restrictions on thickness are such that there are very few instances where veneers are peeled or sliced commercially in thicknesses greater than 0·2 in.

However, experiments in thick veneer peeling now in progress suggest that with suitable regulation and control of cutting variables the limiting thickness for species of air-dry density up to 35 lb/cu ft may be greater than 0·5 in. Current work being carried out on a modified commercial 3-ft veneer lathe has culminated in the peeling of 0·4-in. and 0·5-in. veneer having a surface quality and strength comparable with that of a sawn and dressed board, and thickness controlled to within ±1%. Investigations are being extended.

Pole Research

Wooden poles are preferred by electricity and communications authorities for supporting overhead lines. In recent years, the increasing use of preservative treatment together with the high cost of poles has led to various investigations by the Division, particularly in relation to the seasoning, preservative treatment, and strength of poles. Results of this research have already brought about economies in the use of poles, but use of a wider range of species has created additional problems which are currently being tackled.

Preservation of Poles

Although the quality of preservative treatment of poles is improving, there are some species in which better preservative penetration is necessary before they can be considered to be satisfactorily treated. Methods of improving penetration are at present being studied, particularly in relation to the region of the ground line, where adequate treatment is of the utmost importance. Attention is also being given to the development of centre rots, including methods for their early detection, a survey of their frequency of occurrence, and possible methods for their prevention. A novel method developed to allow centre sterilization during normal treatment involves drilling a 3-in. hole up the centre of the pole from butt to above ground line. It has the additional advantage of allowing a diffusible preservative to be plugged in the hole. Possible commercial application is being explored.

Theory of the Strength of Poles

A long-term study is in progress to ascertain why poles are stronger than the material cut from them. One possible reason could be the undamaged surface of the pole, although tests so far have not confirmed this. Another reason could be the cylindrical symmetry of the pole, and this theory is now being tested.

Electrical Conductivity of Pole Timbers

It is important to know the conductivity of poles treated with waterborne preservatives. Wood is regarded as a good insulator, but the preservatives used could lower its insulating properties to a degree where precautions are necessary. Experimental work on poles treated with waterborne copper–chrome–arsenic preservatives of both salt and oxide formulations showed that:

- The salt formulation increased the conductivity of the three species tested by factors of 2 to 10 times, depending on moisture content;
- The oxide formulation made little difference to the conductivity; and
- Neither formulation affected significantly the moisture content at any given relative humidity.

The first point above indicates that the surface of poles should be adequately dried after treatment and before use.

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SAP DISPLACEMENT SIMPLIFIED

By F. A. Dale, Preservation Section

ONE of the oldest methods of timber preservation is the Boucherie process in which a waterborne preservative solution is forced under hydraulic pressure into one end of a piece of freshly felled round timber. The solution displaces the free water from the sapwood of the tree and this is forced out from the other end at a rate dependent upon the applied pressure. When the sap has been replaced by preservative solution the process is complete.

Since its invention in 1838 numerous variations of the process have been developed. It is in commercial use in Denmark and elsewhere, although it has now been largely replaced by conventional pressure treatment of dry round timber.

In the past the process has been used to treat softwoods, which allow radial movement of preservative and, because they are reasonably round in cross-section, permit the fitting of a pressure cap without much difficulty. A recent development, the Gewecke process, applies a vacuum to one end of the pole which is submerged in preservative solution.

The introduction of the fixed copper-chrome-arsenic preservatives has enhanced the possibilities of this treatment, as they are permanent and much more effective than the preservatives previously used.

Treatment of hardwood poles with their narrow sapwood by sap displacement is not so simple. Poles are often oval in section and

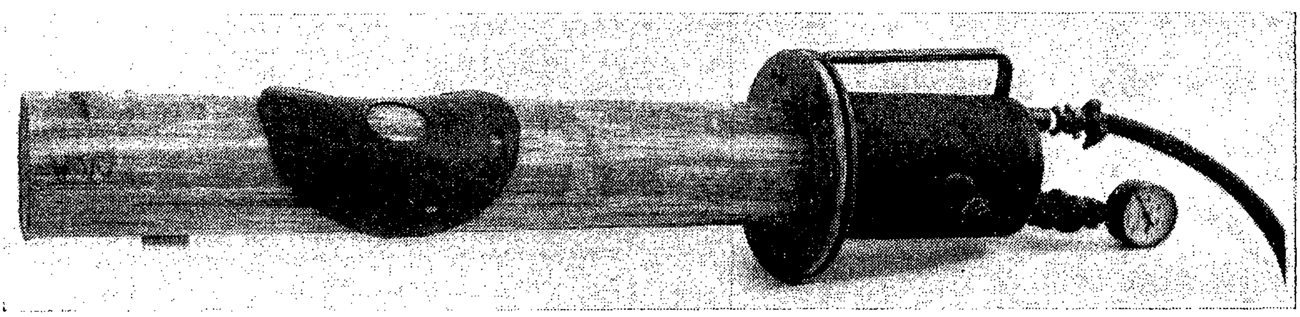

Fig. 1.—The Division's sap-displacement device for use on hardwood poles.

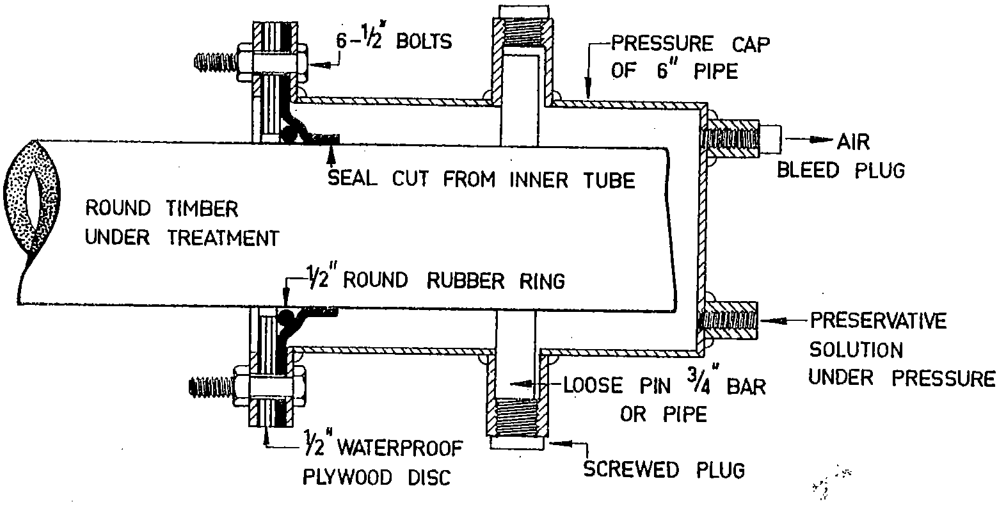

Fig. 2.—Cross-section of pressure cap of the sap-displacement device.

may be split in felling. Any device to introduce liquid under pressure at one end must make a watertight seal without blocking any of the vessels or capillaries which allow liquid movement in the sapwood. This means that the seal must be made on the cylindrical surface, not the end of the pole. In addition the cap must be fixed to the pole without damaging the sapwood to prevent the liquid pressure forcing it off.

A device (Fig. 1) developed by the Division is believed to be the simplest yet conceived and is described for anyone wanting to use the method.

Figure 2 shows a cross-section of the pressure cap. It consists of a short piece of steel pipe closed at one end. At the other end an annular seal made from soft rubber sheet is clamped between a flange welded to the pipe and a loose mating flange. The cap is fixed to the pole by a short piece of bar or pipe passing through a transverse hole in the butt. This bar is held by pipe sockets welded to the cylinder which are then closed with screwed plugs to prevent the escape of solution. The seal itself is prevented from blowing out by a rubber O ring, backed by a waterproof plywood disk with a central hole allowing it to fit easily over the pole. In a cap designed for larger poles this disk would be replaced by adjustable "fingers" of sheet steel or even wood, fitting between the bolts, which would be moved in or out before clamping to suit poles of different sizes and irregular shapes.

Although the prototype has been tested to a pressure of 200 lb/sq in there is probably not much to be gained by using pressures over 100 lb/sq in. Even at 50 lb/sq in a eucalypt pole 20 ft long has been treated in less than 2 hours.

The equipment is cheap and light and can be fitted to a pole in about 10 minutes. In less-developed countries or areas where conventional pressure treatment is not practical, sap displacement using this equipment offers a cheap and simple means of treating round timber with waterborne preservatives. However, the process itself has limitations, and more work is needed before it can be recommended without reservation for hardwoods. Species, time of felling, sapwood width, and other factors could affect the treatment, and only adequate field testing can determine the effects of these variables.

More detailed information may be obtained from the Division for those interested in using this process who consider that it offers possibilities for special purposes. However, it must be made clear that the Division does not recommend the Boucherie treatment as an alternative to pressure treatment of dry poles where this is available.

Among the matters still to be resolved are the distribution of preservative along and around the pole, possible re-use of solution after treatment to reduce costs, and the most effective means of estimating when to stop treatment. Some species also appear to treat only in the outer sapwood.

HIGHLIGHTS OF 40 YEARS' RESEARCH

Paper Science Section

From its earliest days the Division has been closely concerned with problems relating to the establishment and development of the pulp and paper industry and with scientific aspects of the chemistry of wood and its conversion into paper. Even before CSIR was established, research was carried out by its forerunner, the Institute of Science and Industry, on the suitability of Australian timbers for paper manufacture; this culminated, towards the end of the 1930s and in the early 1940s, in the establishment of pulp mills in Victoria and Tasmania.

In the early years of the Section considerable attention was paid to wood analysis, including the development of methods appropriate to indigenous species. In more recent times effort has been concentrated around a few main themes, including the application of high-yield pulping in the Australian environment, consolidation and formation of the fibre network, stock preparation, the origin and nature of cell-wall polysaccharides, hydrogen bonding in relation to molecular and crystal structure, and fibreboard behaviour. Efforts are continually being made to increase the relevance of our work to the practical problems of the pulp, paper, and related industries, while not neglecting the basic scientific progress which is essential for technological advance.

It is impossible to describe in any detail here the studies carried out in the fields of wood chemistry and paper science, or even to give the conclusions: these are to be found in well over 200 scientific and technical publications, and they have been reported at many meetings and conferences, both in Australia and overseas. However, the following examples of the Section's work may serve to illustrate the range and nature of its activities.

Some Direct Applications to Industry.—

- The development or standardization of laboratory beaters, pulp evaluation procedures, and testing instruments (e.g. the Australian tear tester, which is widely used throughout the world).
- Modifications to pulp washers.
- The application of water during the drying process to eliminate paper cockling.
- The assessment of pulping potential from wood characteristics, and the demonstration of the pulping potential of various species, e.g. W.A. eucalypts.
- The use of the DFP rheometer and its modifications for measuring wet strength, and the application of rheological principles generally.
- A method for the removal of metal-ellagic acid deposits from pulp mill equipment.
- A method for reducing the curvature of warped corrugated fibreboard.

However, the main influence of the Section is in providing a continual flow of basic information which can be directed towards industrial problems such as an improved yield, a better product, or more efficient production.

Wood Constituents.—The chemical structure of the carbohydrates other than cellulose present in eucalypt woods has been elucidated, and evidence has been obtained for the existence and nature of linkages between lignin and these materials. Methods for determining the amounts of various constituents in wood have been improved. A theory on the formation of heartwood has been proposed whereby extraneous materials toxic to the living cell are transported to the inner sapwood. Methods have been developed for the classification and identification of Australian plant gums.

Application of Spectroscopy in Wood Chemistry.—In the past decade or so considerable use has been made of infrared spectroscopy and associated techniques for studying the structure and reactions of wood and its constituents. A comparison of the spectra of cellulose and related materials yielded much information which could be applied in characterizing structural features of unknown polysaccharides. Novel methods were developed for studying the chemical nature of wood and the changes taking place during chemical pulping, and spectroscopic techniques were also applied to the study of the shape of molecules.

Hydrogen Bonding in Wood, Paper, and Other Materials.—The presence of a large proportion of hydroxyl groups in cellulose and its associated materials confers a high potentiality for hydrogen bonding on wood pulps. The Section's work has contributed considerably to recognition and acceptance of the significance of hydrogen bonding in cellulose, wood, and paper, particularly its role in interfibre adhesion. Hydrogen bonding patterns have been elucidated for various wood constituents and related compounds. The work on carbohydrates has shed light on the detailed crystal structure of cellulose.

Fibre Separation, Pulping, and Delignification.—The conversion of wood to free fibres has been studied in many ways. Kinetic studies showed that acid hydrolysis occurs in the heartwood of living trees and aids mechanical pulping. Methods of improving the yield of alkaline pulps were investigated. Much emphasis has recently been placed on improving the effectiveness of high-yield pulping processes as applied to eucalypts, having regard to yield, strength, and colour. Continuous attention has been paid to the pulping potentialities of Australian woods, and more recently this work has been extended to cover New Guinea species and exotic plantation species. The pulping behaviour of tension and compression wood has been found to be usually inferior to that of normal woods.

Relationship between Fibre and Paper Properties.—A clear appreciation has emerged of the overriding importance of the lateral conformability of pulp fibres in determining interfibre bonding and hence mechanical and optical transmission properties of paper. Conformable fibres can collapse during pressing and drying of the paper web in such a way as to provide a high relative bonded area which makes best use of the bonding potentiality of the pulp. The significance of conformability is also shown in the relationship between wood basic density and paper properties, which is important in the selection of species for afforestation. A series of investigations into the influence of fibre morphology on paper properties has led to a good appreciation of the wood characteristics required by the paper industry for specific purposes. An instrument has been developed for measuring the mechanical properties of individual fibres. The effect of fibre chemistry on paper properties has also been studied from various angles, and a fairly clear picture of the role of hemicelluloses and residual lignin has emerged.

Stock Preparation: Beating and Additives.—Many investigations of the beating process and of the performance of laboratory beaters have been made. The way in which beating influences a range of fibre, pulp, and paper properties has been extensively investigated and summarized. Some 20 years ago a comprehensive study was made of the influence of electrolytes on pulp and paper properties. In recent years considerable attention has been paid to the mode of action of various additives which are used for modifying paper properties. For example, the complex question of additive retention in the presence of alum has been studied theoretically and experimentally. Methods which have been developed for the measurement of the electrical properties of fibre surfaces are of considerable use in this work.

Hydrodynamics of Fibre–Water Systems.—Studies have been made on the flow properties of fibre dispersions and on the phenomena of drainage, flocculation and network formation, and viscoelasticity. Apparatus has been developed in which rate of flow of liquid through a fibre pad, the pressure drop profile across the pad, external applied load, and pad thickness can be controlled and measured. The application of a theory, based on the drag exerted by individual filaments to a flowing liquid, for predicting permeability from pad geometry and flow rate has given much better results than previous treatments for highly porous systems. A series of investigations on the flow of eucalypt suspensions through pipes was initiated in collaboration with the University of Melbourne.

Deformation and Fracture of Paper.—An instrument to determine the rheological properties of paper (stress–strain, creep, and relaxation curves) was designed and built and used to evaluate the effects of beating, fibre fractionation, drying tensions and dimensional changes, and mechanical conditioning. From observations on a variety of treated pulps, an appreciation of the mechanism of interfibre bonding emerged, and was to provide an experimental basis for theories of paper strength. Experiments on the mechanism of fracture showed that the Griffith crack theory could be applied to paper.

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Kiln-dried Timber — Is It as Strong as Air-dried?

IN SPITE OF EVIDENCE to the contrary from past investigations, there is a continuing belief, particularly amongst some tradesmen and others handling timber, that kiln-dried wood is more "brittle" than wood that has been air dried and is inferior to it in strength properties.

Recently a comprehensive series of tests was conducted on several timbers, including both hardwoods and softwoods, to obtain sufficient data to help put this matter beyond reasonable doubt. Before proceeding to describe this experiment and discuss the results obtained from it, there are one or two points that should be emphasized.

Firstly, there is good practice and bad practice in kiln drying. For that matter, there are good and bad practices in air drying. However, timber can be subjected to more extreme drying conditions in a badly operated kiln than it is likely to experience when drying under atmospheric conditions. Results of bad kiln drying are therefore likely to be far more serious than those of bad air drying. Investigations carried out by the Division over many years have established suitable kiln-drying schedules and sound air-drying procedures for most of the commonly used timbers of Australia. Only the effects of sound practice in both kiln and air drying are being considered here.

The second point relates to the known effect of reconditioning on the properties of some hardwoods, particularly the ash-type eucalypts, which are prone to collapse (Newsletter No. 260). Such collapse-prone timbers, when either air or kiln dried, have a higher density than normal as a result of the collapse that has taken place. As a direct result of this increased density, the wood of these timbers also has higher intrinsic strength properties than normal. When the timber is reconditioned to remove the collapse, the density returns to normal, as do the strength properties.

In the experiment designed to obtain a comparison between the strength properties of kiln- and air-dried timber, samples were obtained to represent at least six trees of each of the hardwoods jarrah, messmate stringybark, mountain ash, blackbutt, and spotted gum, and of the softwoods radiata pine and Douglas fir. From the samples, twelve sticks were selected for each species and given an initial air drying from the green condition to approximately 30% moisture content. At this point, the sticks were cut into a number of shorter end-matched lengths which were randomly allocated to the various drying treatments. Of the two softwoods, half the material was kiln dried and the other half air dried. The material from the hardwoods was similarly allocated but subsequently, after drying, half of the kiln-dried pieces and half of the air-dried pieces were given a normal reconditioning treatment. All of the material was then

Comparative Effects of Air Drying, Kiln Drying, and Reconditioning on the Strength Properties of Timber*

(Average results for air-dried unreconditioned material = 100)

	Air-dry Density	Modulus of Rupture	Modulus of Elasticity	Maximum Crushing Strength	Shear Strength	Hardness	Izod Value	Resilience Factor
Messmate (*Eucalyptus obliqua*)								
AD†	100	100	100	100	100	100	100	100
KD	102	111	110	109	100	97	88	112
AR	97	101	101	103	95	92	80	101
KR	97	101	113	108	97	91	89	98
Jarrah (*E. marginata*)								
AD	100	100	100	100	100	100	100	100
KD	101	93	97	102	101	103	92	90
AR	99	92	96	102	98	91	85	90
KR	99	95	100	103	99	92	80	92
Mountain ash (*E. regnans*)								
AD	100	100	100	100	100	100	100	100
KD	102	103	105	106	94	101	86	100
AR	88	90	94	93	89	83	77	90
KR	95	90	100	105	90	72	55	84
Blackbutt (*E. pilularis*)								
AD	100	100	100	100	100	100	100	100
KD	101	106	103	103	107	96	88	110
AR	98	103	100	103	106	103	82	105
KR	103	107	102	109	109	101	81	113
Spotted gum (*E. maculata*)								
AD	100	100	100	100	100	100	100	100
KD	101	104	103	103	102	102	89	104
AR	100	102	101	99	101	104	92	103
KR	101	103	102	106	101	101	87	105
Average for 5 hardwoods								
AD	100	100	100	100	100	100	100	100
KD	102	103	104	105	101	100	88	104
AR	97	98	98	100	98	96	84	99
KR	100	100	101	106	100	94	72	100
Radiata pine (*Pinus radiata*)								
AD	100	100	100	100	100	100	100	100
KD	98	103	100	109	104	109	84	105
Douglas fir (*Pseudotsuga menziesii*)								
AD	100	100	100	100	100	100	100	100
KD	100	103	99	103	103	103	92	107
Average for 2 softwoods								
AD	100	100	100	100	100	100	100	100
KD	99	103	99	106	103	107	89	106

* All figures shown are averages of at least 12 test values.

† AD, air dried; KD, kiln dried; AR, air dried and reconditioned; KR, kiln dried and reconditioned.

allowed to reach equilibrium moisture content in a conditioning room operating at 65% relative humidity.

After reaching equilibrium, each piece was converted to a series of test specimens, for bending, compression parallel to grain, shear, hardness, and Izod (impact strength). These specimens were then subjected to standard test procedures. The moisture content at test was approximately 12% for all specimens of all species.

The average test value for each property in each species is shown in the table, expressed as a percentage of the average value obtained from the air-dried and unreconditioned material. From an examination of the tabulated values it can be clearly seen that:

(*a*) In all properties, with the exception of impact strength, i.e. Izod value, in all species there is no difference of any practical significance between the strengths of air-dried and kiln-dried material.

(*b*) Again with the exception of Izod value, and possibly hardness, in all of the hardwood species there is no practical difference between the strengths of air-dried and reconditioned, and kiln-dried and reconditioned material.

(*c*) Except in mountain ash, which is a species well known to be collapse-prone, there is little practical difference between the strength properties of the material whether reconditioned or not.

In all cases the Izod value, which is one measure of shock resistance, shows a marked decline for the treatments other than air drying. This may be the feature that has led to the persistent claim that kiln-dried timber is more brittle than air-dried wood. However, this must be put in its correct perspective. The Izod test measures the total capacity of a piece of wood to absorb impact loads, i.e. the shock load that will cause complete failure. In practice, however, one is not so interested in the shock load that will cause, for example, an axe handle to fail as in the shock that the handle will absorb without failure. The resilience factor shown in the last column of the table is a measure of this ability to absorb shock loads without failure. As can be seen, this resilience factor is much less affected by the timber treatment than is the Izod value, and is more in line with the other properties.

The average effects of the drying and reconditioning treatments are shown in the values for the five hardwoods and two softwoods.

Summarizing, the results of this investigation fully confirm the previously obtained data upon which the Division has based its opinion that, in spite of some loss of impact strength, kiln-dried timber does not differ in its structural properties from air-dried timber.

Standard Names for Imported Timbers

The Standards Association of Australia has published a new standard of great interest to designers, manufacturers, and purchasers in the many sections of industry which specify imported timber.

Issued under the reference AS O118, Nomenclature of Commercial Timbers Imported into Australia, the standard provides a uniform means of identifying by name the many imported timbers. It supersedes an earlier nomenclature in the interim series, SAA Interim 363.

The standard comprises three parts. Part I gives a comprehensive tabular presentation of the standard trade common names, the botanical names, and authors, whether the timber is a hardwood or a softwood, principal producing countries, and other names that have been used for the timbers, including in some instances the names used in the various producing countries. Altogether 389 timbers are identified by a standard trade common name, and are arranged alphabetically with numerical cross reference.

Part II provides in alphabetical order every name that appears in Part I, whether standard name, botanical name, or other name, with cross reference to Part I. Part III is an index of the authors of the botanical names.

The Division assisted in the provision of information for inclusion in AS O118, but the principal work of compiling the document was undertaken by officers of the Commonwealth Forestry and Timber Bureau of the Department of National Development.

Copies of AS O118 may be obtained from the offices of the Standards Association for $5 each.

Research Projects

Tannin Adhesives

Investigations of tannin adhesives were initiated in the Division about 12 years ago, with the primary objective of developing adhesives for the plywood industry. Many tannins may be reacted with formaldehyde to form resins, some of which have potential use in the manufacture of waterproof adhesives. The main advantages are that in Australia commercial tannins are cheaper than phenol, which is the most important base for waterproof plywood adhesives, and that they are also reactive, thus permitting shorter pressing cycles.

Adhesives based on commercial mangrove- and wattle-bark extracts have been studied intensively in the Division, and as a result of this work waterproof adhesives based on wattle extract have been used in the plywood industry since about 1962. Recent laboratory studies have led to the development of glues with improved bond quality which allow greater flexibility in assembly procedures. However, these have not yet been tested under commercial conditions.

Chemical and physical properties of commercial quebracho extracts have been studied with a view to their use as adhesive bases. Some formulations have given promising results in laboratory tests.

Creosote for the Wood Preservation Industry

Domestic gas has for many years been produced by coal distillation in vertical retorts. By-products from this process have included creosote which is now extensively used as a wood preservative. With the advent of new gas-making processes, and, more recently, the promise of wide availability of natural gas, the wood preservation industry will in future obtain its supplies of creosote produced from Australian coke-oven tar. In anticipation of this change, the Division is testing Australian coke-oven creosote to establish its suitability for this purpose. Results so far indicate that Australian coke-oven creosote is similar in composition to American coke-oven creosote, which has been used very satisfactorily as a wood preservative for many years.

Is Preservative Performance affected by Timber Species?

Field and laboratory tests carried out in recent years indicate that the timber species may considerably affect the performance of wood preservatives. Treated softwoods have usually performed better than similarly treated hardwoods, although sometimes the reverse is the case. The following evidence for this effect has been established:

- Marine tests in which the behaviour of treated pine and eucalypt is markedly different.
- Field tests in which several preservatives have performed appreciably better in pine than in eucalypt.
- Leaching tests in which copper–chrome–arsenic preservatives have proved to be better fixed in pine than in hardwoods.
- Laboratory decay tests in which the effect of timber species on the threshold has been pronounced with both creosote and waterborne preservatives.

Penetration of Preservatives in Wood

Over the years, a great deal of research has been done to improve the penetration of wood preservatives in species which are traditionally difficult to treat. Various forms of incising have been used, and the high pressure treatment developed by this Division has also been tried on a wide range of timbers. Recently, following overseas reports, tests were made to assess the value of adding slack wax (a petroleum refining by-product) to creosote oil, but no improvement could be detected.

A series of tests has been conducted to compare the penetrative properties of coke-oven creosote with those of the vertical-retort creosote at present in use in the preservation industry. Using eight different timbers, including both softwoods and hardwoods, differences in penetration and absorption appeared to be negligible or, if anything, slightly in favour of the coke-oven creosote.

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HIGHLIGHTS OF 40 YEARS' RESEARCH

Physiology and Microstructure Section

OVER the years the Section has changed its name from Wood Structure to Wood and Fibre Structure and now to the present one. This reflects the change in emphasis of the work that is required to provide the type of information needed at a particular time. The Section aims to replace the uncertainty and speculation regarding some aspects of wood and its products with accurate and precise data that will enable rapid and rational understanding of utilization problems. This in turn enables direct improvements to be made without a lengthy trial-and-error approach. That the Section is one of the leaders in this field can be gauged by the number of overseas workers who for many years have spent periods of several months or more with the Section, and the numerous invitations to members to give lectures locally and overseas.

One of the earliest objectives of the Section was to investigate the anatomy of Australian timbers of potential commercial importance. This enabled the establishment of methods of identification of woods, which at that time were almost entirely lacking. Identification keys have been made not only for Australian timbers but also for the timbers of New Guinea, Fiji, British Solomon Islands, and Malaysia, and for a number of timbers imported into Australia. The experience was invaluable in wartime, when in certain territories it was necessary to recognize quickly the most suitable timber for utilization in particular circumstances. This work which was done mainly with the optical microscope was extended to ascertain some of the relations between microstructure and properties.

The Section was the first group to apply electron microscopy to the study of wood and so greatly extend the limit of knowledge of fine structure of wood and the physiology of its growth. This technique together with that of X-ray diffraction contributed appreciably to a precise and basic understanding of the fine structure of the cell wall, knowledge of which was rudimentary at that time. Concurrently, a study was commenced on the growth and differentiation of wood fibres and tracheids.

These studies (together with those on anomalous differentiation, when reaction wood is formed) clarified the situation regarding several aspects of structure of the cell wall and the resulting properties of wood. This information was important in the early days of utilization of eucalypts (particularly in the pulp and paper industries) which have several properties that are dissimilar to those of softwood. The complex nature of the work required several years of intensive study to unravel most of the complex aspects of this topic. However, with the accurate understanding of the microstructure of the cell wall we now have, it is possible to interpret electron micrographs and provide relatively quickly a visual explanation of the behaviour of wood and its products in different ways.

Electron microscopy confirms and extends other information in providing a precise understanding of wood properties. For example, we have provided pictorial evidence of hydrogen bonding between two fibres after a certain period of beating; we have shown the precise location of retention of fillers in the paper sheet made under different conditions, the mode of retention of ink on paper surfaces, and the penetration path of liquors into wood. These studies are now being augmented with the use of the scanning electron microscope.

The lignin in the cell wall and between the cells of eucalypts differs from that of softwoods. As a result of chemical studies the differences in this complex material are known, so that the understanding of the removal of lignin during pulping and its influence on properties is greatly improved. Recently, biochemical studies on lignin formation have given further understanding of these aspects.

Eucalypts differ from most other woods in that they have a thick cell wall, a high extractives content, and frequent occurrence of kino (gum). The last two aspects affect a number of properties of wood and, in particular, its behaviour in the pulping industry. One of the major problems encountered in eucalypt pulp mills was shown to be due to ellagic acid, and attention was drawn to the variable amounts of it in pulpwood. Other extractives have been shown to be responsible for much of the colour in eucalypt pulp. A book on the significance of wood extractives to the pulp and paper industries has been published. It is the first reference text on this topic, and already has come into wide use throughout the world. It draws attention to differences in type and amount of extractives in different pulpwoods.

Some extractives are responsible for most of the corrosion and blunting of cutting tools used in processing green timber. The Timber Conversion Section has used this information to develop methods of minimizing the effect. On the other hand, the rapid formation of certain extractives appears to be a key factor in the development of resistance to *Sirex* attack in radiata pine. The Section also assisted in the establishment of a mangrove tannin extract plant in Papua and reopened the research into the use of this and other tannin extracts as plywood and particle board adhesives. Techniques have been developed for the rapid identification of a number of wood extractives. When heartwood is formed the extractives frequently penetrate the cell wall, and a microspectrophotometer has been modified to show the distribution of lignin and polyphenols in the wall.

Although much of the above information has been collected to understand the behaviour of wood, it can also be used in studies of improved growth rates of trees and quality of timber produced. An examination of the mycorrhiza of fast- and slow-growing trees has shown the method of penetration of the beneficial fungus between the cells of the roots and how the concentration of tannins in the outer layer appears to control this penetration. This and similar work has shown also the various stages in the formation of polyphenols in the cell. For certain purposes, the quality of wood would be improved if the extractives were present in minimal amounts. As most of the extractives are in the heartwood, the mode of its formation is being determined to learn whether it can be modified or its formation delayed. The work has shown that contrary to numerous speculations heartwood extractives are formed at the periphery of that zone and indicates that a fast growth rate will reduce extractives content in the heartwood. Studies have been made of the relationships between the morphology of fibres and paper-making properties.

In recent years the need for improving wood quality has become recognized, and methods have been developed to determine with high accuracy on a routine basis the variations in density across a stem. It is becoming evident that the future timber crops will come from high-yielding species with uniform wood properties. It is probable that these crops will be harvested on a rotation of 20 years or less. To assist this development there will be a greater need for knowledge of the physiology of wood formation and its microstructure. This will, in turn, facilitate the production of an improved material and its application by an increasingly sophisticated wood-processing industry. The Section's work is being directed to this end.

Keeping the Roof over Your Head

By H. Kloot, Timber Mechanics Section

NOTE.—Because of the many relevant enquiries still being received, it has been decided to republish without alteration the following paper, which appeared in Newsletter No. 244, August 1958.

WHEN a violent storm dislodges tiles or sheet roofing, the occupier is probably correct in blaming the elements. However, if his roof is damaged by a storm of only moderate intensity, he might well suspect poor building practice. Most large commercial buildings are designed to withstand the forces due to the worst expected winds, but seldom is consideration given to these forces in the design and construction of homes and other small buildings. Recent press reports of roof damage in wind storms of only moderate intensity indicate inadequate construction, and this in turn suggests a lack of knowledge on the part of some builders of the effects of wind loads on roofs. *The important point to remember is that a roof is seldom blown down—it is sucked off.*

The wind velocity over a roof of a building depends on the height of the building and the degree of protection afforded by other buildings, trees, and the natural configuration of the ground. The force on the roof due to the wind is dependent on its velocity, the amount of air leakage in the building (they are never airtight), and the pitch of the roof. Even on one face of a pitched roof the wind forces vary, and parts of the roof may be subject to quite high-intensity forces from relatively moderate winds.

On the windward side of a pitched roof with a slope steeper than 1 in 3, there is an overall downward pressure which, even in a gale, the roof as a whole can carry without distress. If, however, the pitch is less than 1 in 3, there may be an upward or suction force on the windward side of the roof; the lower the pitch the greater the suction. On the leeward side, irrespective of the roof's slope, there is a suction which, combined with the pressure built up inside the building as the result of air leakage, tends literally to "raise the roof". For a wind velocity of 22½ m.p.h., the upward force over all the leeward side of the roof (or over the whole of a flat roof) is equivalent to 1 lb/sq ft. At 45 m.p.h. the force represents 4 lb/sq ft, and at 63 m.p.h., 8 lb/sq ft.

Opposing this uplift is the weight of the roof itself, and the fixing of the roof to the walls. Tiled roofs vary in weight from 12 to 18 lb/sq ft, according to the type of tile, and so even if they were not properly tied down it is obvious that it would need a gust of wind of considerable velocity to lift them.

Roofs covered with sheet materials, such as iron, aluminium, or fibro-cement, are quite a different matter. Including the weight of the roofing timbers, these may weigh as much as 8 or 9 lb/sq ft when ceiling joists are tied to the rafters, or as little as about 4 lb/sq ft. Thus the weight of the roof may not always be sufficient to counterbalance the uplift of the wind. The remainder of the force required to hold such roofs against the lifting force must therefore come from the fixing of the rafters to the wall plates and ridging. If the rafters, and ceiling joists if any, are adequately nailed to each other and to the wall plates, and the wall plates are well fixed to the studs, there should not be much danger of the roof being lifted. Too often, in practice, the nailing of rafters and joists to the wall plate is thought of purely in terms of locating these members in their right positions. Poorly nailed joints are not only useless in a high wind but can fail in winds of quite moderate intensity. This is because each time the wind force exceeds the weight of the roof, some movement will occur in the inadequately nailed joints. Over a period this straining can result in loosening of the nails to such an extent that they may offer little or no resistance to a wind which normally would not be considered severe enough to cause damage.

Skew nailing of the rafters and ceiling joists to the wall plate can be quite effective. The nails should be driven to a solid head contact, penetrate well into the plate, preferably for more than 1 in., and should not be so close to the edges as to cause splitting.

Important as it is to tie the rafters to the wall plate, it is equally important to effectively tie the wall plates to the studs. Here it should be noted that nails driven into end grain exert virtually no resistance to withdrawal.

A simple means of effectively holding a roof down is to tie each rafter to the nearest wall stud by a loop of metal strap. If each end of the strap, which must be tightened as much as possible, is held to the sides of the studs with two or three 1-in. clouts, this will provide all the fixing necessary to withstand winds up to 90 m.p.h. In gable roofs, effective toe nailing of the other ends of rafters to the ridge will ensure that the whole roof is secured as a unit. Metal framing anchors specially designed to take the place of strapping and toe nailing may be purchased in Australia. These were originally designed for the earthquake and hurricane areas of America and have been used there with considerable success.

So far this discussion has been limited to the wind effects on the roof as a whole. It will be readily appreciated that the need to hold down effectively each sheet of roofing material (or individual tiles) is even more important. The force required to hold the roof covering down is greater per unit area than that required to hold the roof and supporting members as a whole, because the individual sheets are not assisted by the weight of the rafters, purlins, and battens. In addition, the upward force on the roof is not uniform, and in certain areas, such as overhanging eaves, the suction may be considerably greater and the uplift forces larger than those mentioned above. It is therefore essential that the nailing of the sheets in place should be adequate and not regarded as a matter simply of holding them in place to keep out the rain.

It is not practicable, in a short article such as this, to go into the details of the proper nailing to be used to ensure adequate roof construction.* So much depends on the type of roofing material, the roof pitch, the span of the rafters, and the species of timber used. The location of the building is also important: whether it is in a closely built-up suburb or in open country, whether in Tasmania or north Queensland. As a matter of routine these factors are always taken into account in the design of large buildings, and it is hoped that this brief discussion will draw the attention of architects and builders to the need for giving careful attention to this aspect of design in smaller buildings such as houses, which after all represent a tremendous capital investment.

*Of considerable interest in this respect is the information given in "Traditional Roof Framing for Tiled Roofs", N.S.B. No. 44, available at a cost of 5c from the Building Research Liaison Service, Department of Works, 44 Burwood Rd., Hawthorn, Vic. 3122.

Course for Sawmill Managers and Executives

THE Division of Forest Products' next course for sawmill managers and executives on the theme "Latest Developments in Sawmilling Equipment and Techniques" will be held in Western Australia in October, immediately following the Seventh All-Australia Timber Congress.

The location for this second series has been moved to Western Australia because in the opinion of the course organizer, M. W. Page, the technical developments that have recently taken place there are outstanding, particularly in the field of one-man benches.

This course, *to which sawmillers from all Australian States and overseas are invited,* will be limited to approximately 30 participants and will consist of a lecture and discussion series commencing in Perth on October 13, followed by an extensive conducted tour of sawmills during which developments will be studied in detail.

Enquiries and applications should be addressed to The Chief, Division of Forest Products, CSIRO, P.O. Box 310, South Melbourne, Vic. 3205.

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WATERPROOF PARTICLE BOARD

By K. F. Plomley and A. Stashevski, Timber Conversion Section

ALTHOUGH the particle board industry is a comparatively recent development, its importance in the overall market of building materials is already well established. Since the inception of particle board manufacture in Australia in the early 1960s the Division of Forest Products has taken an interest in the industry, particularly in relation to studies of board properties, methods of testing, and production control problems.

Particle board properties may be modified to suit the requirements of special applications by changes in manufacturing methods. In particular, the use of different adhesives may have profound effects on board properties.

Particle boards bonded with phenolic resins are currently produced in various parts of the world but have not yet achieved major economic importance. The main problem is in the selection of a waterproof adhesive which is readily available at reasonable cost and which will provide the board with the desired properties at an economical level of resin addition.

The Division has carried out research on adhesive properties of tannins for a period of about 15 years, and tannin adhesives developed by it have been used commercially by the plywood industry for some years.

Recently, studies have been conducted in the Division on the manufacture of boards from commercially produced radiata pine particles and two types of commercial tannins. Early results indicate that waterproof boards can be produced with both types of tannins at a level of 12% tannin solids.

At a slightly higher level of addition, the hygroscopic swelling of boards that were either immersed in boiling water for periods of up to 90 hr or soaked in cold water under vacuum at atmospheric and elevated pressures up to 90 lb/sq in for prolonged periods, was controlled to an acceptable level. On redrying the boards returned to within 2–5% of the original thickness.

Tests of the hygroscopic movement of the boards exposed to atmospheres of varying humidity have not yet been completed, but early observations indicate improved performance when compared with urea-bonded boards.

The boards have also been subjected to the mechanical tests provided by specification AS O115–1968, with results comparable to or better than urea-bonded boards.

These results appear very promising as they provide properties that could open new areas of board application where water resistance and greater stability and strength are required.

Tannins suitable for adhesives are readily available in uniform quality and their cost in Australia is close to that of urea formaldehyde. The glue solids addition indicated by experimental work to date favours the economics of the board.

Information on the methods used and the properties obtainable will be published as results become available.

How Does Heat Tensioning of Saw Blades Work?

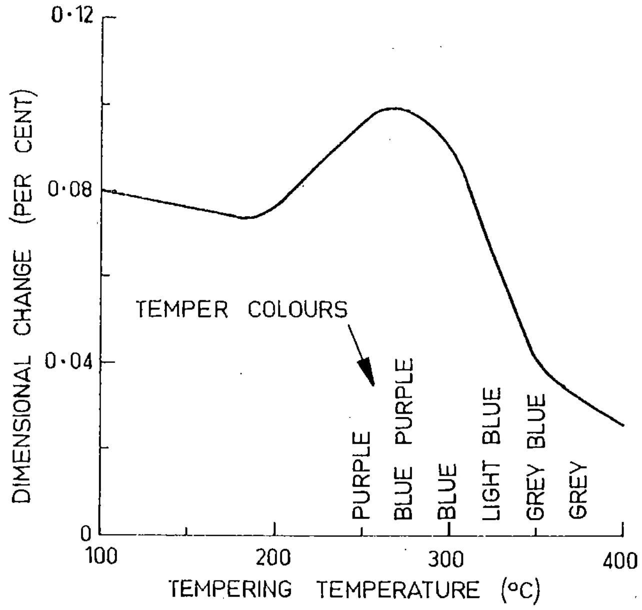
By W. M. McKenzie, Timber Conversion Section

IN RECENT YEARS the use of heat instead of mechanical methods to tension saws has been developed into a routine procedure, especially since "crawler" devices providing uniform heating have been invented.

Thus we know that heat tensioning works, and has the advantages of being cheap to carry out and uniform in its effects. But how does it work, what is the optimum treatment, and can it replace mechanical tensioning entirely?

Tensioning puts the rim of a saw blade under tension along the edge, thereby stiffening the running saw and offsetting the slackening effects of expansion at the rim due to heat when sawing.

Quinn, in *Forest Industries* (September 1967), states that the rim must be heated to a temperature in the range 285–480°C, corresponding to a sequence of temper colours beginning with deep blue and paling to silvery grey, well illustrated in a Bethlehem Steel Company chart. Thelning, in *ASSAB Bulletin* I-E (1966), explains that during heating in this tempering range, steels of the kind used in saw blades undergo changes in structure which result in an overall shrinkage. The diagram shows his graph for a strip of low-alloy steel with 0·90% carbon. This shows a steep reduction in final dimension as the tempering temperature increases from 250 to 400°C, and above about 330°C there was an overall shrinkage from 100°C of up to about 0·06%. If, as in the rim of a saw blade, this shrinkage is restrained, a large tensile stress is developed. Technically, the change in the metal causing an overall shrinkage is transformation of the martensite structure containing ε-carbide to a bainite structure containing cementite, which is smaller in volume. The hump in the graph is due to conversion of austenite (retained in hardening) to martensite and bainite, which are larger in volume.



Effect of tempering temperature on change in length of a steel with 0.9% carbon. (From Thelning.)

The graph suggests that for effective tensioning the temperature should be at least 330°C, not 285°C as suggested by Quinn. A further point, emerging from another of Thelning's graphs, is that up to 450°C tempering time has little effect, so that in heat tensioning the time taken does not affect the result.

Heat tensioning experiments in our laboratory provided support for these deductions. Saws about 20 in. in diameter were rotated very slowly by driving at the centre and were heated by means of oxy-torches just below the gullets to temperatures of about 330°C as indicated by the temper colours. This was well past their buckling temperature and the temporary distortion was large. It is thus preferable to drive and restrain the blade at the rim, leaving the centre free to move.

The effect of tensioning was assessed by measuring the natural vibration frequencies of the blades, because these indicate how loose or tight a blade is and how resistant it is to deflecting forces and heating effects during sawing. The result for one saw is shown in the table.

Effect of Heat Tensioning on the Natural Frequencies of a Saw
(Stiffness increases with natural frequency)

Saw No.	Diameter (in.)	Thickness	Nodal Diameter	Natural Frequency Untensioned Theoretical	Actual Before	Actual After	Change (%)
1	14	0·098	0	98	72	61	−15·3
			1	105	69	67	− 2·9
			2	131	107	112	+ 4·7

This shows that the frequency for zero nodal diameters was lowered. This is the shape taken when the centre of a saw is pushed through; when the frequency is low the saw is loose, and so the saw becomes looser. The shape with one nodal diameter, in which the blade flutters like a leaf, is hardly changed. This is usual with mechanical tensioning, and guides or packing are used to help prevent this kind of deflection. The shape with two nodal diameters dividing the blade into quarters is very important, because it is the one usually taken by a saw when it buckles in sawing. This frequency was raised 5%, increasing the resistance to deflection by sawing forces and decreasing the likelihood of resonant vibrations. It has been established that this improves a saw's performance.

Can heat tensioning entirely replace mechanical tensioning? The increase in frequency shown in the table is not as great as can be achieved by hammering or rolling, but this blade had already been mechanically tensioned. Until experiments can be carried out on completely untensioned saws, it will not be known whether the use of heat alone will provide sufficient tensioning.

Our experiments did not show, and it cannot be expected on technical grounds, that heat tensioning will remove irregularities from a blade. The temperatures required would be above 760°C, i.e. red hotness.

However, if heat tensioning could be used to improve the tension and performance of large circular saws, which are very difficult to hammer or roll, the benefits would be considerable.

Research Projects

Assessment of Raw Materials for Manufacture of Pulp for Paper-making

Over the last year or two, the increasing demand for paper and paper products has led to a growing interest in new sources of pulpwood supply. With traditional temperate forests already taxed to the limit, attention is being directed towards hitherto unexploited tropical forest resources. Tropical forests, as a rule, contain a large variety of species which must be assessed in the laboratory for pulping suitability before commercial utilization can be recommended.

The Division's long-established pulp and paper assessment laboratory has in the past two years examined nine species from New Guinea, Queensland, and the Northern Territory.

The New Guinea timbers were *Eugenia* sp. and *Dysoxylum* sp. The former produced good-quality pulp by the sulphate process but NSSC (neutral sulphite semi-chemical) pulps were much poorer; yields were satisfactory by both methods. *Dysoxylum* gave rather low-strength pulps.

Extensive plantations of exotic pines in Queensland have led to an interest in their pulping potential, and an examination was made of the quality of pulps obtained from different age classes of *Pinus elliottii*, *P. taeda*, and *P. caribaea*, and also of a native species ex plantations, *Araucaria cunninghamii* (hoop pine).

The three *Pinus* species gave pulp with higher tearing but low burst and tensile strengths than comparable *P. radiata* pulps.

In the Northern Territory, large areas of eucalypts not used for sawmilling may provide suitable raw material for pulping. *Eucalyptus tetrodonta*, *E. nesophila*, and *E. miniata*, all of which have high basic density and dark heartwood, are three of the main eucalypt species growing in the Territory. Pulp yields were satisfactory but strength properties other than tear were rather low. The eventual economic use of these and similar high-density woods for pulping will depend on the development of suitable blending procedures with other pulps, or on exploration of their suitability for fine papers where strength is of minor importance.

ABSTRACTS

Fine Structure of the Host–Parasite Relationship of *Diplodia pinea* on *Pinus radiata* by R. C. Foster and G. C. Marks.* *Aust. For.* **32**(4), 211–25. (*D.F.P. Reprint 778.*)

THIS PAPER describes the fine structure of *Pinus radiata* tissues inoculated with the fungus *Diplodia pinea*, which is consistently associated with the dead top disease in this species.

The fungus was introduced into the pith of clonal material and the tissues were examined in optical and electron microscopes. Details of the disturbances and abnormalities caused are described and the mechanism by which they occur is discussed.

Electron Microscopy and Cell Wall Porosity by G. W. Davies. *Appita*, **21**(4), 117–30. (*D.F.P. Reprint 714.*)

AS PART of an investigation into the penetration of pulping liquors into wood cell walls, the retention of silver, gold, manganese, and chromium particles within the cell walls of wood fibres has been used as an indication of the porosity of wood. After impregnation with solutions of salts of the above metals at different concentrations, sections were examined in the electron microscope. This paper discusses in detail the results of this examination, and will undoubtedly be of interest in wood preservation research as well as in pulping research.

* Victorian Forests Commission.

Determining Costs by Operations Analysis: A Case Study on Veneer Narrows by B. T. Hawkins and L. N. Clarke. *Aust. Timb. J.* **34**, 11. (*D.F.P. Reprint 754.*)

DURING the production of plywood veneer by rotary peeling, it is inevitable that "narrows", i.e. pieces not of the full width sought, will be produced. The study described in this paper shows how some estimate was made of the minimum width of narrow which can be processed economically. It appeared that the cost of processing narrows was approximately independent of the thickness of veneer, whereas the cost of veneer was directly dependent on the thickness, hence the minimum width that was economical to process decreased as the thickness of the veneer increased. The paper discusses detailed processing costs for $\frac{1}{10}$-in. and $\frac{1}{24}$-in. veneer narrows, and indicates the economic limits for each thickness.

The Frictional Behaviour of Wood by W. M. McKenzie and H. Karpovich. *Wood Sci. Technol.* **2**(2), 138–52. (*D.F.P. Reprint 715.*)

BECAUSE of the importance of friction in the mechanics of cutting wood, this investigation was primarily concerned with determining the more important variables affecting steady sliding friction between wood and steel, but friction between wood and other materials, including wood itself, was also examined briefly. Of a world-wide selection of species, most woods had similar friction coefficients except on very smooth steel, and only a few "greasy" species had significantly lower coefficients. A notable deviation from the classical laws of friction was that the friction coefficient varied with sliding speed. Except with highly polished steel surfaces, the coefficient decreased as sliding speed increased. Steel roughness, wood moisture content, and sliding speed showed large interactions which are explained in terms of adhesion and lubrication.

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Boultonizing of Sawn Hardwood Rail Sleepers

HARDWOOD sleepers treated at high pressure with preservative oils are performing very well in tests throughout Australia, but for a number of reasons the various railway systems have not put any quantity into service.

One of the biggest obstacles in the way of greater use is that 6–12 months' air drying is needed before even medium-density timbers are dry enough to accept sufficient preservative to give a "case" or envelope treatment. Another reason is that a proportion of sleepers accepted for drying will be rejected before treatment because of splitting, collapse, or twisting. Obviously it would not be fair to ask the treater to bear the cost of these. Apart from this the outlay involved in large stocks of sleepers for air drying for large contracts could exceed one million dollars.

One answer to these difficulties is accelerated drying. Kiln drying is not an economic proposition and drying degrade can be as bad as or worse than that obtained by air drying. Other methods available are vapour drying, steam and vacuum drying, and boultonizing. Of these, boultonizing, or boiling in oil under vacuum, is the most attractive.

In 1959/60 when sleepers for test in Queensland and New South Wales were treated by the Division, it was found that air-dried brush box was impossible to treat at high pressure but some sort of "case" treatment could be obtained by boultonizing green incised sleepers. High pressure afterwards gave little improvement. However, all the brush box sleepers are performing well in test.

With a view to making further comparisons of air drying and boultonizing, four sleepers each of green brush box (*Tristania conferta*), rose gum (*Eucalyptus grandis*), satinay (*Syncarpia hillii*), and scribbly gum (*Eucalyptus haemastoma*) were obtained from Queensland. Half of each sleeper was kiln dried under moderate summer conditions simulating air drying. The matching halves were boultonized in creosote for periods of 12–18 hr, finishing conditions being about 235°F at 25 inHg vacuum. They were then treated at 1000 lb/sq in with creosote. Moisture contents after boultonizing and creosote retentions in the treated case before and after pressure treatment were determined by extraction. Overall creosote retentions were determined by weighing before and after pressure treatment. The results of treatment show that in all four species the case retention was improved by boultonizing. The overall retention was substantially improved in satinay and brush box, and the penetration in the latter was outstanding. Only in scribbly gum and rose gum, which treated easily after air drying, were the overall retentions lower after boultonizing.

An outstanding feature of the boultonized material is that very little distortion or collapse has occurred. The green cross-section was maintained and a fine internal checking pattern that allowed deep penetration was obtained in most cases.

Boultonizing also has possibilities in other species. A comparison of penetrations obtained in P.M.G. cross-arms of blackbutt (*Eucalyptus pilularis*) and Sydney blue gum (*E. saligna*), boultonized at Wauchope, N.S.W., and treated at 200 lb/sq in, showed average penetration patterns that were indistinguishable from those of cross-arms of the same species air dried and then treated at 1000 lb/sq in. This suggests that these two species would be very amenable to boultonizing.

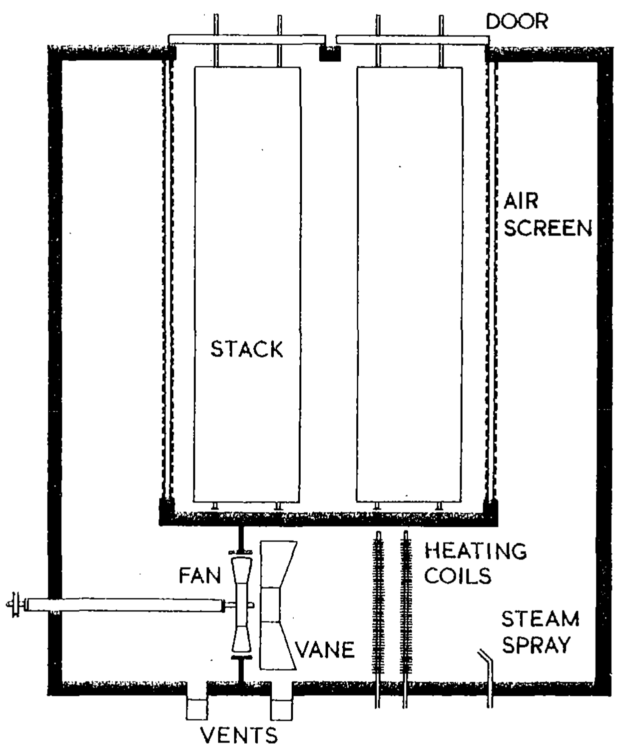
The improvement in results of recent tests compared with those of 1960 is probably due to the use of higher temperatures and vacuums. "Setting" of the case by rapid drying, followed by fine internal checking in the core, have been suggested as being largely responsible for the stabilizing of the green cross-section. It would be unwise to expect this effect to be as pronounced in collapse-susceptible timbers.

At least two of the State railway systems are very interested in these developments and comprehensive laboratory tests and commercial plant trials are being planned.

A SCREENED TIMBER DRIER

By K. Fricke, Timber Conversion Section

A SCREENED DRIER has been developed in the Division which incorporates many features of importance to the timber industry. Several driers of this general type have been built over the years and this latest development combines well established principles with some new features. A prototype holding 8000 super ft has been built and is drying and reconditioning Victorian ash eucalypts successfully.



Plan of screen kiln.

The main aims of this design are to keep the capital cost low, to use a single air circulating fan, to simplify the manufacturing and packaging of all equipment, to mount all heavy equipment at floor level and thus facilitate the use of lightweight well insulated walls and roof, to give sufficient anti-corrosion protection to allow reconditioning in the drier, and to ensure that the vents have the ability to close tightly.

As can be seen from the diagram, the fan is mounted at the back of the drier near the heating coils, with the spray inlet pipe and vents nearby to facilitate assembly and maintenance. A stationary vane assembly is fitted close to the fan to direct the flow of air evenly over the finned copper heating coils and so obtain a better heat transfer. The reversible fan on the prototype is of coated mild steel construction and the shaft and special bearings are sealed into a pressurized tube to prevent access of kiln vapour.

The screens used are similar in function to those used in the CSIRO screened veneer drier described in Newsletter No. 215. Their use simplifies kiln equipment and location but they must be specially designed for the particular unit to give adequate control of air flow in the drying zone.

The two vents are mounted on the back wall and incorporate a water level control system that will give a complete water seal when closed. Careful vapour sealing of the structure is necessary to minimize losses during reconditioning.

Tests on the prototype have shown that the uniformity of air and temperature distribution are entirely satisfactory and that all temperature schedules can be closely controlled.

Further information will be supplied on request to the Chief, Division of Forest Products, P.O. Box 310, South Melbourne, Vic. 3205.

Research Projects

Effect of Moisture Changes in Timber under Load

It is commonly observed that large deformations can occur in loaded beams and other structural members when the moisture content is changing while they are under load. The deformation under changing moisture content is often several times larger than the creep that is observed in similar structural members kept under load for a long time at constant moisture content.

A knowledge of the magnitude of these large deformations is most important for the design of wooden structures, and experiments are in progress at the Division to clarify this behaviour. This information will be of particular interest to the building industry in those States where it is customary to use green scantling which dries under load. Indications to date are that the combined action of load and moisture change has a much greater effect on compressive than on tensile deformations. The amount of deformation depends on the moisture content loss but not on the rate of drying.

In loaded beams in which moisture content increases and decreases periodically, deformation appears to rise indefinitely. In experimental beams that have been under load under indoor and outdoor exposure for 12 years, an increase in bending deflection is still observed during each summer when moisture is lost during the onset of the hot weather. This suggests that appreciable moisture fluctuations should be avoided in practice.

It was also established that the behaviour of hardboard and particle board subject to moisture change while under load is similar to that of natural timber, but the percentage increases in deformation are greater.

While often a disadvantage, the strong effect of moisture changes on loaded and deformed wood can be very useful, particularly to reduce the stress in restrained wood or to correct distortion of panels. Laboratory studies designed to gain an understanding of the microscopic and molecular processes of interaction between loaded wood and water are in progress.

This work bears on research concerned with specific uses of solid and composite timber products, particularly in timber engineering structures, seasoning, and the application of panel products.

Conversion of Wood to Pulp

The conversion of wood into its individual fibres is known as pulping, whether it is performed by chemical or mechanical means or by a combination of both. One of the principal pulping methods now used on Australian eucalypts is the neutral sulphite semi-chemical (NSSC) process, which is well suited for the production of pulps to be used in the manufacture of fibreboard containers and unbleached wrapping papers. The process consists of a chemical stage in which part of the lignin (the material that binds the fibres together in the wood) is dissolved, followed by a mechanical stage during which the partially delignified wood chips are rubbed between rotating metal disks to produce a pulp, i.e. a mass of individual fibres, from which paper or paper board can be produced.

Several aspects of the NSSC process are being investigated in order to extend the range of usefulness of these pulps, with particular attention being given to methods of obtaining a favourable balance amongst the yield of pulp obtained from the wood, the strength of the paper that can be made from the pulp, and the optical properties of the pulp, such as colour and brightness. The effect of removing soluble coloured extraneous materials from wood chips with various solvents before pulping has been shown to improve strength properties and colour but to reduce the yield. A study of the pulping behaviour of wood from very old trees of *Eucalyptus obliqua* and from regrowth trees, over the temperature range 150–190°C with cooking periods up to 6 hr, has shown that the old wood gives poorer yields of pulp. The influence of pulping conditions on the nature of the degradation products formed during the process has been studied, and modern techniques have been applied to the study of the components of the "black liquor" (the liquid remaining after pulping is finished). Apparent differences were observed in the nature of the lignin removed at various stages of the pulping process. Another approach has been to study the reactions, under NSSC pulping conditions, of model compounds related to lignin but of a simpler chemical structure. It has been shown that under certain conditions the lignin can be readily rendered soluble, but that when the building blocks of the lignin molecule are linked in a particular way, the chemical reactions necessary to make the lignin soluble cannot take place.

Sequential Digester for Pulping

The current trend in commercial pulp production is towards continuous digestion, which is rapidly replacing the older batch cooking. In a continuous digester the wood chips move through a large reaction vessel through which the cooking and washing liquors are circulating, either in the same or in the opposite direction. The concept of sequential digestion is an extension of that of continuous digestion in that it envisages, at each stage of the pulping process, the application to the wood chip and the fibres derived from it of the best conditions for lignin removal, for retention of cellulose and the carbohydrates associated with it, and for achieving the ultimate pulp properties required. Apparatus is under construction in which variables such as temperature, the nature of the pulping liquor, the chemical concentration, the acidity, etc., can be varied with time, if necessary abruptly and rapidly.

ABSTRACTS

Microscopic Observations of Wood Fracture by G. W. Davies. *Holzforschung* **22** (6), 177–80. (*D.F.P. Reprint 739.*) Availability.—Research workers.

This paper describes microscopic studies of fracture in wood, particularly of wood broken in tension. It was shown that splitting occurred in the region of the S1–S2 boundary and across the middle lamella.

Examination of longitudinal sections prepared for use in a microtensile testing machine were shown to contain failures induced during microtoming. These were sufficient in number to explain discrepancies in results previously obtained from studies of specimens examined in the microtensile testing machine.

DOCTORATE FOR CHIEF OF DIVISION

Dr. R. W. R. Muncey has been advised that his thesis entitled "The Environment in Buildings: Studies aimed at the Provision of Optimum Conditions" has been accepted for a Doctorate of Applied Science, University of Melbourne. The research covered by the thesis was carried out when Dr. Muncey was an officer of the Division of Building Research, CSIRO.

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A Boost to Timber Engineering

COMPARED WITH many overseas countries, timber engineering in Australia has developed very slowly. However, it could receive a significant boost with the projected publication of a "Timber Engineering Design Code". To capitalize on the possibilities of this important new technical basis for promoting timber engineering, the timber industry must follow up with an adequate and reliable supply of timbers of closely controlled qualities. Such action is absolutely essential to enable the construction of satisfactory engineering structures and to build up the confidence of architects and engineers to design for and specify timber.

Over the past 30 years two of the Division's publications, first the Handbook of Structural Timber Design and later the Timber Engineering Design Handbook, have been accepted as the authoritative references for the design of engineering structures using Australian timbers. However, it appears that there is now a need for a new authoritative guide to encourage and ensure reliable timber engineering design, which will assist engineers who may be involved in timber design and also serve as a reference for building permit and inspection authorities.

The production of the desired Timber Engineering Design Code is being sponsored by the Standards Association of Australia. The initial meeting to organize the drafting of the Code took place in August 1967. To speed up its production, a preliminary draft was subsequently produced by officers of the Engineering Section of this Division. The committee responsible appointed by the SAA accepted this as a basic working document when it was submitted in March 1968. Then it established several drafting panels to deal in detail with different sections of the Code and to consider the desirability of making variations and extensions to the draft. Engineers representing the timber research laboratories, universities, design consultants, the timber industry, and also building regulatory authorities are working together on the drafting panels and on the main committee.

Preparation of the Code of Timber Engineering Design is now well advanced. Some special research projects have been undertaken by this Division to obtain new data for incorporation into the Code. At the same time, several of the Division's specialist officers have been deeply involved with the drafting panels in making extensions and variations to the initial drafts of the several sections of the Code.

The Code aims to set out clearly all necessary rules for dependable designs for a wide range of different types of timber engineering structures. It should facilitate timber engineering design in a way comparable with that provided for steel and concrete, on the basis of the SAA engineering design codes for those materials. It will follow a similar format to these codes.

Although the Code will not serve all the purposes for which the Timber Engineering Design Handbook was published, its introduction at this stage should prove most valuable. Not only will it incorporate the main design recommendations as set out in the Handbook, but also it will include new data and changes in engineering design procedures that have recently been made possible by new research data. Among innovations to be introduced in the Code are design procedures based on the new strength grouping system for Australian timbers, which was referred to in Newsletters Nos. 324 and 329, and also modifications in the procedure for the design of columns. In addition, new rational and comprehensive rules for the design of beams and arches have been drafted. Generally these involve considerations of lateral instability which are related to the shape of the cross-section, span, and to loading.

As a complementary document, it is proposed to publish a technical commentary on the Code. This will explain the main factors that govern the significant recommendations incorporated and will give further guidance to assist engineers in the application of the Code.

Although much thought has already been given to the present draft, considerable additional study is required. The new design concepts which are included will be given particular attention, as some of them are in advance of any corresponding provisions incorporated in timber engineering design codes elsewhere in the world.

The design recommendations in the draft must be tested extensively in a wide range of design conditions. While some "proving tests" of this nature will be done by the panels, the SAA must depend on engineers generally to test the draft Code. Much of this work should be done when the Code is published for public review. The tentative time-table aims at completion of an official SAA draft publication for public review by June 1970.

In view of the Code's importance, the timber industry is urged to consider now, the best means of facilitating its adoption and wide use as soon as it becomes available. If effective application of the Code is achieved, it will undoubtedly extend the use of timber in engineering. Before this can happen, however, the widest possible application of quality control in the marketing of timber is essential; this fundamental should be the first and immediate aim of the industry.

NATURAL FINISHES ON WOOD

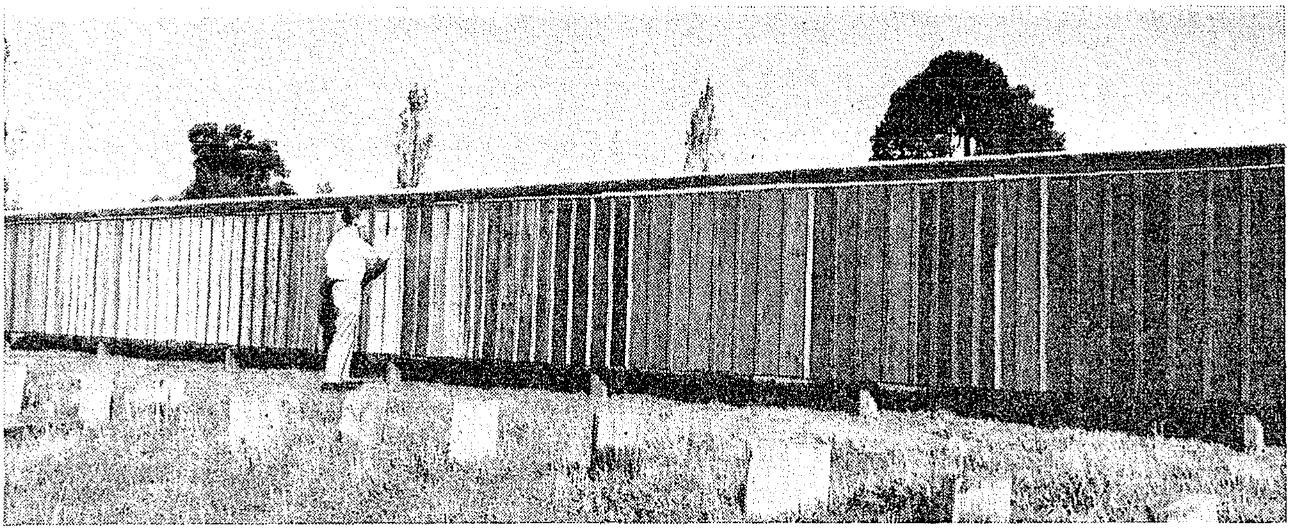
By W. D. Woodhead, Timber Conversion Section

DURING RECENT YEARS there has been an increased demand for houses that feature exterior timber with a natural appearance. This style is not novel, and such buildings are commonplace on the west coast of North America, in Scandanavia, and in many parts of Europe. Under the climatic conditions that prevail in these places a good service life is obtained. However, the Australian climate is harsher than that in many other parts of the world, and architects designing houses for the local environment must take this into account. Features that are frequently incorporated include wide eaves to reduce the incidence of sunlight, narrow profiles for vertical weatherboards to avoid cupping caused by the wide variation between summer and winter conditions, and the use of clear coatings only on surfaces not directly exposed to the sun.

The Division has received many enquiries about the effect of exposure on the appearance of untreated wood and for information on suitable preservatives and finishes. This interest has been due partly to the increasing use of western red cedar and Californian redwood in Australia, and partly because a timbered appearance is popular with house owners.

To supply the desired information, a trial was devised in 1966 and conducted over a 3-yr period.

The trial took the form of a test fence (see photograph) facing north in a suburban area of Melbourne, and consisted of boards 5 ft long, 8 in. wide, and $\frac{3}{4}$ in. thick. Sawn and dressed face surfaces were included. The boards were erected $\frac{1}{2}$ in. apart on a post and two-rail fence with hot-dip galvanized or cadmium-plated nails. A galvanized roof



protected the upper ends of the boards from the weather and the back of the fence was sheathed. In order to give a comparison between the exposed surface and the original, plywood strips were used to protect the top 6 in. of the face of each board.

Six timbers were included in the test: Californian redwood, western red cedar, radiata pine, alpine ash, brush box, and King William pine. Preservatives and finishes included a commercial waterborne copper–chrome–arsenic (CCA) preservative, a low-priced commercial wood-preservative oil consisting of 5% pentachlorphenol in diesel-ine, creosote, and a preservative oil stain based on the "Madison Formula". The oil stain has been widely used in the United States and is often specified by architects in Australia. The CCA preservative was applied only to radiata pine.

Film-forming clear surface coatings are not often used in exposed situations; preferred finishes are usually pigmented preservative oil stains to prevent surface mould and to give an even colour. Such finishes allow moisture which has been absorbed to evaporate from the wood and so prevent the onset of decay. In the trial, however, for comparison several boards were dipped in a water-repellent sealer and varnished with a reputable commercial exterior clear finish preparation.

After the boards were erected in April 1966, no maintenance was given except to those that had been clear-finished: these were lightly sanded and recoated after a period of 16 months.

Some conclusions can be reached about the performance of the different combinations after a 3-yr period of exposure. They apply primarily to Melbourne, however, and might not be the same in regions with different climatic conditions.

Effect of Weathering

Most species without any surface treatment become unevenly stained and dull grey in colour, with surface mould and checking present. The only untreated species that were not affected by mould and weathered to a grey-brown colour were Californian redwood and western red cedar. Even with these timbers, differential fading between sheltered areas and those exposed to the sun detracted from the appearance. A sawn surface was found to retain a more attractive appearance, as surface checks were less visible.

Application of Preservative Oil Stains

Much of the degrade which appeared on the untreated boards of all species was prevented by the application of two coats of preservative oil stain. This almost eliminated the effect of shading and reduced the incidence of surface checking. Surface mould was completely prevented. Sawn surface boards retained more finish and showed less checking and better resistance to erosion of the pigment than did dressed boards. Only the latter would require a further coat of finish before three years' exposure. Re-application is easily carried out after the surface is brushed to remove dust.

Pressure-treated Radiata Pine

Preservative treatments are essential for radiata pine to be used in exterior situations, and boards pressure treated with copper–chrome–arsenic salts gave a very satisfactory performance. There was only slight fading and the amount of surface checking was acceptable. Oiling the boards reduced checking.

Creosote Treatment

Radiata pine impregnated with creosote performed well. After three years the colour had faded considerably but was not unattractive. Drawbacks to the treatment are increased resin exudation from knots and some slight bleeding of creosote during initial exposure. The odour of creosote persists after treatment and could be a nuisance in domestic situations.

Pressure impregnation of alpine ash at 200 lb/sq in was totally unsuitable as penetration was incomplete and creosote bled onto the surface and remained as sticky globules.

Pentachlorphenol in Dieseline

Impregnation of radiata pine with this preparation improved the stability of the boards, eliminated surface mould, and reduced surface checking. Dipping also improved these characteristics, although to a lesser extent. Without any pigmented surface finish the boards developed a patchy colour due to the uneven absorption of oil and soon had an unacceptable appearance. Pigment dispersed in the same preparation and applied by brush after erection was largely eroded. It chalked so badly as to be impracticable for houses although suitable perhaps for fences.

Conclusions

The exposure trial carried out over a 3-yr period has demonstrated that it is practical to have exterior panelling with a natural finish that requires only minimum maintenance.

- Only the imported Californian redwood and western red cedar performed adequately without any finish, and even these timbers showed a marked colour difference between exposed and sheltered areas.

- CCA-treated radiata pine gave a good performance, particularly when oiled.

- Commerical preservative-containing oil stain finishes gave a good performance on brush box, King William pine, and alpine ash timbers by preventing surface mould and retarding checking. Western red cedar and King William pine were in excellent condition with this finish after three years' exposure.

- Sawn texture boards made surface checking less visible and retained a greater amount of finish than did dressed boards. Users could expect sawn boards to last at least three years before recoating is required, compared to two years for dressed boards, depending upon the exposure.

- Electroplated cadmium nails were found to corrode and stain the wood after only a short period of exposure. Hot-dip galvanized nails performed well.

- Some boards showed a tendency to become concave and it is suggested that grooved or twisted shank nails be used to restrain the boards. Boards should not be greater than 6 in. wide.

- Slight surface breakdown of the clear-coated panels was apparent after 16 months, when they were recoated. More severe breakdown had occurred by the end of the 3-yr exposure period.

It is recommended that timbers of low durability should not be used without suitable preservative treatment. The preservative oil stains referred to and included in this test are intended to reduce the incidence of surface degrade, and non-durable timbers cannot be rendered durable for outside situations by a single superficial brush application. If the procedures outlined above are applied to suitable timbers, the user should obtain a long-lasting attractive appearance at reasonable cost.

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Metric Measurements — Golden Opportunity or Unfortunate Necessity?

By R. W. R. Muncey, Chief of Division

Will the timber industry grudgingly introduce metric dimensions with maximum procrastination and minimum effort, or will it see and seize in this change an exciting opportunity glittering in its prospects and golden in its possible returns?

We can easily attempt to postpone the change, we can make it quite slowly, we can merely say 25 millimetres instead of an inch, and, apart from a little re-education, a few new words, and possibly some profanity, things will remain much as before. This would cause no more than small transient effects on productivity, although the long-range trend would most likely be generally downwards.

On the other hand, we can attempt to turn the change in units to our benefit by grasping this chance to infuse new ideas into our industry, plan for the broadening of the market for timber in the 1970s, 1980s, and 1990s, and set out to make timber increasingly the chosen material, especially within the building arena—truly a golden opportunity that will come to the brave and imaginative.

The Building Scene to the Turn of the Century

Over the next 30 years, the number of dwelling units (and indeed of all buildings) in Australia will need to be doubled. Will the dwellings be mostly high-rise flats? Will there continue to be many individual homes? How much timber will be used in building them?

These are surely open questions at the moment. How they will be answered will depend on what is done and decided over the next few years. That change will come, in both dimensions and otherwise, is inevitable. If the timber industry merely follows the dictates of other areas, what now glisters will not necessarily materialize as gold. **If we, by creative ideas, fine technology, and quality service, offer the community a superb product, then the future will follow our pattern and the gold will be ours.**

Most Rewarding Profit

We can fairly confidently guess

- that many in the Australian community will continue to prefer individual dwellings for family living;
- that wages will increase faster than material costs;
- that materials and components demanding minimum assembly time and labour will be preferred;

- *that timber will not hold its place in the market merely "because that's how it was in grandad's day";*
- *that the preferred house material will be the one offering good service at an economic price.*

Our industry has strong traditions—they stretch back quite a few millenia—and changes do not come easily. Operatives and executives need a deal of convincing to adopt new ways, even ones offering notable profit. But here, a change is being imposed on us, and some additional change, decided after a broad realistic look at the whole sphere of timber in buildings, might be no tougher to implement, yet most rewarding in the profit account.

What Do We Need to Look At?

Why did we choose 4 by 1½ studs sometimes and in other places 3 by 2, why are our joists spaced 18 in., why . . . ? Very often, it seems, these dimensions just "happened" back in the early days, and it could well be that the total pattern is not optimum for the 1970s, even if it was for the 1930s or some other earlier time.

Timber must provide quality with economy; it must suit the builder in the erection of the house. What type of house design will ensure this? Do we need to transfer more of the construction from building site to factory? How can we influence and guide consumers' tastes? *There is not much doubt that the emphasis for timber must come from the timber industry.* We cannot expect the building industry to prepare or commission special designs just to accommodate timber. ***We** must demonstrate to and convince builders and public that there are attractive, salable houses at economic prices which include a substantial timber content.*

To contribute to this aim, we may well need to rationalize and reduce the bewildering variety of dimensions. We shall have to seek an improved overall economy and probably aim for nominal and actual timber sizes to correspond more closely than is the case with present products.

Now is the Hour

The chance is there but we need to start right now. I believe the timber industry has the wit and the drive to seize the opportunity and subsequently to reap its due rewards, but I am concerned about the initiative to begin and the goodwill to compromise and cooperate. I propose that we reconsider from scratch the whole question of building design and hope to bias the answer to the special advantage of timber. I know that this is bold and ambitious and accept that it will require imagination and hard work.

But the change to metric sizes is coming and, with marginally additional upheaval, this could be turned to our advantage. We shall not gain the possible reward by any divine right, nor will it come to the lethargic—*we will have to make it happen.*

So, I look forward to learning that senior timber men are plotting together how to turn this new factor to the advantage of our industry, and I pledge the services of the Division to play its part in this endeavour.

ABSTRACTS

A Microscopic Study of Paper made from *Pinus radiata* by G. W. Davies. Proceedings 4th Tappi Biology Conference. (D.F.P. Reprint 790.) *Availability.*—Research workers.

Because Australia is poor in native softwoods, its pulping industry must rely on exotic pine species for its long-fibred pulp. The best utilization of available material is therefore of great importance.

Studies have been made of the products obtained when *Pinus radiata* D. Don is pulped by various chemical and semi-chemical methods. Handsheets were formed from *P. radiata* pulp prepared by the sulfate, sulfite, and cold soda processes. Replicas of the upper and lower surfaces and cross-sections through these sheets were examined in both optical and electron microscopes. It has been shown that degree of lignification affects conformability and, consequently, the number of possible binding sites, although the type of bonding is not greatly altered. The surface available for bonding is also discussed, together with its relationship to wood fracture and its variability within a pulp type. A comparison with similar studies on hardwood pulps has been made.

NEW FILM ON WOOD

It is now nearly 20 years since the film "Science and Wood" was produced by the CSIRO Film Unit to give some indication of the type of research carried out by the Division. Most of the work depicted in this film has been out of date for many years, but last year it came to notice that the film was being used mainly by schools because of the short segment it included explaining the structure of wood.

It was apparent, therefore, that the demand for a film dealing with the broad aspects of wood technology is a continuing one and, after canvassing the interest generally, the Division approached the various timber promotion organizations in Australia to seek financial support in the production of such a film.

This support was readily given and the result is a new film, titled simply "Wood". This 16-mm film is in colour and runs for 27 minutes. It gives a brief glimpse of most of the aspects of forest products utilization in Australia and some idea of wood technology as it affects utilization.

After giving an indication of Australia's forest resources, the film shows briefly the structure of wood, differences between hardwoods and softwoods, and then the logging and sawmilling sections of the industry.

The seasoning of sawn timber is then shown, followed by preservative treatment of wood. The production of plywood, hardboard, particle board, and pulp and paper are then covered in sufficient detail to give an appreciation of the importance of wood as a raw material for a wide range of industrial uses.

At the time of writing, "Wood" is available on loan from the Timber Development Association in Sydney, Adelaide, and Perth, the Tasmanian Timber Association in Launceston, and the CSIRO Film Library, 314 Albert Street, East Melbourne, Vic. 3002.

S.E.M. (Select ex Merchantable) is Out!

In the Australian timber trade the term "*select ex merchantable*" has for a long time been associated with Douglas fir (oregon). It must be noted, however, that this term was coined purely for convenience, and has varied substantially in meaning from place to place, from person to person, and from time to time. No limits on the size of defects allowed in *select ex merchantable* timber have ever been defined, so it is not a strength grade: indeed the load-carrying capacity of such timber could vary widely and in a completely unpredictable way. In a structural context, obviously it would be extremely dangerous to specify any load-bearing component in such a vague manner. Yet this has been done in the past and unfortunately is still being done, sometimes with disastrous results.

Since 1966, standard grading rules published by the Standards Association of Australia (AS O106–1966) have been available; these provided for two construction and two engineering grades of Douglas fir. This standard has recently been reviewed and copies of the revised standard may be obtained from the SAA.

It should be noted that while, as before, one of the grades described in the new standard is called "Select Merchantable", there is no such term, grade, or grade definition as *select ex merchantable*. When applied to Douglas fir (or any other species), particularly in construction work, *select ex merchantable* has absolutely no technical meaning, and there is no basis for confidence that timber purchased under this description will give a satisfactory performance in any structural situation. The term, therefore, should not be used under any circumstances as a basis for purchase of Douglas fir (or other species). The grade names used in standards such as AS O106–1969 are the only ones that should be referred to when specifying structural timber.

Overseas Appointment

Mr. R. G. Pearson, a Principal Research Scientist in the Engineering Section of the Division, resigned in August to take up a position as Associate Professor of Wood Mechanics at the North Carolina State University, Raleigh, N.C., U.S.A.

In 1966 Mr. Pearson was invited to spend a year as visiting professor at the same university, and he subsequently received, and accepted, an invitation to take up a permanent position.

The application of timber, plywood, and other wood-based materials to engineered structures has comprised the major part of his field of work with the Division. The complete revision of the strength grouping system and the derivation of new sets of working stresses for Australian timbers, the design in plywood of concrete formwork, the provision of the extensive tables for the Code of Light Timber Framing, and design recommendations for the proposed Timber Engineering Design Code are some of the major practical aspects of his work which will have, for many years, an important impact on the structural use of timber in this country.

To many in the timber industry and to consulting engineers, he is best known as the principal author of the Timber Engineering Design Handbook and for the series of post-graduate lectures on timber engineering he gave several years ago in most of the States. For several years he lectured on this topic to students at the University of Melbourne, at both the undergraduate and post-graduate levels in the School of Engineering.

Although most of his research has been connected with the performance and design of columns and the structural analysis of trusses, one of his most important contributions has been in the application of random sampling, particularly for standard mechanical tests on timber. On the basis of his original paper published in 1952, the sampling technique used by the Engineering Section was drastically altered from that in use overseas, with a resulting increase of 7–10 times in the rate of accumulating information on the properties of Australian timbers. This sampling technique has since been adopted in New Zealand and elsewhere, particularly in countries with a newly developed timber economy where information on the properties of their timbers is required with a considerable degree of urgency.

DONATIONS

The Division gratefully acknowledges the following donations, which have been received over recent months:

	$
Radiata Pine Association of Australia	500.00
Plywood Distributors Association of Victoria	92.83
F. A. Trotter, Murwillumbah, N.S.W.	3.00
Bowen & Pomeroy Pty. Ltd., North Melbourne	50.00
Allen Taylor & Co. Ltd., Coffs Harbour, N.S.W.	5.00
A. A. Swallow Pty. Ltd., South Melbourne	200.00
Timber Preservers' Association of Australia	50.00
Bright Pine Mills Pty. Ltd., Vic ..	200.00
Hudson Engineering (Aust.) Ltd., Melbourne	15.00
Westralian Plywoods Pty. Ltd., Perth	100.00

Materials

A. Woodward, Bungaree, Vic. 70 untreated pine fence posts for experimental purposes	21.00
R. F. Services, Fitzroy, Vic. Laminating resins for experimental purposes	20.00
Automated Building Components, Springvale, Vic. Gang nails and plates for experimental work	27.50

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At Sea with Treated Timber

By J. Beesley, Wood Preservation Section

THE SEA is never still. Powerful currents sweep across the ocean floor, affecting coastal waters and even the climates of the lands against which they wash. The changing seasons cause variations in the magnitude and direction of these deep ocean currents and so also affect the coastal waters. The tides create movement on a smaller scale and even the waves are seldom still.

Along the shore, rivers both great and small discharge into the sea not only fresh water, which affects salinity in their immediate vicinity, but also their burden of sediments, industrial wastes, and sewage. As the currents and tides receive, dilute, and distribute these discharges along the coast, localities as close together as the opposite shores of an estuary, the opposing aspects of a point, or even the two sides of a man-made structure such as a jetty or breakwater may be subjected to differences of temperature, salinity, pollution, or exposure sufficient to affect the plants and animals growing there.

In some instances, these differences in habitat conditions will persist and may be regarded as being semi-permanent or "seasonal". In other cases, a change of wind, the turn of the tide, or a new current may alter or even reverse the differences. Thus the sea is never still, and the creatures which live in it, particularly those that frequent the coastlines, must be adapted to take advantage of conditions detrimental to competitors or predators or else have evolved some protective mechanism to enable them to survive periods of adversity.

The sea abounds with life. Marine organisms capable of boring into timber for food or shelter occur right around the Australian coast. The distribution and abundance of these organisms and the level of their activity are affected by factors such as water temperature, salinity, pollution, and currents, as well as by the availability of utilizable food sources.

Unquestionably, the hazard from marine borers is higher along the northern shores of Australia than in the more southerly and temperate waters, but where the dividing lines should be drawn is still a debatable matter. It is not yet possible to set definite limits to the range of occurrence of any particular marine borer because, in a specially favourable year, the chance occurrence of a combination of factors might permit a species that is essentially tropical to extend its range far beyond its normal limits and, once established there, to survive for some time. Conversely, some adverse factor or factors of purely local significance might preclude the occurrence of the borer from a particular port, or part of a port, well within its normal range of habitat.

Along the Queensland coast, it has been well established (Qld. Forest Service Bull. No. 12, July 1936) that one of the most destructive species of marine borer normally occurs only in waters of low salinity and that certain other species are found only where salinities never fall much below that of the open sea. No adequate investigation has ever been made of the ability of the Queensland species, which normally favour brackish water, to survive even for short periods under conditions of full salinity, nor of the ability of the full-salinity species to tolerate periods of reduced salinity. It is known, however, that sea-going vessels can generally be cleaned of fouling and other growths by comparatively short-term storage (48–60 hr) in fresh water and that similar exposure to sea water will cleanse most boats of fresh-water slimes and algae.

What is not so generally known is that some marine borers can penetrate soft rock, poor concrete, and similar materials without food value almost as readily as they can bore into wood. Others, in a period of only a few months, are capable of excavating massive tunnels over an inch in diameter and several feet long in the hardest of Australian ironbarks. Little wonder then, that no timber, preservative treated or not, is completely immune from damage by marine borers.

Experience has proved that marine piles from timbers such as Burmese teak, South American greenheart, and Australian turpentine are more resistant to the attack of marine-boring animals than most other species. In many ports, these timbers can be relied upon to give years of useful service as piles with a minimum of maintenance. In certain other ports, however, marine-borer attack can seriously weaken them within a comparatively few years. Although these differences in performance are sometimes attributable solely to the presence of different organisms, they are just as likely to be due to some factor of the environment, such as exposure to wave action, which prevents (or permits) an organism that is present at each site from predominating.

Similarly, conflicting results are sometimes obtained when resistance trials are made on untreated specimens or on timber specimens that have been given preservative treatment. In fact, in one trial made in the U.S.A., the results obtained at a site in a sheltered port were quite contrary to those obtained from a more exposed site only a few miles away. Therefore, when interpreting the results of any tests of timber specimens in a marine environment, many factors must be taken into consideration and the conclusions reached from the results of tests of limited extent should be applied with great caution.

In spite of the many advantages of timber piling, in Australia as elsewhere, harbour engineers are often forced to think in terms of steel or concrete when planning new structures (or modernizing old ones) to meet the requirements of modern methods of handling cargo. Nevertheless, considerable quantities of timber piling are still required for fendering, as mooring piles and in the construction of many small jetties and wharves. For various reasons, including availability and cost, suitable piles of a resistant timber such as turpentine are not always obtainable, and preservative-treated timber is specified.

Unfortunately, Australian experience with commercially treated hardwood timber piling extends over less than 10 years—and even such limited experience has not been an unqualified success. For example, in one Australian port, treated spotted gum piles were so severely damaged by marine borers within four years that it was considered necessary to replace more than 90% of them. At other ports, where the hazard was regarded as being no less severe, similar piles showed little evidence of deterioration. Since the majority of treated piles on the Australian coast have been in service for less than five years, it would be unfair to allow one or two unfortunate experiences to prejudice the use of treated timber in the many ports where it can reasonably be expected to give superior service.

The evidence available from service records and from the results of controlled tests indicates that, in most Australian ports, preservative-treated timber piling can be expected to perform as well as or better than the most resistant of the naturally durable timbers, but this evidence is still too meagre for predicting useful service life.

From the results of the Division's longest test of treated timber exposed to a marine borer hazard, which was installed about 10 years ago in four widely separated ports around the Australian coast, the following general conclusions seem to be valid.

● In softwood (coniferous) timbers a double impregnation, using a fixed water-borne preservative of the copper–chrome–arsenic type at a retention of 1·5 to 2·0 lb/cu ft, followed by impregnation with creosote oil at a retention of about 20·0 lb/cu ft, gives the best results.

● In softwoods, impregnation with a fixed waterborne preservative of the copper–chrome–arsenic type to a retention of about 2·0 lb/cu ft is the best available single treatment.

● In eucalypt timbers, best results are obtained from impregnations of from 17 to 20 lb/cu ft of creosote oil.

● After about 10 years' exposure, the condition of timbers of low to moderate natural resistance to marine borer attack, when treated in the recommended manner, is likely to be as good as or better than that of untreated turpentine exposed to a similar hazard for the same period.

● When *Limnoria* is present, creosote impregnation gives satisfactory protection to eucalypts but is unreliable in softwoods.

● Even when *Limnoria* is NOT present, creosote impregnations of less than about 20 lb/cu ft cannot be relied upon to give softwood timbers complete protection in all Australian ports.

The results of the first inspection of a newer and more extensive test, installed only two years ago, conform to the pattern established by the older test.

The Division would be glad to receive reports or service records dealing with the performance of preservative-treated timber piling in Australian waters.

WILBY EDISON COHEN, 1902–1969

WITH THE DEATH of Dr. W. E. Cohen in Tasmania on September 22, 1969, the Division of Forest Products lost one of its foundation members and the Australian pulp and paper industry one of its most distinguished pioneers.

Dr. Cohen was born in Perth and was educated at Perth Modern School and the University of Western Australia. Throughout his life he retained a deep attachment to both these institutions. He joined CSIR in 1927 and served it and subsequently CSIRO for 40 years; for a long period (1930–52) as Officer-in-Charge of the Division's Wood Chemistry Section, as Chairman of the Committee of Management (1965–66), and later as Assistant Chief of the Division (1966–67). Upon his retirement from the Division in 1967, he plunged vigorously into consulting work and remained professionally active up to the time of his death.

In 1923 he received his B.Sc., and the following year he was awarded the Amy Saw Scholarship for research in chemistry and finished an honours degree. On joining CSIR in 1927, he became associated with L. R. Benjamin, R. B. Jeffries, and J. L. Somerville in the early pulp and paper team. He was transferred from this work to take charge of the semi-commercial tannin extract plant and laboratory which had been established in Western Australia by CSIR in cooperation with the W. A. Forests Department. Dr. Cohen reorganized the experimental work and carried it through to the successful conclusion which resulted in the establishment of the tannin extract industry in Western Australia.

He returned to Melbourne in 1930 as Officer-in-Charge of the Wood Chemistry Section of the Division and became associated with the late Dr. H. E. Dadswell in work on fibre separation and other problems. In the next few years he was responsible for a vigorous programme of work on the chemistry of Australian woods, wood extractives, chemical identification of wood, methods of analysis (particularly the determination of lignin), essential oils and resins, ash constituents, bark utilization, and chemical effects of weathering. In 1933 studies were initiated on the paper-making properties of *Pinus radiata*, mainly from the point of view of pitch problems. In 1935 an extensive programme of fundamental investigations into the paper-making properties of Australian woods was commenced in cooperation with Australian Paper Manufacturers Ltd. Soon after, Dr. Cohen went to the Madison Forest Products Laboratory in the U.S.A. on a Commonwealth Fund Fellowship, and A. W. Mackney (now Deputy Managing Director, N.Z. Forest Products) acted as Officer-in-Charge of the Section.

Upon his return from Madison in 1937, Dr. Cohen resumed his studies of wood chemistry, but work of direct relevance to the pulp and paper industry was gradually intensified. Australian Paper Manufacturers Ltd., Associated Pulp and Paper Mills Ltd., and Australian Newsprint Mills Pty. Ltd. began contributing to the work of the Wood Chemistry Section. This arrangement led to the Pulp and Paper Co-operative Research Conferences, which had a very considerable influence on the research carried out by the paper companies, and which, after the war, gave rise to the proposal to form a technical association for the pulp and paper industry.

In 1939 the Wood Chemistry Section was concerned mainly with methods of preparing samples for analysis, the determination of pentosans, extractives, and carbohydrates, and the effects of alkali on wood. Dr. Cohen considered that his early work with Dr. Dadswell might, under more propitious circumstances, have led to the development of the cold soda process, and he retained a lively interest in the effect of alkali on wood in relation to both fibre separation and the development of a reliable method of determining the lignin content of Australian hardwoods.

Towards the end of 1939 he began a series of studies on the performance of instruments used in pulp evaluation. With the meticulous thoroughness that characterized all his work, he developed stock dividers to facilitate the accurate sampling of pulp suspensions and he studied the performance of the Lampen mill, Clark Kollergang, and Valley Niagara beaters, developing a standard procedure for the Lampen mill. In collaboration with the late Z. Merfield, he developed the now widely used Australian dynamic tear tester. Dr. Cohen had begun his university studies in the Faculty of Engineering, later switching to Science, and in later life he was able to adapt very easily to work of an instrumental rather than a chemical nature.

During the 1940s the work of the Wood Chemistry Section continued to develop under his leadership. Just after the war he visited Japan for nine months and was in charge of the pulp and paper branch of the Natural Resources Section at Allied Headquarters. After his return various basic studies were initiated. Perhaps the most significant of these was a very thorough investigation of the effects of electrolytes on pulp properties, undertaken in collaboration with A. J. Watson.

Towards the end of 1952 Dr. Cohen became ill and sickness kept him away from work for 2½ years. Dr. Dadswell took charge of the Section during this period, with D. E. Bland, A. J. Watson, C. M. Stewart, and H. G. Higgins as Group Leaders. This arrangement continued until 1960 with Dr. Cohen working as a project specialist within the section, except for a year's research work at the U.S. Forest Products Laboratory in Madison in 1957. In the period after his illness Dr. Cohen's main research interests were in the utilization for pulping of thick-walled fibres derived from dense hardwoods and in the dimensional stabilization of paper and veneer.

During his long career Dr. Cohen received a number of significant awards. The University of Western Australia awarded him a D.Sc. in 1936, and in 1940 he received the H. G. Smith Memorial Medal of the Australian Chemical Institute. Further honours were to follow: the Grosvenor Laboratories Prize in 1946 and a Senior Fulbright Fellowship in 1957. In 1951–52 he was President of Appita, the technical association of the pulp and paper industry which he had helped to establish. Upon his retirement from the Division in 1967 he was elected an Honorary Member of Appita. He was also a Fellow of the Royal Australian Chemical Institute.

Wib, as he was known to his friends, will be affectionately remembered for a long time. His administrative functions were always carried out in an extremely orderly and conscientious way, yet with a friendly humility and a sense of humour. In science he was insistent on the value of experiment and observation, an approach which was well suited to the requirements of a developing industry.

Dr. Cohen's contributions have earned him a permanent and honourable place in the history of CSIRO and of the Australian pulp and paper industry.

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Drying of Young Plantation Pine for Building Purposes

By F. J. Christensen, Timber Conversion Section

FOR MANY YEARS timber has held a pre-eminent position in the construction and building industries as both a structural and finishing material. It is now losing ground to bricks and concrete and is facing increasing competition from fabricated steel framing. Timber has been readily accepted because of its relative cheapness, high strength–weight ratio, ease of fixing and erection, and superior fire resistance (of heavy members). On the other hand, it is subject to biological deterioration and is expensive to maintain, particularly in external applications. With respect to the last point, there has been a very definite swing away from timber cladding of houses in recent years. As shown in the table, annual production of weather(chamfer-)-boards in Australia has declined from 29 million super ft in 1958/59 to 21 million super ft in 1967/68, despite an increase in population from 9·9 million to 12 million during the same period.

Although the initial cost of the alternative is greater than for timber cladding, bricks have no maintenance costs compared with high recurring costs for the conventional paint-protection system. Perhaps this is an area in which lost ground can be recovered. With good development and promotion, preservative-treated, fire-proofed, and dyed pine weather-boards would be favourably priced compared with imported redwood and western red cedar in applications where distinctive appearance is required; they would also have appeal where hot climates dictate light construction or where transport costs of bricks to remote areas are high.

The table also shows that total sawn production of local timber has remained almost static for the past nine years: 1460 million super ft in 1958/59 and 1481 million super ft in 1967/68, with per capita consumption falling from 147 to 123 super ft respectively. This trend is likely to continue unless industry substantially increases product research and development, upgrades timber quality, improves product image and merchandising, and reduces price by conducting market research and planning production to obtain the utmost recovery from the available raw material. However, as softwood plantations mature, the more uniform quality and easier harvesting of logs will provide some relief to the producer as the proportion of this material in the total cut increases.

Why Less Demand for Timber?

What factors are responsible for the trend to decreasing per capita usage of sawn timber? A significant one is the construction of high-density office and flat buildings in which timber usage is practically negligible with present methods of construction. This

Australian Production of Selected Items of Timber

Item	Quantity (millions of super ft) 1958/59	1963/64	1967/68
Undressed, sawn (local logs)			
Hardwood, incl. brush and scrubwood	1159	1157	1173
Pine, natural forest	113	97	82
Pine, plantation	188	234	226
Total	1460	1488	1481
(Per capita consumption, super ft)	(147)	(133)	(123)
(Population, millions)	(9·9)	(11·2)	(12·0)
Weather-boards, local and imported	29	23	21
Kiln-dried timber (all species)	226	254	301

situation is likely to continue unless product development and promotion can win back this market, possibly by devising new products and techniques that exploit the unique properties of wood.

Another factor is increasing cost. Although sawn timber itself is the cheapest structural material, its cost has risen by 30% since 1958 compared with 10% for fabricated steel. However, this is only part of the story. Not enough attention has been directed towards reducing high on-site labour costs by factory pre-cutting and prefabricating of timber framing components and wall sections, followed by field assembly and erection with the aid of mechanical handling equipment. This approach could help to make timber more attractive by reducing cost and minimizing wastage by over-ordering.

In keeping with building practice in Great Britain and the U.S.A., adoption of the above techniques would be feasible only if all components were produced from adequately dried and dimensioned timber. This does not necessarily mean drying to the 12–14% moisture content generally specified for joinery, flooring, and mouldings, but enough to ensure that the quality of the job is not jeopardized by subsequent movement. It is of interest to note in the table that, whatever the reason, the production of kiln-dried timber has increased by 33% in the past nine years.

An Attractive Product

Some green scantlings deservedly have a poor product image. First, appreciable variation in dimensions from nominal size increases the labour content on a job, e.g. checking-out plates and floor joists and packing and trimming studs and joists. Second, shrinkage and distortion of members add further labour costs owing to the need to straighten frames.

This situation could be vastly improved by use of dried and dimensioned structural timber, including jointed and laminated members. The Division is currently making a start in this area with attention to the drying of both softwood and hardwood studs, each of which has its own particular problems.

The successful merchandising of a prestige product depends on guaranteeing its performance. For structural members, essential process control measures are visual or machine grading of each individual piece of timber followed by appropriate branding to set the seal on its quality. Softwood studs: there is already a market for dried and dimensioned radiata pine studs, some of which are finger jointed. This product is gaining acceptance as builders recognize its virtues. Twist and spring developed during drying can be minimized in this species by sawing away from the pith so as to ensure none is included. While this practice of selective sawing can be adopted for relatively large-diameter logs from late thinnings, seasoning techniques now being investigated may permit material from small-diameter logs to be dried within allowable limits of distortion.

Although the average acreage under radiata pine in Australia is 69% of the total area of coniferous plantations, the figure is only 3% for Queensland (which has 20% of the nation's plantations). The principal plantation species in this State are hoop pine (48% of the total) and slash pine (36%). Like many other conifers, trees of these species develop spiral grain which can be severe in the juvenile wood, i.e. the angle of spirality is likely to be steepest near the pith and increases with height in the tree.

In Australia, there is a general tendency for exotic conifers to exhibit a left-hand spiral (fibres in a sawn board run from bottom right to top left) and for native conifers to have a right-hand spiral (fibres run from bottom left to top right), although there are exceptions both within and between trees of a particular species. (The general grain-angle pattern for conifers in the U.S.A. is a left-hand spiral in young trees, gradually changing to a straight-grained condition after 40–80 years, and then finally a right-hand spiral after 80–120 years. However, these time spans may not be relevant to Australia where rates of growth for the same species can be much higher than in the U.S.A.)

Sawn timber can also have diagonal grain resulting from sawing at an angle to the prevailing grain direction. Spiral and diagonal grain have the unfortunate effect of increasing the possibility of drying distortion, particularly twist and spring, by introducing a relatively large component of shrinkage in the longitudinal direction. Normally, longitudinal shrinkage is so small (about 0·1%) that its effects are negligible and drying distortion is confined to the radial and tangential directions. However, with spiral and diagonal grain present, the anisotropy of shrinkage in the longitudinal and transverse directions causes twisting. (On the other hand, spring is due to unequal release of growth stresses or to differential longitudinal drying shrinkage across the width of quarter-sawn material.) Unlike normal transverse shrinkage which commences at about fibre saturation point, there is evidence to indicate that the onset of longitudinal shrinkage is not significant until the moisture content falls to 15% or less. Therefore, it would be advisable to dry softwood studs to at least 12% moisture content without an appreciable gradient, to ensure that a reasonable proportion of the longitudinal shrinkage and, therefore, twist has had an opportunity to occur.

In Queensland, at present, there are increasing quantities of plantation-grown hoop and slash pine first thinnings becoming available. The volume greatly exceeds that required for case manufacture, blockboard, and sundry other uses, but the log quality and size would generally not be suitable for shelving and similar products; hence it is logical to consider the utilization of this material for structural purposes. Unfortunately, trials with 2-in. studs sawn from first thinnings have shown a tendency to twist excessively during drying although spring in drying does not seem to be troublesome.

Both the Forest Products Branch of the Queensland Department of Forestry, and the Division have done a little independent work on this problem, but they will now be conducting further experimental work on a cooperative basis. In general, drying parameters will be determined on small samples at the Division, and tested on commercial quantities and lengths of timber by the Forest Products Branch in their experimental kiln at Rocklea.

The present approach is to dry at high temperatures, taking advantage of the plastic-elastic properties of wood under such conditions. Very rapid drying rates can be achieved at high temperature. Work to date with short samples indicates that 2-in. slash pine studs can be dried to 10% moisture content in less than 24 hours. However, the palliative effects of drying under restraint cannot be confirmed until tests are made on commercial-length material.

Finally, a break-through in the drying of studs and other members cut from small-diameter conifer logs may help to conserve part of the $25 million a year of foreign exchange currently being used for the import of sawn conifers (1967/68). This corresponds to 255 million super ft of timber (mainly oregon) compared with the present Australian sawn softwood production of 308 million super ft. Current prices for 4 in. by 2 in. studs are $16 per 100 lineal ft for radiata pine framing and $22 for sawn merchantable oregon.

Control of End Splitting in Round Timber

A SIMPLE METHOD of limiting the extent of end checks and splits in round timber has been tested and its effectiveness demonstrated in some reputedly fissile timbers, namely *Eucalyptus regnans*, *E. cypellocarpa*, *E. obliqua*, *E. sieberi*, *E. fastigata*, and *E. nitens*.

Where it is required to control splitting at only one of the end faces produced by cross-cutting, such as when heading-off a pole, the technique requires only a saw-cut (groove-cut) to be made around the log to approximately half the depth of the radius prior to cross-cutting at a point 6–8 in. away from the groove-cut. However, when the cross-cut is made at the centre of a long log a groove-cut is, of course, required on either side of the proposed cross-cut in order to stress-relieve each freshly cut end.

Theoretically, the groove-cutting technique has an advantage over other end-restraint methods in that it reduces the magnitude of longitudinal compressive and tensile stresses before cross-cutting and thereby positively reduces the amount of longitudinal strain energy (and hence the amount of end checking and splitting) that takes place when the cross-cut is subsequently made. It also has the advantage of being carried out at stump using only a chain saw, provided that the log is well supported to prevent sagging, and headed off to preclude springing, during sawing.

It must be pointed out, however, that the technique is, by its nature, designed to limit growth stresses only; it cannot be expected to prevent or control every form of fracture such as those due to either falling stresses or bending stresses during cross-cutting. In this respect, however, the groove-cutting method does appear to be a prospective diagnostic tool to differentiate between the various causes of end fracture, and work is already planned in this area.

A brief description of the technique has been given in Div. For. Prod. Tech. Note No. 4 (available on request), and this has aroused interest in a number of countries. We would be interested to see this method of growth stress split control tested wherever forestry authorities or users claim their timber to be free splitting or highly stressed. In this regard we have been advised that the technique will be tested on fissile material (including plantation-grown eucalypts) in Malagasy, Uruguay, Italy, Germany, Hawaii, and New Guinea, and we anticipate hearing results of these tests in the near future.

ABSTRACTS

Electrical Conductivity of Three Treated Pole Timbers by L. N. Clarke and R. Donaldson. *Electl Engr Merch.* **46**(5), 1969. (*D.F.P. Reprint 695.*) Availability.—Preservation industry and pole-using authorities.

In order to determine the effects on electrical conductivity of treatment with copper–chrome–arsenic preservatives, the Electrical Engineering Department of the University of Queensland and the Division of Forest Products have carried out complementary investigations, the former dealing with large specimens and high voltages, the latter with small specimens and low voltages.

This paper is a report on investigations on three typical pole timbers as used in Australia.

Drying of Round Timbers for Treatment by F. J. Christensen. *Aust. Timb. J.* **35**(2), 1969. (*D.F.P. Reprint 761.*) Availability.—Timber and preservation industries.

Drying the sapwood to a specified moisture content is an essential preliminary to the satisfactory pressure preservative treatment of round timbers.

At present, air drying is the only commercial method used in Australia for round timbers. Improved dried quality and shorter drying times could result from the use of drying practices recommended in this paper.

Several accelerated methods of drying already used overseas are described. Experiments in Australia with some of these methods have demonstrated their suitability for a number of indigenous timber species. Commercial acceptance of accelerated drying will depend on its economic value or the need to utilize round timbers from species that cannot be air-dried satisfactorily.

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