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Measuring Soft Rot in Cooling Tower Slats

A New Technique

By H. Kloot, Timber Mechanics Section

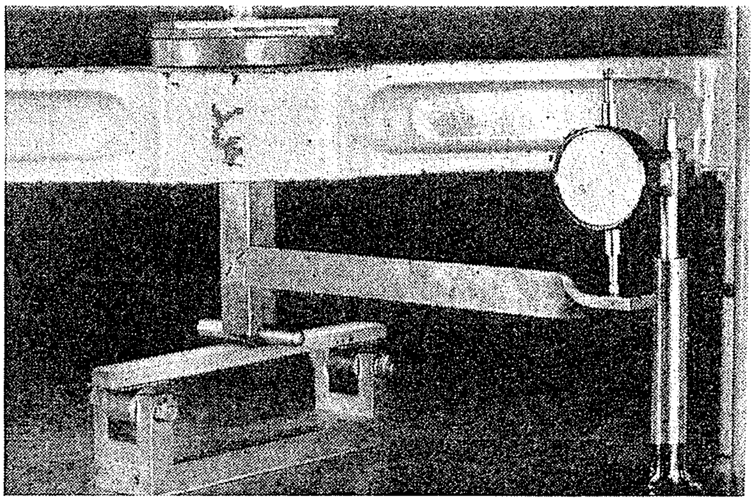
IN FOREST PRODUCTS NEWSLETTERS Nos. 268 and 269, the field and laboratory techniques for estimating the relative durability of timbers against fungal and borer attack were described. In the same article, reference was made to the commencement of a field investigation to compare the natural resistance to soft rot of a number of timbers, the tests being conducted in 30 cooling towers throughout Australia. For this work it was decided to use a new technique for determining the degree of breakdown due to soft rot in the timber. After six years of experience with it, there seems little doubt that the technique is sound, and capable of producing fairly accurate quantitative information on the rate of deterioration due to this type of fungal attack.

Basically the procedure involves the measuring of the stiffness in bending of each specimen slat before it is placed in service and at more or less regular intervals afterwards. The slat is simply supported over a span of 8 in. and loaded at its mid-span (Fig. 1). For each of several increments of load, the deflection of the slat at its centre is measured (Fig. 2). The total load applied is considerably less than that necessary to rupture a sound slat and so the specimen, unless it is rotted practically right through, is not damaged in any way.

Because bending stiffness, i.e. load per unit deflection, is dependent on the beam's width and the cube of its depth, small changes in dimensions, particularly in depth, have a large effect on the measured stiffness. Thus this procedure provides a very sensitive measure of the loss of section or degree of breakdown due to fungal attack. It is important, of course, that the specimen be at the same moisture condition each time it is tested for stiffness. This is relatively easy to arrange as the slats are initially tested in the green condition and are kept wet in service in the cooling towers.

Two assumptions are made in analysing the stiffness test results to determine the loss of section. Firstly, it is assumed that the depth of fungal attack is uniform over the full length of the slat and over all four faces, a not unreasonable assumption having regard to the service conditions. Secondly, it is

Fig. 1.—Specimen slat being loaded as a beam in the testing machine.



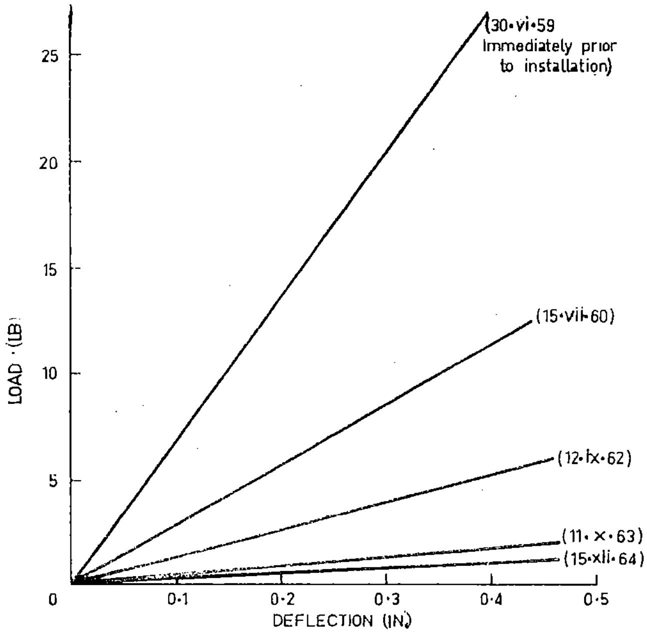


Fig. 2.—Load–deflection graphs for a softwood slat at various times during service in a cooling tower.

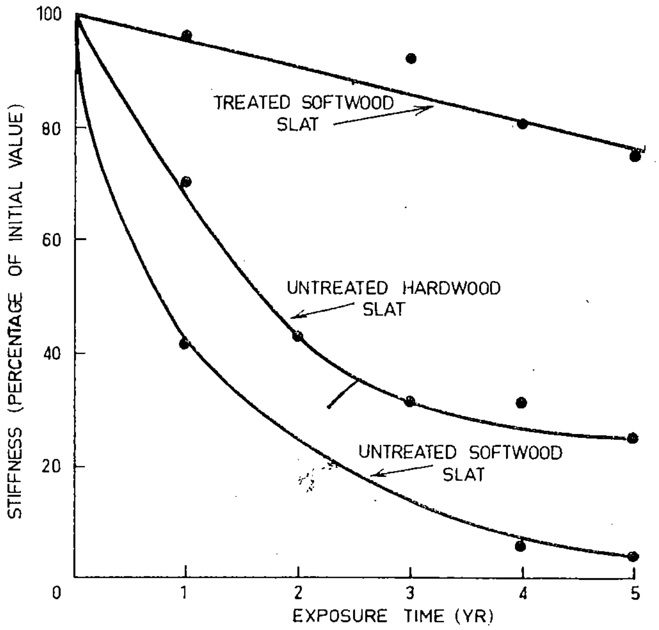


Fig. 3.—Change of stiffness with time for three different slats.

assumed that there is a sharp line of demarcation between wood affected by soft rot to the stage where it has neither strength nor stiffness left, and completely unaffected wood having the same properties as the whole slat had when it was first prepared and tested before being placed in a cooling tower. There is, of course, no such line of demarcation, but rather a zone through which the wood shows a varying degree of effect of the fungal attack. Thus the depth of attack, as measured by this technique, will always be an underestimate but nevertheless will provide an accurate measure of the *effective* depth and of the *effective* cross-section left unattacked.

The calculations necessary to convert the change of stiffness of a slat into a measure of loss of section are relatively simple but time-consuming, each one requiring approximately five minutes' work on a desk calculating machine. Because more than 8000 of these calculations need to be done on the results obtained so far, the work will be programmed for a computer.

To illustrate the results given by the procedure, Figures 3 and 4 show respectively for individual slats of an untreated softwood, a similar wood treated with preservative, and a hardwood, the change in stiffness and the effective loss of cross-section over a period of six years. When the results for all of the slats for all species involved in the investigation have been analysed, it should be possible to compare not only the resistance to soft rot of the various timbers but also the incidence of soft rot attack in the 30 cooling towers, and relate this to the varying conditions under which these towers operate.

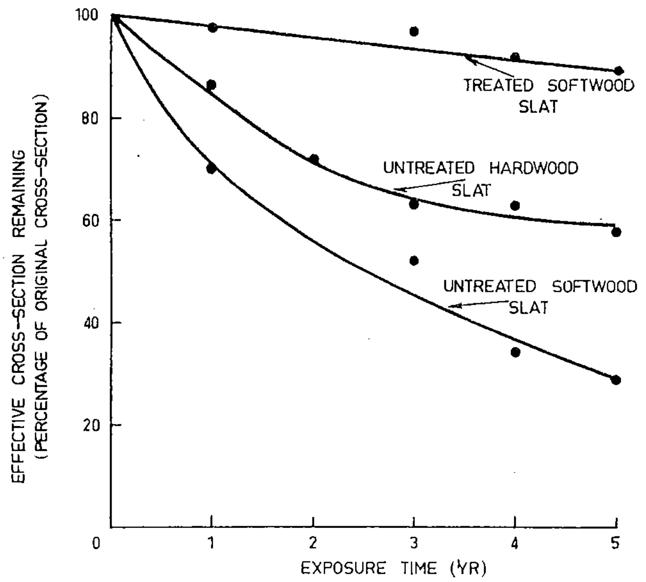


Fig. 4.—Values from Figure 3 converted to indicate effective cross-section remaining after fungal attack.

RADIATA PINE

RADIATA PINE is the standard trade common name for the timber of *Pinus radiata* D. Don (syn. *P. insignis* Dougl.). Other common names of the species are Monterey pine and insignis pine.

Distribution and Management of Plantations

Radiata pine was introduced into Australia from the United States of America; it has been planted extensively in most States and is now of great economic importance. By 1963, a total of more than 400,000 ac of plantation had been established: South Australia, 151,000 ac; Victoria, 114,000 ac; New South Wales, 90,000 ac; Tasmania, 25,000 ac; A.C.T., 24,000 ac; and Western Australia, 16,000 ac. Rate of planting, currently about 40,000 ac per annum, is likely to increase.

On suitable sites the tree grows rapidly in plantations, and at an age of 40 yr may attain a height of 130 ft and a diameter of up to 2 ft 6 in. The trunk is usually straight and the bark can be up to 2 in. thick near the butt of mature trees. Branches occur mainly in whorls at fairly regular spacing but intermediate branches are produced at irregular intervals. Plantations are thinned several times during growth, at ages varying with site and economic conditions. Final felling is commonly planned at about 40 yr, but the favoured age is not the same everywhere. From earliest thinnings, logs 6 in. end diameter and over are accepted for sawmilling, while smaller logs are used for case manufacture and also as fence posts and pulpwood for the manufacture of paper, fibreboard, and particle board. Logs from later thinnings and clear fellings are utilized for saw logs, peeler logs, poles, and piles; pulpwood is recovered from tops of trees and from stems of sizes or shapes not suitable for sawmilling.

Timber

Radiata pine is a softwood with straw-coloured sapwood and pinkish, slightly darker heartwood. The stem of a young tree may be entirely sapwood, as heartwood formation does not commence until the stem is about 15 yr old. Growth rings are prominent due to bands of darker late wood, and cause a pronounced figure especially on a back-sawn or rotary-peeled surface. Mature wood usually has straight grain away from the vicinity of knots but there is a tendency for the grain of wood formed earlier to be spiral.

Air-dry density varies considerably, ranging from 25 lb/cu ft in young fast-grown wood to about 34 lb/cu ft in mature heartwood.

Seasoning

Radiata pine can be dried quickly with little degrade and it is economically kiln dried from the green condition. This prevents attack by blue-staining fungi that can develop during air drying in humid weather conditions. Boards containing juvenile wood tend to warp as they dry, due to spiral grain, but the industrial practice of weighting stacks and giving high temperature–high humidity stress-relieving treatment during drying reduces the practical significance of distortion. Shrinkage from the green to 12% moisture content condition is moderate, viz. 3% in a radial (quarter-sawn) direction and 5% in a tangential (back-sawn) direction. Once the timber has been dried it remains dimensionally stable unless fluctuations in moisture content exceed the common atmospheric range.

Durability

For the majority of locations in which timber is used in housing, joinery, furniture, panelling, and in other dry sheltered places, radiata pine can be expected to give long service. Where the hazards from decay and termites are severe, the timber shows very low resistance. High durability can be induced by treatment, as the timber is permeable, after partial air drying, to oil and waterborne preservatives which may be applied by pressure or other conventional means.

Dip-diffusion treatments can be carried out with water-soluble salts on green timber. Sapwood and most heartwood are easily penetrated, but some trees develop heartwood that is untreatable. Details of treatments and preservative loadings appropriate to particular end uses may be obtained from the Division of Forest Products, CSIRO, the State Forest Services, or the Timber Preservers' Association of Australia.

Structural Applications

Variations in the conditions under which radiata pine is grown are reflected in the strength and related properties of the wood. For structural applications selection needs to be well considered and deliberate. The juvenile wood in the centre of rapidly grown trees has inferior strength characteristics, and wood formed at about 20 yr and later has been found to be considerably stronger than that formed earlier. The considerable variations within and between trees lead to uncertainty whether radiata pine in the green condition qualifies for Strength Group D among the structural timbers. However, as the timber dries rapidly and shows an unusually large increase in strength when dry, it is regarded as having Strength Group D qualities when seasoned.

The Division's recommendations for radiata pine for structural purposes are:

"Radiata pine scantlings sawn full to size should be used in the same nominal sizes as Douglas fir (which is cut scant) if the scantlings are unseasoned, and provided they are graded to equivalent grading rules.

"In the dry condition radiata pine should be inter-changeable with unseasoned Douglas fir of the same grade."

Rules for the visual grading of structural sections of radiata pine in the seasoned condition have been published by the Standards Association of Australia as:

SAA Int. 377 (1959).—Sawn Radiata Pine for Use as Light Framing Material.

SAA Int. 376 (1959).—Sawn Radiata Pine for Structural Engineering Applications.

In some districts radiata pine is obtainable mechanically graded and certified for strength, and this class of material is expected to become available widely in the future. When such material is chosen for structural use, working stresses should be based on the grade value stamped on the timber.

Working and Finishing Properties

Radiata pine may be sawn and worked easily with hand or machining tools; the grain is not raised by machining or sanding operations. Radiata pine peels well to produce smooth veneers. Defect-free material may readily be bent without significant degrade. Fastenings such as nails and screws do not cause splitting, but in structures that are heavily loaded, additional or more efficient fastenings may be required than for hardwoods. The load-bearing capacity of the joint is comparable with other softwoods.

The timber takes paint and varnish readily but produces a non-uniform effect with stains due to differential absorption. The timber glues well with all the commonly used woodworking adhesives, and therefore is a useful timber for laminating.

Uses

Radiata pine is used for a great many utility purposes as well as in structural and industrial applications. The Standards Association of Australia has drawn up grading rules covering sawn material in AS O72, Sawn Radiata Pine Graded on Face Appearance. Other standards, namely SAA Int. 376 and 377, which have been referred to above, concern sawn radiata pine for structural uses. Sawn radiata pine is used in quantity for case manufacture and, when pressure-treated, for railway sleepers.

Dressed timber is used for flooring, weatherboards, mouldings, and other milled products. Grading rules covering these uses include AS O73, Radiata Pine Milled Flooring and Decorative Lining; AS O74, Radiata Pine Milled Weatherboards, Fascia, Door Jambs and External Sheathing; AS O75, Radiata Pine Milled Mouldings. Radiata pine is also used for many general-purpose end products including furniture, joinery, and smaller individual items such as toys, brushware, and handles.

In the round, radiata pine is used for fence posts, piles, and poles. For such purposes the material is treated to an appropriate loading with preservatives, usually by pressure impregnation.

Radiata pine wood chips are the raw material for large industries manufacturing paper pulp, fibreboard, and particle board. The timber is also used for plywood and wood wool manufacture, and its sawdust is used in the wood flour industry.

Availability

Radiata pine is readily available in most areas of Australia as flooring and other milled lines. Kiln-dried sawn timber in 1 in. thickness having widths up to 12 in. is also available. Material of thickness greater than 1 in. is coming into greater supply as plantations in Australia continue to reach maturity.

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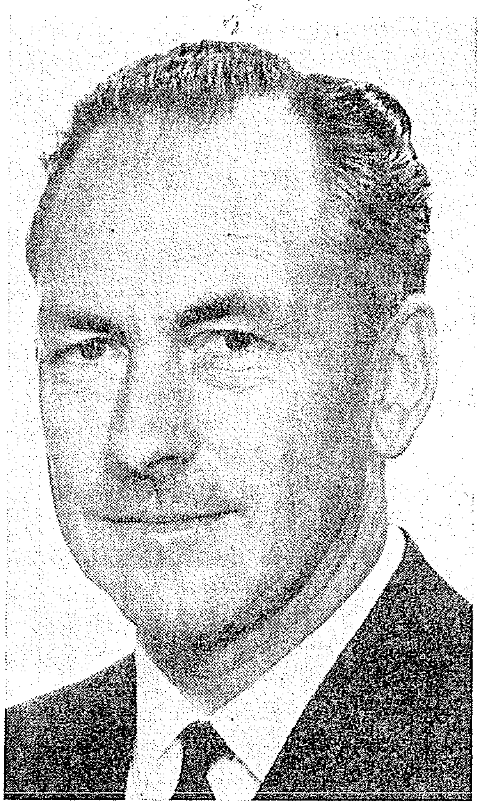
New Chief of Division



MR. R. W. (ROY) MUNCEY, M.E.E., A.Inst.P., A.M.I.E.Aust., is expected to take up his appointment as Chief, Division of Forest Products, CSIRO, on March 1, 1966, in succession to the late Dr. H. E. Dadswell, who died in December 1964.

Mr. Muncey, who is 47 years of age, received his secondary education at Geelong College, Victoria, where he was Dux in 1935. After spending approximately two years as a Pupil in Engineering with the Victorian Department of Public Works, Mr. Muncey joined the Melbourne and Metropolitan Board of Works as an Engineering Draughtsman, where he remained until 1941. During that time he completed, on a part-time basis, the first and second years of the Engineering course at the University of Melbourne. He graduated B.Eng.Sci. in 1942, after a very distinguished course, and B.E.E. in 1943. He gained his M.E.E. in 1951.

Mr. Muncey joined CSIRO in 1944, and for the following two years he was engaged on electronics research at the Lubricants and Bearings Section, now the Division of Tribophysics. In March 1946, he joined the Division of Building Research, as Officer-in-Charge of Architectural Physics. During the latter part of his 20 years' service in this position, he has been Acting Chief of the Division of Building Research on two occasions, in 1961 and 1965. He has published some 40 scientific papers, mainly on acoustics and on the insulating properties of building materials. He has been overseas twice, in 1950 and 1959.

Besides his scientific achievements, Mr. Muncey has distinguished himself in some extra-curricular activities. As advocate for the CSIRO Officers' Association, he brilliantly and successfully presented the Research Scientist case before the Arbitration Court in 1963. During the past year he has been investigating superannuation problems on behalf of the High Council of the Commonwealth Public Service Organizations. Since 1943 he has been an active member and lay preacher of the Methodist Church. He is married and has three daughters and a son.

HERITABILITY OF WOOD CHARACTERISTICS

THE LIMITED AVAILABILITY of timber from natural forests and increasing demand have led to the planting of forests to supply Australia's timber and pulp needs of the future. This planting is likely to be considerably extended. Similar considerations apply to the planting of forest crops in many other countries.

With the planting of new forests, a great opportunity exists to control and improve the quality of the wood produced. The user will be concerned with obtaining trees of the most desirable form, including freedom from large branches in a long merchantable bole. He will also be interested in the inherent strength qualities and other characteristics of the timber, including its shrinkage on seasoning, stability of shape, moisture take-up with atmospheric changes, etc. As a consequence, considerable interest has developed in the genetic approach to wood quality improvement, but it is apparent that there is a great paucity of information concerning the inheritance of wood characteristics.

To supply vital information on the heritability of desirable wood characteristics, extensive studies have been undertaken. Considerable work has been done at this Division; other studies have been undertaken by the Queensland Department of Forestry, especially in connection with tree form and vigour, and additional studies have been made by other forestry organizations, including the Australian Forest Research Institute. Unfortunately, studies of the heritability of characteristics of timber are very much handicapped by the lack of a suitable range of controlled parent and progeny trees for sampling and research. However, much exploratory work has been done to help define the problem and to indicate the practicability of obtaining useful results. Gaps in this work will be filled in progressively as more suitable material becomes available, and the studies will be extended to provide definite evidence of the practicability of control of heritability of important properties of timber.

Already studies of heritability have been made on the width of growth rings, which is an indication of tree vigour, on the percentage late wood, which has a significant effect on the strength of the timber, and on certain pulping characteristics. The heritability of average cell length has also been studied, as this has a significant effect on pulp- and paper-making characteristics; the basic density has been investigated, because it is a measure of many strength properties; longitudinal shrinkage has been studied, as this affects the stability of the timber in various uses; and the development and severity of spiral grain have been measured, as it causes undesirable twisting of the timber with moisture changes. The heritability of the angle made by the spirally oriented cellulose chains in the cell walls of the wood has also been studied, as this has an important influence on the dimensional stability of the timber under varying atmospheric and other moisture conditions, and appears also to have an influence on the strength properties of wood and paper.

Through a study of heartwood formation, it may be possible to link this also with heritability. When the controlling factors in heartwood formation are known, it may be possible to improve the durability of timber during its growth, so that it develops adequate resistance to severe decay hazards, to insect pests that attack the tree, and to those that attack the sawn timber.

With the very large investment in tree plantations being made now and likely to be greatly increased in the future, it is obviously desirable to ensure that the wood produced is of the highest practicable quality for the contemplated future markets in solid timber, veneer, wood, pulp, and paper. The return from the investment in growing trees can be very much influenced by the wood's quality in respect to the various uses, and so too can the overall economy of the country.

D.F.P. PUBLICATION ABSTRACTS

Essential Quality Controls in Timber Engineering by J. D. Boyd. *Aust. Timb. J.* **31**(5): 37–9. (*D.F.P. Reprint 616.*) Availability—Timber engineering industry.

IN THIS PAPER, the author makes the point that to develop a wider use of timber structures by engineers and architects and a ready acceptance by building inspectors, the timber industry must take steps to virtually guarantee the quality of the timber and the satisfactory performance of all timber structural components with which they will be concerned during manufacture.

It is stated that manufacturers of timber structural components such as roof trusses should foster the confidence of potential users by carrying out rigid quality control of both materials and procedures, and by testing samples of the completed building components. Also, attention is drawn to the fact that the manufacturer's interest and influence should extend to delivery and erection procedures, otherwise he cannot ensure maintenance of the quality of his component as manufactured. Without such control he will lose goodwill.

The organization of a cooperative quality-control service by all manufacturers of components is recommended, in order to establish a firm basis for the development of a virile timber engineering industry.

The Clearance Angle of Circular Rip-saws by R. L. Cowling. *Aust. Timb. J.* **31**(3): 43. (*D.F.P. Reprint 607.*) Availability—Sawmillers, saw doctors, saw manufacturers.

THE TOPS OF SAW TEETH require clearance to prevent them from rubbing on the surfaces generated by the top cutting edges.

In an investigation of clearance angles, a technique involving spraying the tops of the teeth with white lacquer was used. Extended abrasion of the lacquer was taken to indicate lack of clearance.

As a result of this work, it was found that tooth deflection had a major influence on the clearance angle required in practice.

Tooth deflections are caused by lateral forces acting on the saw blade or teeth, and, if they could be avoided, clearance angle would depend chiefly on feed speed and would approximate the very small calculated value of about 2° for most purposes. Measures to reduce tooth deflection are suggested, but it is considered that under conditions usually encountered in Australian sawmills, the clearance angle should not be less than 15°.

Australian Plant Gums. I. Classification and Identification of Gums from Arborescent Angiosperms by A. T. Proszynski, A. J. Michell, and C. M. Stewart. Div. For. Prod. Technol. Pap. No. 38. Availability—Industry, forestry, and research organizations.

THE IMPORTANCE OF PLANT GUMS in commerce has been largely neglected in Australia, but world consumption of over 50,000 tons per annum, and a price of up to $600 per ton for acceptable gum, have prompted a closer look at this minor forest product.

To provide the background to better appreciation of the commercial possibilities of Australian plant gums, work on their classification and identification has been initiated that will also provide some knowledge of their physical and chemical properties.

In this paper, which is Part I of a series, results of the investigation of 15 Australian gums and a comparison with 12 commercial gums are reported.

Assessment of Adequacy of Timber Structures by Test with Special Reference to Timber Roof Trusses by R. G. Pearson, *Aust. Timb. J.* **31**(5). (*D.F.P. Reprint 617.*) Availability—Design engineers, truss manufacturers.

TESTS to determine the adequacy of timber structures require careful planning and detailed knowledge of the effect of differences between test and service conditions.

There are two main categories of test, namely, type-acceptance tests for assessing a proposed new structural form, design, material, or element, and lot-acceptance tests for assessing a particular structure or batch of structures.

To determine the adequacy of the strength of a structure, a proof load equivalent in its effect to that due to the expected service loads must be calculated. A structure able to withstand the proof load without distress should also be adequate in service, providing certain effects due to time that cannot be fully allowed for in a short-duration test, such as shrinkage, are not serious.

A structure needs to have adequate stiffness, and this may be as dependent on the joint characteristics as on the members. Both joints and members are greatly affected by moisture content changes and duration of loading, so due allowance must be made for the effects of these factors.

Not only must a structure be able to sustain satisfactorily its service loads, but it must also resist without distress the handling it receives in transport and during erection. Two tests to ensure that joints can withstand handling stresses are described.

Gullet Cracking in Saws by D. S. Jones. *Aust. Timb. J.* **31**(7). (*D.F.P. Reprint 619.*) Availability—Sawmillers, saw manufacturers.

GULLET CRACKING of saws is a constant problem in the sawmilling and woodworking industries, particularly in wide band saw blades, but also in circular saws.

The basic causes of gullet cracking are either the inability of the blade to resist the normal applied stresses, or excessive stresses.

In this paper the author considers these causes in some detail and outlines measures to cure or prevent such cracking.

Some Economic Aspects of the Sharpening of Circular Saws in Australian Sawmills by D. S. Jones. *Aust. Timb. J.* **31**(7). (*D.F.P. Reprint 624.*) Availability—Sawmillers, saw doctors, saw manufacturers.

WHILST THE USE of automatic saw sharpeners for sharpening band and frame saw blades is well established, their use on circular saws has been limited. In an attempt to reduce sharpening costs some sawmillers are now evaluating the use of such machines. Factors to be taken into consideration differ from mill to mill and from region to region, but the principal ones are as follows: ease of obtaining skilled labour; proximity of the mill to the sharpening service; species sawn; number and diameter range of saws to be sharpened; and state of existing equipment.

This paper presents a review of sharpening and is intended to assist sawmillers in considering the factors that may apply to their specific conditions. Four stages of progressive mechanization are discussed, beginning with the sharpening procedure incurring the least capital investment and finishing with the most mechanized.

DONATIONS

The following donations have been received by the Division over the last three months:

"Woodpecker" Sawmillers & Traders, Bentley Park, W.A. ..	$4.20
R. W. Scammell, Devon North, Vic.	$4.20
F. A. Trotter, Murwillumbah, N.S.W.	$2.00
Murray Valley Sawmills Pty. Ltd., Nathalia, Vic.	$60.00
Radiata Pine Association of Aust...	$500.00
N. C. MacLeod & Sons, Seaspray, Vic.	$20.00
Burwood Timber Mills Pty. Ltd., Springvale, Vic.	$200.00
Perfectus Airscrew Co., Newport, Vic.	$20.00
Shepherdson & Mewett, Williamstown, S.A.	$20.00
Ray & J. Page, Ivanhoe, Vic. ..	$10.00
A. Woodward (Forest Products) Pty. Ltd., Ballarat, Vic.	$10.00
Atkins Timber Co., Port Melbourne. Material to the value of	$50.00
Bowen & Pomeroy Pty. Ltd., North Melbourne. Material to the value of	$50.00
H. Beecham & Co., Spotswood, Vic. Material to the value of	$14.00
Melbourne Harbour Trust. Timber for research purposes.	

PERSONAL

MR. D. S. JONES, B.C.E., an officer of the Division of Forest Products for the past 19 years and author of many articles on saws and sawing, has left the Division to take up an appointment as Timber Development Engineer of the Queensland Timber Board.

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Fence Posts and Fire

By F. A. Dale, Wood Preservation Section

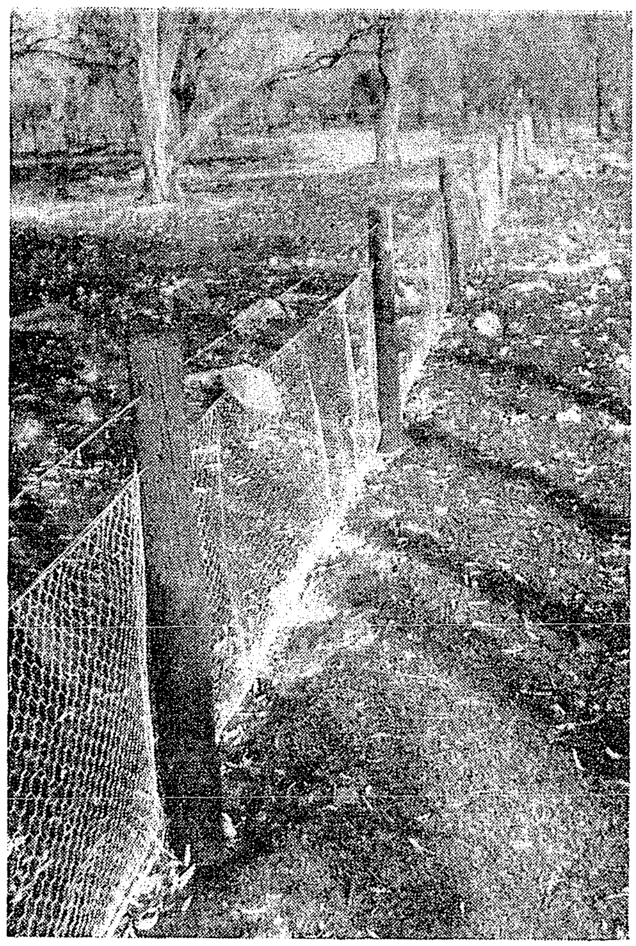
A SURVEY by the Division of Forest Products in 1953 showed that fire was not rated a major cause of fence post failure in Australia. Since then the preservative treatment of round posts has become firmly established. The loss of some treated posts in recent fires has revived interest in fire resistance. This article reviews the present state of knowledge and suggests courses of action for fence post users and the timber industry.

How Serious is the Fire Hazard?

In a survey of fencing practice in Australia conducted by the Division in 1953, a total of 428 users were asked to indicate the main cause of fence post failure on their properties. The percentage of replies giving fire as the main cause of failure in each State was as follows:

Tasmania	nil
Victoria	1
South Australia	3
New South Wales	4
Queensland	18
Western Australia	18

Early in 1965 severe grass fires in Victoria and South Australia destroyed a large amount of fencing, including a few pine posts treated with copper–chrome–arsenic (CCA) water-borne preservatives. The fact that these treated posts, once ignited, may continue to smoulder and can be completely destroyed has caused some alarm. This Division and others have since been re-examining this aspect and the importance of fire in relation to rural fencing.



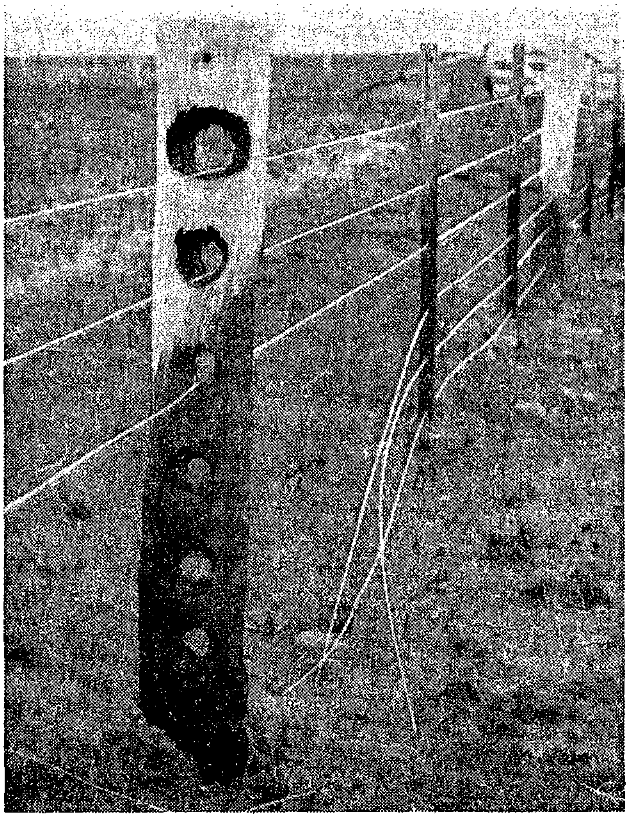
Creosote-treated posts are fire resistant.

Victoria is susceptible to very destructive fires. It has a total area of 56·2 million acres, of which 37·5 million acres are used for agriculture, including crops, fallow, sown and native pasture, and other land used for grazing. Figures supplied by the Country Fire Authority and the Victorian Forests Commission for the summer of 1964/65, which was one of Victoria's worst fire seasons, showed that the total area involved in fires other than forest fires (but including areas bordering State forests) was about 365,000 acres—less than 1% of the State's total *agricultural* area. The average area involved over the previous 10 years was much less.

If the amount of fencing involved in fires is related to acreage burnt, and this seems a reasonable way of assessing it, then the amount of fencing involved per annum would be substantially less than 1%. This agrees with the figure quoted in the survey of 1953. While not attempting to minimize the damage and disruption caused by fire, it is believed that the above figure represents a reasonable estimate of the fire hazard to fencing.

How Resistant are CCA-treated Posts?

This Division has attempted to assess the chances of CCA-treated pine posts being destroyed by fire. Questionnaires were sent to those known or reported to have had fences affected by fire. Information requested included the nature and severity of the fire, the number of posts involved, and the number destroyed. The very few replies received showed a wide variation in the behaviour of CCA-treated pine posts subjected to fire. The results are summarized below.



Old untreated hardwood posts will burn.

ignition to occur. Obviously this will occur sooner on very hot dry days.

This Division would welcome reliable observations of fires affecting CCA-treated posts, including estimates of shade temperature, wind speed, amount and nature of fuel around the posts, and the length of time the posts were exposed to fire.

Property	Location	Weather at Time of Fire	Posts Involved	Posts Destroyed
1	Clare, S.A.	Very hot	>10	1
2	Maffra, Vic.	Very hot	212	120
3	Maffra, Vic.	Very hot	190	30
4	Maffra, Vic.	Very hot	30	15
5	Ararat, Vic.	Very hot	5	2
			447	168

Some of the fences were inspected by the Division. While the results do not cover all cases of fire affecting CCA-treated posts, they are reasonably representative. The fact that less than 40% of the posts involved were destroyed shows that CCA-treated posts in general do not ignite "automatically" and that it probably requires an intense fire of some minutes' duration around the posts for ignition to occur.

Obviously there is still much to be learned about the fire resistance of CCA-treated pine posts. However, properly treated posts will resist fungal breakdown of the sapwood at groundline for 30 years or more. In contrast, an untreated post becomes progressively less fire resistant as it decays at the groundline.

In short, CCA-treated posts, like any other wooden posts, will burn under certain conditions. Treatment is primarily for protection against the much greater hazards of decay and insect attack.

How Fire Resistant are Other Wooden Posts?

The fire resistance of *untreated* wooden posts depends on size, density, age, and the condition of any sapwood. Heavy timbers

CCA-treated posts will scorch, or may burn, depending on the severity of the fire.

are harder to ignite and large timbers are more resistant than those of small cross section. Large untreated hardwood posts are very fire resistant when new, but become less resistant with time, particularly when any sapwood present has decayed. In this condition they will ignite readily when dry.

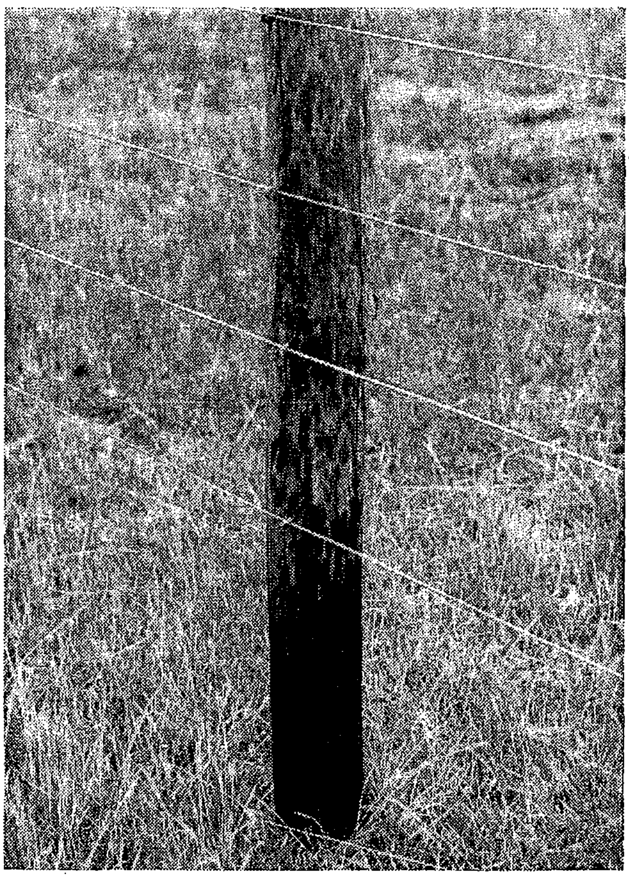
Creosote treatment of round posts, both pine and hardwood, makes them very fire resistant. Such posts will ignite fairly easily, particularly when recently treated, but, once the fire has passed, the flames are self-extinguishing with the evolution of dense smoke. This behaviour was clearly demonstrated in the Mount Dandenong (Victoria) fires of 1962, when a severe fire passed through an estimated 200 creosoted hardwood poles without one being made unusable, although a similar number of untreated poles were destroyed (Newsletter No. 286).

There is some evidence that CCA-treated *hardwood* posts ignite less easily than CCA-treated pine. This is to be expected as they are generally heavier; however, reports of their actual fire performance are lacking.

Why Not Treat All Posts with Creosote?

Since 1957, the preservation of round and sawn timber has become an established industry in all States. In south-eastern Australia, fence post treatment is a considerable part of this. In most treatment plants, radiata pine is the major fence post material and CCA preservatives are used in all but a few, primarily because of their cleanliness and ease of handling. Creosote oil, an equally effective preservative, is used in several large plants and one or two small ones.

It may well be asked why creosote cannot be used for all fence post treatment. There are several good reasons why this is not practical, the main one being that the CCA preservatives are ideal dual-purpose preservatives, but creosote is not suitable for building framing, flooring, or other internal timbers. The CCA preservatives are easily transported as dry concentrates and are used as cold solutions, so that the plants require no heating arrangements. Moreover, the degree of drying of timber before treatment is not so critical. In addition, the preservative loading



More CCA posts survived this fire than untreated hardwood.

can be readily adjusted by varying the concentration of the treating solution, and the treated material is clean to handle almost as soon as it leaves the treating cylinder.

It would serve no good purpose to require those plants using CCA preservatives to change to creosote for the sole reason that this makes timber more fire resistant. The main result would be to make treated fence posts more expensive and harder to obtain. As the industry is now treating about 1 million posts per annum and cannot keep pace with the demand, such a change would harm both the industry and the fence post user, and could affect supplies of creosote needed for other purposes.

Possible Improvements

The copper–chrome–arsenic preservatives are ideal in most respects and the elimination of the tendency to smoulder ("afterglow") is very desirable. Whether this can be done economically without altering the basic characteristics of the preservatives remains to be seen, but the manufacturers are well aware of the need.

Enough boric acid added to the preservative solution will eliminate afterglow, but it does not fix in the wood and can leach or diffuse out rapidly in service, so that it is most unlikely to give more than a year or two of extra protection.

Other chemicals will suppress afterglow but are either too costly or are incompatible with the treating solution. None of them fix like the preservative.

Another approach that deserves investigation would be to treat posts with a fire retardant after the normal CCA treatment, but the problems of cost and lack of permanence could be considerable.

A CCA-treated post with improved fire resistance must be cheap. Both the 1953 survey and the fact that CCA-treated posts are in increasing demand (even in areas recently affected by fires) indicate that availability, ease of handling, and resistance to decay and termites are evidently more important than resistance to fire.

The preservative manufacturers and the Division of Forest Products are continuing to investigate the problem, but the answer is not yet in sight.

The need for improving fire resistance must not overshadow the main reason for treatment of fence posts, that is, to make them resistant to decay and termites. CCA treatments are ideal for this purpose.

Making a Decision

Fence post users must make their own decisions in choosing the type of fence post best suited to their needs. We have tried to make a reasoned assessment of the importance of fire in relation to the other hazards affecting the service life of posts. On the evidence available, fire appears to be of minor importance and the fire resistance of a post should not be the main reason for its selection.

Of course there are situations where fire resistance is important, such as fencing in timbered country or where a history of repeated fires in an area cannot be ignored.

In such cases the use of creosote-treated timber or durable hardwood with the sapwood removed is recommended. Creosote-treated hardwood droppers have proved very resistant to grass fires and should be used where possible. Durable hardwood free of sapwood is the next best alternative.

Where fire-resistant posts are not available the important posts in a fence, such as corner, strainer, and gate posts, should be kept clear of thick grass or other fuel.

D.F.P. PUBLICATION ABSTRACTS

Cemented Tungsten Carbide in the Woodworking Industry by D. S. Jones. *Aust. Timb. J.* **31**(8). (*D.F.P. Reprint 626.*) Availability—Woodworking industry.

MANY FACTS about cemented tungsten carbide and its relation to the woodworking industry are already well known. Although in comparison with steel tools it is very expensive, it can often achieve spectacular economies. There are numerous instances of carbide tools lasting much longer than steel, but these are often offset by reports of rapid breakdown due to brittleness or simple accidents.

This paper presents information on tungsten carbide that would not readily be accessible to the woodworking industry. In addition it presents economic comparisons between tungsten carbide and steel, as used in a circular cutter head and a circular saw.

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CSIRO

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NUMBER 329 MAY 1966

1966##329

Proposed Revision of Strength Grouping System

By R. G. Pearson, Timber Mechanics Section

Forest Products Newsletter No. 324 drew attention to a proposed revision of the strength grouping system* and presented a tabulation of the consequent groupings of the major structural species used in Australia. We are indebted to a number of persons who examined the proposals and offered comments or criticisms. No one disputed the basic principles of the revision, but one writer queried the need for a change in view of impending developments in the machine grading of timber. Others pointed out that certain species were less favourably placed than on the old system.

From the comments made, it seems that it may be helpful to give some of the background to strength grouping and the reasons for revising the system. The criticisms concerning individual species have led to a re-examination of the proposals, and this article will discuss a minor modification that should overcome the objections.

Background to Strength Grouping

The species in common use in Australia for structural purposes are not only numerous but are frequently difficult to identify when sawn. To minimize commercial difficulties in marketing these timbers, it is generally very convenient, and technically not unduly inefficient, to group species of similar properties and regard those in each group as being, for design purposes, identical or, for commercial purposes, equivalent. This was done about 30 years ago when four strength groups called *A*, *B*, *C*, and *D* were established. In effect, four hypothetical species, *A*, *B*, *C*, and *D*, replaced the multitude of actual species. A species was allocated to a group if its bending strength (modulus of rupture), stiffness (modulus of elasticity), compression strength, and shear strength were similar to those of the hypothetical species representing the group. It must be emphasized that all the strength properties used in grouping are calculated from laboratory tests on small clear specimens, and are not the strength properties to be assumed for usual commercial timbers of structural sizes as used under service conditions. Neither the working stresses for structural design nor the quality of material are considered in grouping a species.

One problem in grouping is that the four strength properties considered most basic for engineering purposes are not perfectly correlated with each other, so that for some

* Full details appear in Div. For. Prod. Technol. Pap. No. 35—The establishment of working stresses for groups of species, by R. G. Pearson.

species, one property may indicate one particular group and other properties may indicate another. Placing a species in more than one group is confusing to the designer and reduces the advantage of grouping. Therefore, unless the properties diverge widely from the norm, minor compromises are made and a species is allocated to one group only, the greatest importance being placed on the bending strength and stiffness of the species in the unseasoned condition.

existing strength groups are not quite in line with those for modulus of rupture and compression strength.

The main impetus for a revision arose from recent investigations on structural timbers that have been carried out both here and overseas. These have led to a complete change in outlook about the effect of the type and size of the defects in a timber member, i.e. its grade, on its stiffness. Previously,

Table 1: Proposed Minimum Standard Test Values for Strength Groups

(To replace Table 3 in D.F.P. Technol. Pap. No. 35)

Property	Moisture Condition	Strength Group						
		S1	S2	S3	S4	S5	S6	S7
Density* (lb/cu ft)	Green	56·0	47·5	40·0	33·5	28·0	23·5	20·0
	Dry	69·0	58·0	48·5	40·0	32·5	26·5	22·0
Modulus of rupture (lb/sq in)	Green	15000	12500	10600	9000	7500	6300	5300
	Dry	23000	19500	16500	13600	11500	9750	8250
Modulus of elasticity (10^6 lb/sq in)	Green	2·36	2·06	1·80	1·55	1·32	1·15	1·00
	Dry	2·72	2·36	2·06	1·80	1·55	1·32	1·15
Maximum crushing strength (lb/sq in)	Green	7500	6300	5300	4500	3750	3150	2650
	Dry	11800	10300	9000	7750	6700	5800	5000
Maximum shear strength (lb/sq in)	Green	1900	1600	1320	1120	950	800	670
	Dry	2720	2430	2180	1900	1700	1500	1320

* In green moisture condition values are basic density, which is oven-dry weight/green volume.

Need for Revision

A major difficulty with the existing system is that four strength groups as originally defined do not cover the full range of properties for all the species now, or shortly to be, in use. The plantation-grown pines in particular cannot be fitted into the scheme, one or two extra groups being needed for them.

In addition, much more information has been gathered about Australian species since the four strength groups were established. Consequently, the properties for the hypothetical species representative of the groups may be determined more precisely for Australian timbers. Test data now indicate, for example, that the values for modulus of elasticity and shear strength set down for the

grade was believed to have no significant effect on stiffness, and so all grades of a given species, or strength group, were assumed to have the same modulus of elasticity. Stiffness as well as strength is now known to vary with grade. The resulting relationships are the basis of machine grading, which is being rapidly developed in several countries including Australia. As a corollary, working stresses based on earlier assumptions must be amended to take account of this variation of stiffness with grade.

In addition to the above, it would be desirable for working stresses for visually graded material to be compatible with those for mechanically graded timber. Furthermore, working stresses must be derived for a new visual grade recently introduced under the name of "building grade"*.

Although the grouping of species and the derivation of working stresses are separate operations, the working stresses for each group depend on the properties of the hypothetical species representative of the group. As indicated above, changes and extensions to the strength groups and the working stresses have become necessary, so the time seemed opportune to introduce a rationalized system based on the latest information and also more convenient and flexible than the existing system.

Objection has been raised to any change in the system on the grounds that machine grading will eliminate the need for strength groups and visual grades. Even if machine grading should fulfil all its promise, however, it is unlikely that it will be practicable in the immediate future to have sufficient machines in operation to handle the majority, much less all, of the scantlings and other structural timbers used in Australia. Furthermore, the machines are not suitable, at least at present, for heavy engineering timbers such as those used for wharves and bridges, nor can they be used for round timbers. Therefore, a simple means of classifying timber, such as is provided by strength grouping, should prove useful for many years.

Modification to Proposals

Objectors to the groups allocated to several species under the revised system have pointed out that the working stresses for these species would be lower than their present ones. As the present working stresses have led to satisfactory performance in service of these timbers over many years, the argument is reasonable and a reduction is not justified. However, to make special cases of these species by putting them in a higher group just to increase their working stresses would obviously undermine the rational basis of the system. It is preferable to remove the anomaly in such a way that only the properties of a species determine its grouping, and not its behaviour in structures.

Consequently, to determine the cause of the anomaly, a re-examination was made of the procedure used to determine the group properties in relation to the working stresses. Attention focussed finally on a factor previously recommended in Australia and elsewhere to allow for the effect on the strength properties of the difference between the size of structural members and laboratory test specimens. It is well established that bending strength tends to decrease as timbers become larger, but whether an independent factor to take account of this decrease is necessary for sizes common in ordinary building frameworks is not so certain. This is because factors to allow for grade are based on tests on structural sizes, and the size effect is, therefore, to some extent incorporated in the grade factor. In the more recent tentative recommendations, a small allowance of 7% was made for the size effect, but on review its introduction seems to have been unnecessarily conservative.

Accordingly, the properties of the hypothetical group species have been recalculated with no significant allowance for the size

Table 2: Proposed Change in Grouping of Species

Species	D.F.P. Newslett. No. 324	Amended
Blackbutt	S3	S2
Bloodwood, brown	S4	S3
Fir, Douglas	S6 (strength) S4 (mod. of elasticity)	S5
Gum, mountain	S5	S4
Gum, scribbly	S5	S4
Gum, shining	S5	S4
Gum, swamp	S5	S4
Gum, yellow	S3 (strength) S5 (mod. of elasticity)	S4
Karri	S4	S3
Oak, tulip red	S4	S3
Pine, celery-top	S5	S4
Pine, radiata	S7	S6
Pine, cypress, white	S7	S6
Stringybark, messmate	S4	S3
Stringybark, red	S4	S3
Tallowwood	S3	S2
Walnut, yellow	S5	S4

* See A.S. O82—1965, Sawn eastern Australian hardwoods, and A.S. O83—1963, Sawn south-eastern Australian eucalypt hardwoods.

effect. At the same time, some improvement in consistency of grouping species according to their various properties has been achieved, by basing the group properties for density, modulus of elasticity, compression, and shear of seasoned timber on the correlations between those properties and modulus of rupture of seasoned timber, instead of on the modulus of rupture of unseasoned timber. The minimum species average values that are now proposed for the new strength groups S1–7 are given in Table 1. The species listed in Newsletter No. 324 have been reclassified according to the properties in Table 1; where the groupings differ, the change is shown in Table 2.

No changes in the working stresses given in D.F.P. Technological Paper No. 35 appear warranted at present, except possibly a slight reduction in shear stress. Studies in progress relating to machine grading should indicate whether the values of the modulus of elasticity recommended for the working stresses are satisfactory.

Conclusion

The present system of four strength groups has served well for the past 30 years. However, it does not suit all species, particularly the plantation pines which are becoming increasingly important, and it needs to be brought up to date. The proposed system has been designed to cover the full range of species and visual and mechanical grades, and to simplify the working stresses. A small modification of the earlier tentative proposals has enabled the relative position of certain species to be restored to that which exists with the old system. Further amendment to the group properties or the working stresses may be required in the light of experience, and further comments and criticisms will be welcomed.

The proposed system, it is hoped, will provide not only a sounder and more rational basis for the use of timber in construction, but should also be beneficial in the marketing of the various grades and species.

PERSONAL

Mr. R. F. Turnbull, Officer-in-Charge, Utilization Section, Division of Forest Products, has accepted the Chairmanship of the Timber Industry Standards Committee. Mr. Turnbull has been very active for many years on the Timber Industry Standards Committee, and on various subcommittees associated with it.

Mr. J. D. Boyd, Officer-in-Charge, Timber Mechanics Section, Division of Forest Products, left recently on a four months' visit to Japan, North America, Europe, and Morocco. Mr. Boyd will be a member of the Australian delegation to the Sixth World Forestry Congress in Madrid next June.

Mr. H. Kloot, Timber Mechanics Section, has left on an overseas study tour of 4½ months. Among the countries he will visit are South Africa, the United Kingdom, and North America. He will also attend the IUFRO Conference to be held in Paris.

DONATIONS

The following donations were received recently by the Division:

North Queensland Sawmillers' Assoc.	$200.00
John L. Graham, Burnie, Tas. ..	$10.00
Timber Preservers' Assoc. of Aust.	$50.00
W.A. Forests Department	
Sixteen 30 ft karri poles for seasoning degrade studies. Total value incl. freight	$350.00
Automated Building Components (Aust.) Pty. Ltd.	
Gang nail plates. Approx. value	$50.00

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Laboratory Studies on Timber Seasoning Yard Design

The Detection of Air Movement

By R. Finighan and R. M. Liversidge, Seasoning Section

In Newsletter No. 309 (July 1964), a description was given of a wind tunnel that was set up here for the purpose of studying air seasoning yard design with the aid of small-scale model layouts. Various methods of visualizing air movement have been adapted and developed for this investigation. Brief notes on their use are outlined because of their probable interest to other workers in this general field, and because some could have application for use in commercial yards.

Smoke Tracing

A smoke jet fed into the air stream at any desired point enables the general air-flow pattern passing to and around stacks to be examined, and indicates regions of negative pressure, turbulence, insufficiency, etc. (Fig. 1). However, although flow patterns can be observed in this way, smoke tracing does not permit an accurate measurement of air velocities. For our investigations, an oil vapour is used in the tunnel in preference to the more commonly used titanium tetrachloride which, although giving a dense white smoke, is toxic and corrosive. Titanium tetrachloride has been used in commercial yards to observe air flow through and around individual stacks of timber, but care must be exercised in its use for the reasons mentioned.

Point Velocity Measurements

In addition to visualizing the general flow pattern, it is often useful to measure air speeds at particular points in a layout and sometimes within the models themselves. Obviously the velocity-measuring probes used must be small enough to avoid disturbances to the air-flow pattern. A hot wire anemometer, in which a heated element is cooled by the air flow, can be used for this purpose, and probes of suitable size have been developed by the Division's Physics Section using filaments from torch globes. This type of anemometer is suitable only for laboratory use, but a shielded type is available that could be used for field measurements.

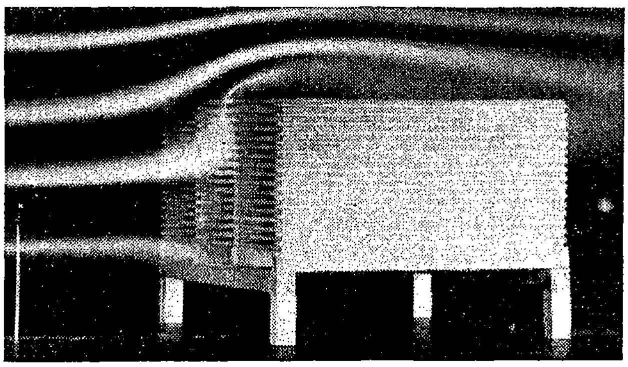

Fig. 1.—Air-flow pattern around a model stack as shown by oil vapour smoke tracing.

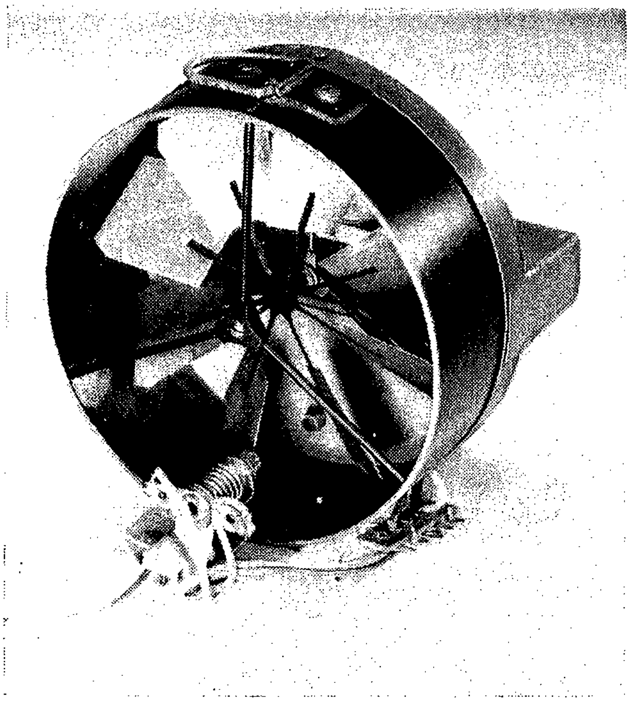

Fig. 2.—A vane anemometer fitted with a photoelectric cell and mask.

Other instruments that have been used for the same purpose in the wind tunnel studies are the direct-reading velocity meter and the vane (or "windmill") type of anemometer. The latter has been fitted with a photoelectric cell and electronic counter in place of the normal gear-driven distance meter. By fitting a mask on the face of the vane anemometer (Fig. 2) to suit the particular stacking strip thickness, the wind velocity through individual slots in a full-size timber stack can be measured.

All velocity-measuring devices used are initially calibrated against a Pitot-static tube and micromanometer.

Measurement of Air Movement

Although the measurement of air velocities at various points gives an indication of the air movement at a particular instant, in practice the velocities in a commercial air-drying yard will vary widely and continually. The drying potential of the layout as a whole is, among other factors, determined by the amount of air flowing through the stacks in a given time. This air flow can be estimated from frequent velocity readings, but a more convenient method is to use some device that indicates the total air movement past any point.

One instrument which has been used to measure drying potential in field studies and which is also suitable for measuring air movement in the wind tunnel is known as an atmometer. This consists of a hollow porous ceramic element that is kept filled with water (Fig. 3, left). A thin film of water forms continually on the surface of the element

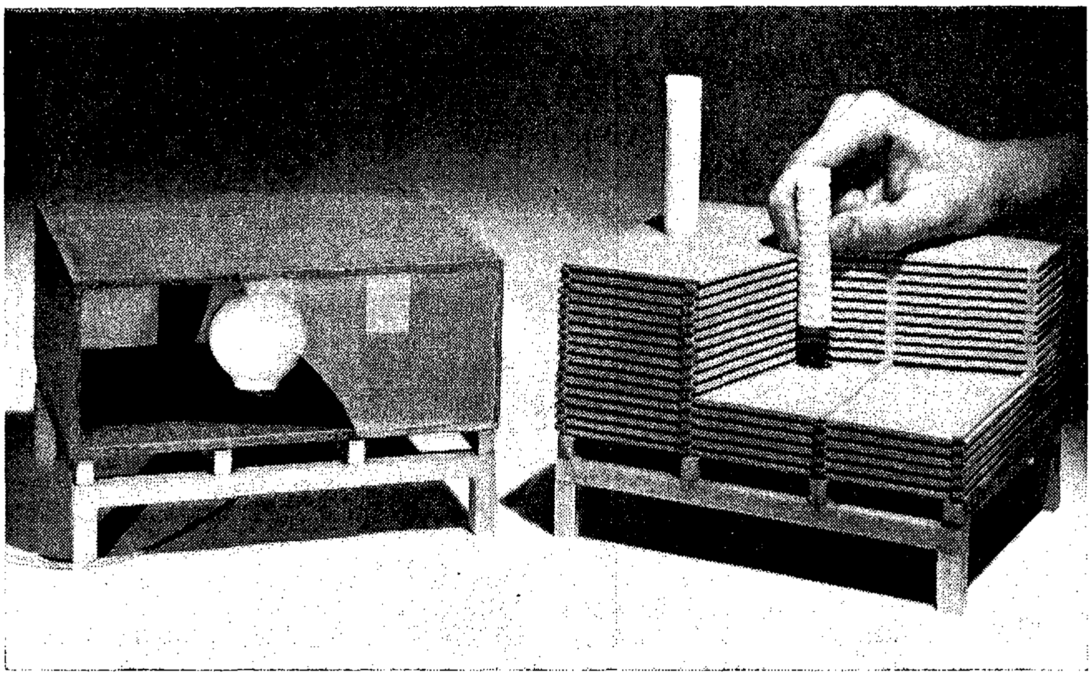

Fig. 3.—Left, *porous bulb atmometer in simplified model stack.* Right, *paradichlorobenzene plugs before and after use.* (*Both models cut away to show details.*)

and is evaporated by the air movement, the amount of water lost over a given period thus indicating the drying potential of the air. By using a number of these instruments an estimate of the drying performance of a yard can be obtained.

Air flow can also be measured by using a chemical indicator that is vaporized in response to the air movement. Chemicals of this type are used in moth-balls, camphor blocks, deodorant tablets, etc. After examining various materials, paradichlorobenzene was found to have suitable characteristics for wind tunnel use. Elements or "plugs" can be cast or pressed into various shapes and sizes to suit the model stack requirements (Fig. 3, right), and by maintaining a standard technique, closely matched plugs can be produced.

The plugs are placed in the model layout wherever the air movement is to be measured, and then weighed at intervals throughout the test. The loss of weight of each plug gives a measure of the air movement in that particular location.

The plugs are sensitive to both temperature and air movement, and, to enable readings taken at different temperatures to be compared, the loss of weight of each plug is related to that of a matched plug placed in the air flow upstream of the model layout.

Some advantages of vaporizing plugs are: no calibration is required; no leads, tubes, or wires are needed; no special instruments are required; they appear unaffected by dust particles in the air.

The possibility of using vaporizing plugs in field studies is being considered.

BLEACHING OF WOOD

By W. D. Woodhead, Utilization Section

MANY TIMBERS exhibit a considerable variation in colour, even in pieces cut from the same tree. The technique of bleaching can be used to reduce this variation and at the same time give a lighter overall shade. Natural colouring pigments in wood fade after a prolonged period of exposure to light, and this effect can be reduced by first bleaching the wood and then tinting it with light-fast chemical stains. Thus the user can not only obtain light-coloured surfaces but can also colour-match different timbers.

Woods differ in the ease with which they can be bleached; when used with some timbers conventional bleaches may even have a darkening effect whilst others become yellowish. It is therefore advisable to try out the bleach first on a small piece of the timber. It may be necessary to bleach several times to reduce the colour sufficiently.

The effect of bleaching will seldom penetrate more than 1/32 to 1/16 in. beneath the surface, so it is necessary for articles or components to be assembled or ready for assembly before bleaching is carried out. The only subsequent operation required should be a light sanding to smooth the grain of some timbers which may have been raised slightly by the bleaching liquids.

It is not possible to bleach from timber stains produced by fungal attack but it is possible to remove some chemical and other stains by the use of various solvents and reagents. One of the most common, blue-black iron stains, may be removed with a dilute solution of oxalic acid.

Bleaches

Proprietary Bleaches.—Probably the simplest method of obtaining a reliable bleach and becoming familiar with its correct use is to purchase the prepared bleach of a reputable paint company. Such bleaches are often in the form of two solutions which are mixed immediately prior to application or used successively. The manufacturer's instructions should be followed closely to obtain best results.

Ammonia and Hydrogen Peroxide.—One of the most powerful and widely used bleaches is a solution of hydrogen peroxide used in conjunction with ammonia or ammonium bicarbonate. Hydrogen peroxide of a strength known as "100 volume", and "880" specific gravity ammonia, may be obtained from industrial chemists. Ammonium bicarbonate also may be obtained from chemists, and a solution is made up by adding 2 oz of the salt to 1 pint of water.

Where a strong bleach is required both the ammonia and the hydrogen peroxide may be used at full concentration, otherwise they may be diluted with an equal volume of water. Ammonia gives off very powerful and unpleasant fumes and should only be used outside or in a very well-ventilated building. A practical alternative to ammonia is ammonium bicarbonate, which has the advantage of being almost odourless.

Before bleaching, the wood surface is first prepared by removing any previous finish, dirt, or grease, and then it is sanded. The ammonia or ammonium bicarbonate is applied with a cloth, swab, sponge, or brush. Immediately afterwards a second swab is used to apply the hydrogen peroxide. The work-piece should be allowed to dry and then inspected to see if sufficient bleaching has been achieved. The process may be repeated one or more times to obtain a further reduction in colour. Care is necessary when using peroxide to avoid splashing it on clothing, and rubber gloves should be worn to prevent contact with the skin. Hydrogen peroxide should be applied with a swab as the chemical quickly spoils a brush.

Caustic Soda and Peroxide.—A strong bleach can be achieved by using caustic soda (sodium hydroxide) instead of ammonia; a solution of suitable concentration is made by dissolving 1 oz of the salt in 1 pint of water. The surface is swabbed with this solution and allowed to dry for 30 min before the peroxide is applied. After bleaching, the surface must be flushed with water and excess soda neutralized with a solution of acetic acid or oxalic acid to prevent reaction with subsequent finishes. Oxalic acid for this purpose is made up in a concentration of ¼ oz per pint of water.

Oxalic Acid.—Oxalic acid may be used by itself as a mild bleaching agent. A solution is prepared by dissolving 2 oz of acid crystals in 1 pint of hot water; this is then applied with a swab or brush. After the surface has been bleached, it is essential that the excess acid is neutralized with a solution of borax to avoid violent discolouration of the surface finish. Borax solution is prepared by adding ½ oz borax to 1 pint of water. It should be noted that oxalic acid is extremely poisonous.

Drying of the Bleached Surface

It is most important that the bleached surface is allowed to dry before any subsequent finishing operations are carried out. From 6 to 15 hr of air drying may be sufficient depending on how heavy an application of bleach was used. If large volumes of solution are applied it may be preferable to dry for at least 48 hr. Failure to dry sufficiently often results in many tiny bubbles appearing in a surface coating, and may even cause blistering. Bleached panels should be laid flat; if they are placed upright when wet a light bleached line will appear along the bottom.

Subsequent Finishing

It is usually necessary to sand the surface after it has dried to remove any bleach residue and to smooth raised grain. This should be done only very lightly with fine paper (1½ grade is suitable), otherwise the thin layer of bleached wood may be cut through in places and the unbleached wood exposed.

Stains may be used after bleaching to tint a surface to the desired shade, or to match other shades before a surface coating is applied. Bleached surfaces may be finished with a gloss, semi-matt, or matt varnish or plastic finish, or with shellac or furniture oil.

Caution: *It should be noted that many of the chemicals mentioned are extremely poisonous and may also cause harm if they come in contact with the skin. Appropriate precautions should be taken by the use of protective clothing and care in the storage and use of the chemicals.*

PERSONAL

Dr. W. E. Cohen, formerly Officer-in-Charge, Special Investigations, has been named Assistant Chief of the Division. Dr. Cohen has been with the Division since its inception in 1928, after having been engaged for several years on investigations into the pulping of eucalypts and radiata pine. For many years he was Officer-in-Charge of the Wood Chemistry Section, and for the past five years has been carrying out special projects mainly concerned with dimensional stabilization of wood and paper, in addition to being responsible for editing the Division's scientific papers.

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1966##331

Exterior Natural Finish Timber

By W. D. Woodhead, Utilization Section

ARCHITECTS, prospective owners, and others concerned with the design of buildings often desire to feature natural-finish timbers in situations exposed to the weather. Ideally, to achieve a natural appearance, timber should be left without any surface treatment. Although a particular wood might have a distinctive colour when newly installed, it will eventually become greyish as a result of weathering and so often present a rather shabby appearance. The purpose of applying a natural finish is to maintain the attractive appearance whilst not masking the figure of the particular wood.

It is necessary also to consider the likelihood of deterioration due to surface checking or splitting, stain, and fungal attack. The characteristics of some timbers make them resistant to deterioration but most timber requires some protection to give a long service life.

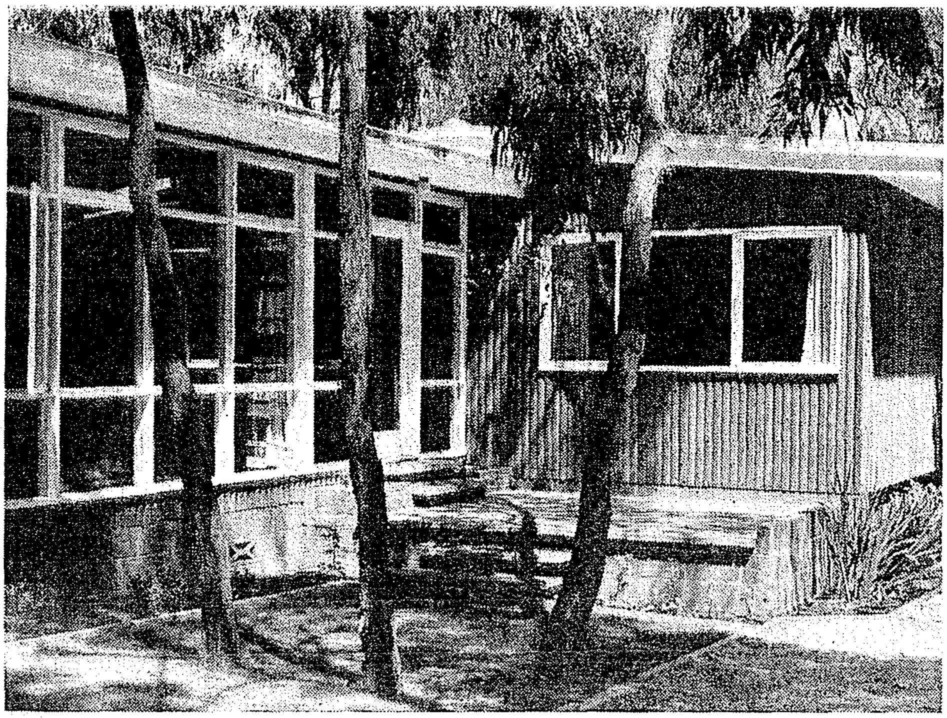
The Division does not actively conduct investigations into wood finishing but, in order to satisfy enquiries on the subject, examines the basis of the problems involved. This article is intended to explain how deterioration occurs and to indicate how improved performance can be achieved. It is certain that with appropriate design, choice of suitable timbers, and adequate protection, naturally finished timber can excel as a building material.

The best overall protection for external woodwork is given by a conventional three-coat pigmented paint system, but this masks the characteristic appearance of the wood surface. There are, however, finishes that do afford some protection whilst maintaining the natural appearance of the wood and these will be discussed. One type comprises the clear coatings such as varnishes and plastic finishes, both of which form a surface film of appreciable thickness. The other type includes oil finishes, which are absorbed to some degree by the timber and do not form a surface film.

Unfinished Wood

When subject to weathering, unfinished wood takes on a greyish colour, depending on the particular timber and the amount and colour of dust in the atmosphere. Loss of colour is due to the bleaching action of sunlight, leaching of extractives, and the establishment of microscopic staining fungi. The retention of dust and dirt is determined by the texture of the surface; a sawn surface holds dirt much more readily than a planed surface. Some species also are prone to uneven discolouration from extractives, and in humid locations moulds may develop on the surface.

Timber is liable to dimensional change across the grain which may, in some species, be of sufficient magnitude to cause surface checking. In extreme cases checks may develop into splits, especially near fastenings. Low-shrinkage timbers noted for their



Contemporary-style house with natural-finish vertical weatherboards. Design incorporating wide eaves and narrow boards shows good building practice.

stability are not usually subject to degrade from this cause.

If the timber has a high natural durability it is unlikely to be attacked by staining fungi, decay, or insects, but timbers of low natural durability may soon deteriorate.

Surface Coatings

Clear coatings, when used in exposed exterior situations, give only a short service life before the coating breaks down, and users have become disillusioned by the high cost of maintenance, or of replacements if maintenance has been neglected. Research by many of the world's leading paint companies is directed to the development of a durable clear exterior finish; however, at the present time it is acknowledged that none of those commercially available can give as long a service life as a conventional paint system.

There are several ways in which deterioration of clear-coated timber first becomes apparent; these are loss of gloss, slight cracking or checking of the surface, and discolouration by staining fungi.

Deterioration of a clear coating is hastened by sunlight, the first sign being a slight yellowing followed by dulling of the surface. After a period the coating becomes brittle and small cracks appear in the direction of the grain and around knots, later extending to show as an overall crazing. Moisture penetrates into these cracks, causing the wood to swell and loosen the bond between the coating and the wood fibres. Subsequently the finish peels off continuous areas, the natural weathering processes follow, and, in time, the wood assumes a greyish colour. If the timber does not have a high natural durability decay may commence and result in loss of strength.

The service life of a pigmented paint system is vastly superior, because the pigment shields the wood/coating interface from sunlight, the ultraviolet portion of which causes embrittlement and loss of adhesion. Some of the more recently introduced clear finishes incorporate ultraviolet absorbers, which perform a similar function to pigment in retarding embrittlement.

To obtain a satisfactory performance from clear coatings, refinishing must be carried out before the surface has started to craze. In such cases, the only preparatory work required is to sand the surface prior to putting on two or more coats of finish. If degrade has become more advanced and the wood surface is exposed and possibly partially weathered, there is no alternative to completely removing the coating by sanding or with a varnish stripper. This should be followed by sanding or planing the wood surface to remove discolouration. If the discolouration is extensive, there is no alternative but to refinish with a conventional paint.

It cannot be emphasized too strongly that use of a clear coating should be considered only if the user is prepared to carry out the necessary maintenance. This involves re-coating at intervals as short as one year in exposed situations.

Oil Finishes

Oil finishes applied to wood enhance the appearance by emphasizing figure and affording some protection to the surface. Oils have only a limited effect in reducing the uptake and loss of moisture, and hence timber is still subject to changes in dimension due to changing weather conditions. Vegetable oils, without the addition of water-repellent and preservative constituents, can also be attacked by mildew, causing discolouration and uneven staining. The most successful oil finishes contain additives in the form of resins and waxes as water-repellent agents, fungicides, and insecticides.

Clear oil preparations do little to prevent fading, and the timber will eventually lose its natural colour and become grey. The addition of pigments as colours in oil considerably improves the performance of oil finishes in preventing loss of colour, and pigments have the advantage of not masking the natural figure and grain pattern of the wood itself. They are particularly useful also for timbers that have uneven colour or have become discoloured or marked during preparation or erection.

The success of oil finishes varies considerably with the type of timber used and its preparation. Some timbers are quite porous and absorb sufficient oil to give very good protection. Others, however, absorb very little and only slight protection is achieved. Oil finishes give a superior performance on sawn surfaces rather than on machined surfaces, as more oil is absorbed and the pigments are held better by the surface fibres. Sawn surfaces are practical for panelling, weatherboards, and beams, but are inappropriate for some other uses, for example, window joinery. Refinishing with oils is required at one- to two-year intervals, but re-application is easy as the surface first needs only to be cleaned with a brush to remove dust, and the oils themselves are comparatively low priced. The need for re-oiling is indicated by the dry hungry appearance of the surface. Re-application of a clear oil over a surface that has previously been treated with a pigment will prevent too dark a colour from being obtained.

With a clear coating, the natural durability and porosity of the timber are of lesser importance than where an oil finish is used, because the timber relies on the coating for protection. With an oil finish, the timber itself is exposed and weathering takes place directly on the surface fibres.

Timbers most suited for use with an oil finish are those having a moderately high natural durability and little dimensional change with change in moisture content. A long satisfactory service life cannot be expected from timbers of doubtful natural durability, and these should not be used without preservative impregnation treatment.

Some timbers are definitely non-durable if left unfinished in exterior situations. However, if they are porous, as the plantation pines are, they can be impregnated with waterborne or oil preservatives. In this way they are rendered as resistant to deterioration from insects and fungi as timbers of the highest natural durability, and are ideal for exterior use.

Applications of an oil finish after erection will assist in the prevention of surface checking in material treated with waterborne preservative.

Building Practices

Protection of exterior woodwork by appropriate design can reduce deterioration and the amount of maintenance required. The design of buildings with wide eaves reduces the exposure of cladding to direct sunlight. Coatings used in such places have a considerably increased service life and fading of unfinished wood is reduced. The use of narrow boards of timbers that have a large movement will reduce the actual dimensional change across the width of a single piece and avoid splitting near nailed fastenings; cupping of the boards after they have become wet is also reduced. Corrosion-resistant galvanized nails and fastenings should be used to prevent discolouration, and nail heads should be punched beneath the surface even if they are not subsequently stopped. Exposed timbers not treated with any finish may be liable to stain from adjacent brickwork and metal fastenings. Whilst these marks can sometimes be removed, they may be prevented to a large extent if a pigmented oil is applied in the first instance.

Future Developments

In many countries, especially in the United States of America, the paint industry is conducting research to develop clear films and coatings that will give long life when subject to severe conditions of exposure. The films are most suited for application to sheet materials such as plywood and are likely to be factory applied. In Australia, several organizations are testing various types of finishes on different timbers and are investigating methods of treatment that give improved performance. Porous timbers impregnated with waterborne preservatives or preservative oils to give durability and freedom from warp and checking, and subsequently treated with pigments to give colour, have shown promise for exterior cladding. There is no doubt that the results from these investigations will enhance the status of timber as an exterior building material.

In the meantime, the following points should be considered when it is proposed to use timber externally as a naturally finished material.

- Incorporate design features that give protection to exposed wood surfaces.
- Choose a timber of proven durability and stability in situations of changing moisture content if an oil finish is to be used or if the timber is to be left completely unfinished.
- Always use corrosion-resistant metal fastenings.
- Avoid the use of clear coatings unless frequent maintenance can be assured.
- Use oil finishes in conjunction with rough sawn surfaces in preference to planed faces where practicable.
- Use a pigmented oil finish that contains a recognized wood preservative and preferably additional water-repellent constituents.
- Refinish before deterioration becomes too far advanced; this should be when a coating assumes a dull appearance and when an oiled surface appears very dry.

PERSONAL

Dr. W. E. Cohen, Assistant Chief of the Division, has been elected an Associate Member, representing Australia, of the Committee of the Pulp, Paper, and Board Section of the Applied Chemistry Division of the International Union of Pure and Applied Chemistry.

The Committee consists of titular members from Finland, Sweden, U.S.A., Britain, Italy, Canada, Germany, and Russia, and associate members elected from Australia, Japan, Czechoslovakia, France, and Norway.

Dr. H. Morita, a research chemist of the Canadian Department of Agriculture in Ottawa, is spending his sabbatical leave at the Division. He is involved in a general research programme on soil humus and is particularly concerned with the polyphenolic components of the soil. In Australia, he will examine aspects of the polyphenols in eucalypt leaves.

DONATIONS

FROM THIS ISSUE of the Newsletter, the separate heading "Materials" will be included in the section listing donations to the work of the Division.

In order to carry out its research programme, the Division from time to time requires for test purposes large quantities of wood, wood products, and other materials. Many firms, in recognition of the work the Division does for industry, make no charge when they fill orders for test material. These gestures are greatly appreciated, as a corresponding amount of money is then made available for purchase of instruments and other equipment, thus improving the Division's facilities.

Materials

Celcure (Australia) Pty. Ltd., Melbourne
1 cwt of Celcure A $30.00
Wm. Cook Pty. Ltd., Port Melbourne
Sawn timber .. .. approx. $22.00
Saxton Timber & Trading Pty. Ltd., Footscray
2 creosoted poles .. .. approx. $40.00

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Shrinkage and Density of Australian and Other Woods

By R. S. T. Kingston and Antonia E. von Stiegler, Physics Section

Introduction

Owing to the continued demand for information on shrinkage and density, it has been decided to reprint the more important of the data in D.F.P. Technological Paper No. 13, Shrinkage and Density of Australian and Other South-west Pacific Woods by R. S. T. Kingston and C. June E. Risdon, as Newsletter articles.

In the tables that follow this introduction, which will be continued in subsequent Newsletters, no values have been given for green density or moisture content, as most material arriving for test has undergone some drying and hence such values are not available. However, if the approximate green moisture content of a species is known by the user of these tables, an estimate of green density can be made from the basic density using the formula:

$$D_G = D_B (1 + M_G/100) \text{ in lb/cu ft,}$$

where D_G is the green density in lb/cu ft, D_B is the basic density in lb/cu ft, and M_G is the estimate of green moisture content (%). The density of completely waterlogged wood (D_S) is given by:

$$D_S = 62{\cdot}4 + 0{\cdot}35\ D_B \text{ in lb/cu ft.}$$

This is an upper limit to the value of the density of wet wood.

Explanation of Tables

Species are listed in alphabetical order of common names, and, where standard common names (Standards Association of Australia 1954, 1965) are not available, by the name commonly used in the State where they are chiefly found. Standard common names are printed in capital letters. The eucalypts are listed first, and will be followed by other species and some overseas woods commonly marketed in Australia. All figures are for mature material, i.e. material from trees of greater age than those in which properties change appreciably with age.

Density values tabulated include air-dry densities at 12% moisture content both before and after reconditioning, and the basic density, which is defined as the mass of the oven-dried specimen divided by its volume when green.

Shrinkage values are expressed as a percentage of green dimensions and values from green to 12% moisture content both before and after reconditioning are given, the difference being an estimate of the incidence of collapse. The unit shrinkage is also tabulated. This is the shrinkage for 1% change in moisture content and applies only between about 5% and 25% moisture content. The

Continued on back page

SHRINKAGE AND DENSITY OF AUSTRALIAN AND OTHER SOUTH-WEST PACIFIC WOODS

The value given in the first line is the species mean (i.e. the mean of tree means). In the second line the probable range for individual results is given. B.R., before reconditioning; A.R., after reconditioning; Tang., tangential; Rad., radial.

Species	Density (lb/cu ft)			Shrinkage (%)					
	Basic	Air-dry		Unit A.R.		Green to 12% Moisture Content			
						Tang.		Rad.	
		B.R.	A.R.	Tang.	Rad.	B.R.	A.R.	B.R.	A.R.
I. EUCALYPTS									
ASH, ALPINE	31·9	41·4	40·9	0·35	0·22	8·5	6·3	5·2	3·5
N.S.W., Vic.	24·8–35·8	31·1–47·2	29·9–48·3	0·27–0·43	0·13–0·33	4·1–12·2	4·2– 8·8	1·1– 7·7	1·7–4·8
ASH, MOUNTAIN	31·2	42·4	39·4	0·36	0·23	13·3	7·1	6·6	3·7
Tas., Vic.	26·1–36·3	33·3–51·8	31·8–49·4	0·27–0·46	0·12–0·35	2·4–21·4	4·4–9·7	1·5–11·9	1·4–6·4
ASH, SILVERTOP	41·7	53·8	50·9	0·36	0·25	10·6	7·0	5·7	3·8
N.S.W., Tas., Vic.	36·6–46·9	45·4–64·0	42·9–60·6	0·29–0·43	0·16–0·34	7·1–14·3	3·4–9·8	2·3–8·9	1·7–6·2
BARREL, BROWN	35·0	46·1	43·2	0·33	0·21	8·9	5·9	5·7	3·4
N.S.W., Vic.		38·1–55·5	38·2–50·8						
BLACKBUTT	43·6	55·2	53·7	0·37	0·26	7·3	5·8	4·3	3·5
N.S.W., Qld.	36·5–50·5	47·4–63·6	45·0–62·7	0·31–0·43	0·20–0·33	3·8–12·4	3·5–9·3	2·0–6·9	2·1–5·1
BOX, BLACK	56·2	69·3	67·6	0·33	0·22	5·8	4·0	2·6	2·2
Vic.		64·0–75·1	61·2–74·8						
BOX, GREY	55·9	70·2	68·7	0·43	0·23	7·4	6·1	3·3	2·7
N.S.W., Vic.	47·3–66·6	64·9–77·4	62·6–76·9			4·4–10·0	4·1–8·1	1·1–5·5	1·1–4·5
BOX, GREY, COAST	54·6	69·3	67·7	0·42	0·31	8·2	6·6	3·9	3·4
N.S.W., Vic.	49·0–60·7	62·7–76·3	61·4–74·4	0·34–0·49	0·24–0·38	6·8–9·6	5·2–8·1	2·7–5·2	2·2–4·7
BOX, RED	53·0	66·4	64·3	0·36	0·26	6·1	4·6	3·5	2·7
N.S.W., Vic.	48·7–57·7	61·5–71·5	59·4–69·6			5·0–7·5	3·4–6·1	2·5–4·5	1·8–3·9
BOX, WHITE	56·2	69·4	68·1	0·39	0·19	6·8	5·7	3·2	2·8
Vic.		63·5–75·4	62·7–73·7						
BOX, YELLOW	56·1	67·1	65·6	0·39	0·26	6·2	4·6	2·8	2·3
N.S.W., Vic.	52·3–60·8	61·0–75·9	59·3–74·6	0·27–0·50	0·16–0·34	4·9–7·5	3·4–6·0	1·9–3·7	1·5–3·0
CANDLEBARK	33·6	45·7	40·8	0·34	0·22	12·2	6·2	5·5	2·9
N.S.W., Vic.	28·0–37·4	37·7–52·3	34·3–46·0	0·26–0·41	0·15–0·27	2·6–24·3	3·3–10·0	1·1–9·8	1·3–4·2
EURABBIE	44·5	57·9	53·6	0·40	0·28	12·7	7·9	5·2	3·8
Vic.	37·7–52·0	47·3–70·8	43·6–66·6	0·30–0·49	0·21–0·36	8·7–16·4	5·6–10·6	3·0–7·6	1·7–6·5

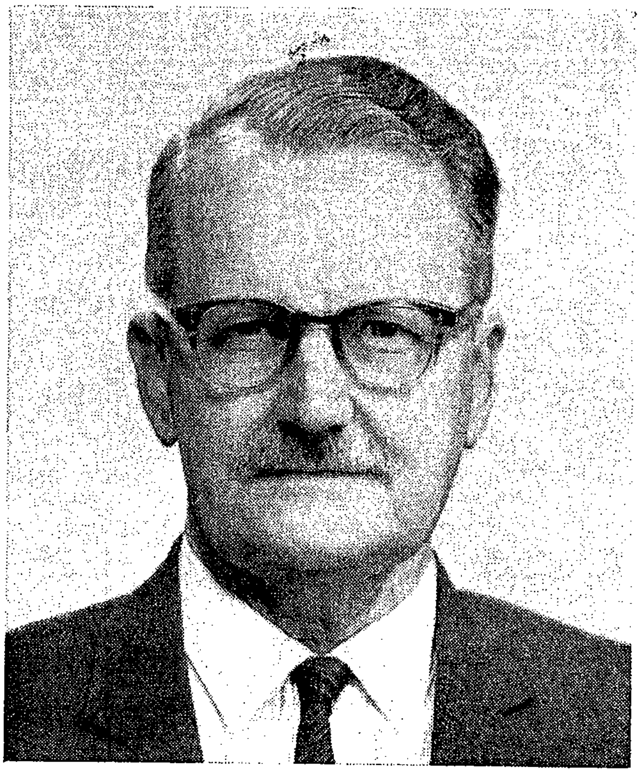
Species	Density (lb/cu ft)			Shrinkage (%)					
	Basic	Air-dry		Unit A.R.		Green to 12% Moisture Content			
						Tang.		Rad.	
		B.R.	A.R.	Tang.	Rad.	B.R.	A.R.	B.R.	A.R.
GUM, BLUE, SOUTHERN Tas.	44·2 35·3–52·2	62·9 51·5–74·2	57·6 47·0–68·2	0·61 0·37–0·86	0·49 0·28–0·70	15·2 9·0–20·9	9·7 5·2–14·1	7·2 2·9–11·3	4·9 1·2–8·0
Vic.	40·4	55·6	51·9	0·41	0·29	13·5	8·9	5·9	4·3
GUM, BLUE, SYDNEY N.S.W., Qld.	40·9 30·9–47·6	52·6 41·1–60·8	50·3 38·6–62·7	0·34 0·25–0·43	0·24 0·13–0·33	9·5 5·0–13·4	5·8 3·0–8·7	5·4 2·5–7·2	3·7 1·4–5·9
GUM, BRITTLE N.S.W.	38·4 32·0–45·0	54·5 43·5–64·9	47·0 38·4–55·6	0·27 0·20–0·35	0·22 0·15–0·28	12·8 8·5–16·7	5·2 3·6–6·7	8·9 4·1–13·0	3·3 1·9–4·6
GUM, TROPICAL (GHOST) N.T., Qld.	42·9 35·0–52·8	51·8 42·0–64·2	51·6 41·9–63·8	0·27	0·29	4·6 3·1–6·3	4·3 3·0–6·0	2·9 1·3–4·6	2·6 1·1–4·2
GUM, GREY, MOUNTAIN N.S.W., Vic.	41·6 35·4–48·8	54·5 45·1–66·0	50·4 41·0–62·3	0·39 0·33–0·45	0·27 0·20–0·35	11·9 7·8–16·1	7·2 3·8–11·0	5·3 2·9–7·9	3·6 1·6–6·0
GUM, MAIDEN'S N.S.W., Vic.	46·8 41·2–53·4	61·9 54·9–70·3	57·8 50·4–66·9	0·41 0·30–0·52	0·27 0·21–0·33	11·2 5·5–17·0	7·7 4·6–11·1	5·2 2·1–8·1	3·8 2·1–5·5
GUM, MANNA N.S.W., Vic.	34·9 27·2–42·7	48·6 33·7–59·1	44·3 33·3–54·3	0·34 0·23–0·45	0·22 0·11–0·33	12·0 2·0–18·4	6·8 3·2–11·0	5·1 1·9–8·1	3·2 1·2–6·1
GUM, MOUNTAIN A.C.T., N.S.W., Vic.	33·2 26·3–40·2	43·0 31·7–54·3	39·3 30·1–48·5	0·35	0·22	11·5 2·3–20·7	5·8 0·0–11·7	5·4 0·0–12·0	2·9 0·3–5·6
GUM, RED, FOREST N.S.W., Qld., Vic.	48·6 41·5–55·9	62·2 54·8–70·4	59·1 49·7–69·4	0·34 0·21–0·46	0·25 0·12–0·37	8·6 3·0–14·8	5·8 3·5–8·3	4·8 2·3–7·3	3·4 2·0–4·9
GUM, RED, RIVER N.S.W., Qld., Vic.	44·3 37·1–51·0	57·0 51·0–62·8	53·3 45·9–60·8	0·31 0·17–0·44	0·22 0·11–0·31	8·9 2·3–15·4	4·8 2·0–7·6	4·4 1·5–6·9	2·7 1·4–3·9
GUM, ROSE N.S.W., Qld.	37·3 23·0–44·0	47·0 28·1–55·9	46·9 33·9–59·7	0·34 0·25–0·42	0·25 0·14–0·34	7·2 3·3–10·0	5·5 4·0–7·1	4·0 1·6–5·9	3·4 1·7–5·0
GUM, SCRIBBLY N.S.W., Qld.	40·0 33·1–47·1	56·6 49·1–64·2	50·6 43·2–58·0	0·32 0·20–0·44	0·23 0·14–0·31	14·5 2·6–26·3	7·7 3·0–12·3	6·9 2·1–11·7	3·9 2·3–5·6
GUM, SHINING Vic.	32·7 27·8–37·7	42·4 34·6–49·4	39·9 33·0–47·0	0·33	0·22	9·4 3·5–12·8	5·9 3·0–7·9	4·9 1·6–7·8	3·0 1·2–4·6
GUM, SPOTTED N.S.W., Qld.	49·3 25·8–64·5	61·7 47·8–68·5	60·5 46·6–67·3	0·38 0·32–0·45	0·32 0·27–0·37	6·1 4·0–9·4	5·0 3·2–8·4	4·3 2·4–6·3	3·7 2·2–6·3

correct way to use these values has been discussed in Newsletter No. 325—The Shrinkage of Wood and its Movement in Service.

For both shrinkage and density the mean values are given first; for example, for GREY IRONBARK the mean basic density is given as 57·1 lb/cu ft, and below this is the range of values likely to be encountered in practice due to the variation in the properties of wood from locality to locality, tree to tree, and even within a tree. In this species, values are shown as being likely to fall between 53·9 and 60·1 lb/cu ft. Occasional pieces could have values outside this range but such occurrences are rare enough to be unimportant in practice.

Figures tabulated, except where no range is given, are based on tests involving at least five trees. The more important species involve many more, for example, BLACKBUTT, 42 trees; SPOTTED GUM, 48 trees; ROSE GUM, 33 trees; KARRI, 35 trees; and ALPINE ASH, 41 trees.

PERSONAL



MR. R. F. TURNBULL, Officer-in-Charge of the Utilization Section, has been appointed Chief Scientific Liaison Officer, London, and relinquished his duties at the Division on June 30.

Mr. Turnbull, who is well known to members of the timber trade throughout Australia, joined the staff of the Division as Utilization Officer in 1931. After graduating B.E. (Hons.) from the University of Western Australia, he undertook training in timber utilization research in American and English laboratories under a CSIR Studentship.

During the years up to 1939, he developed laboratory and field work aimed at improving the utilization of Australian timbers and substituting them, where possible, for imported timbers.

In 1939 he was appointed Secretary of the Central Timber Advisory Panel, set up to advise the Government on problems related to timber usage in wartime, and later he became Assistant Timber Controller in the Ministry of Munitions. On resuming duties at the Division, he concentrated for some years on assisting industry to improve the standard of sawmill design and practice. More recently he has been responsible for mill and production studies to assess the yield and cost of production from different types of logs and different species; these studies will provide data for national valuations of supplies for sawmilling purposes.

Mr. Turnbull has also been active for many years on various committees set up by the Standards Association of Australia and was recently made Chairman of the Timber Industry Standards Committee. He has also been a member of the AusTIS Council since 1957. In addition he has played an important part in education with regard to timber production and use, having been a specialist lecturer at the University of Melbourne for 16 years. Mr. Turnbull was also on the Advisory Committee on Technical Education, Tasmania, the Council of the T.D.A. of Victoria, and several corresponding Committees of the International Union of Forestry Research Organizations.

Mr. Turnbull carried out specialist studies in the U.S.A. in 1947, Ceylon in 1959, Japan in 1965, and attended international conferences in Singapore in 1952, Hong Kong in 1959, and made a world tour in 1957.

Mr. Turnbull has spent the past month preparing for his London appointment and leaves Australia early in August.

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A Note on Northern Territory Cypress Pine

MECHANICAL TESTS have recently been carried out on a sample of Northern Territory cypress pine (*Callitris intratropica*). Three localities, Maningrida, Katherine, and Melville Island were represented in the sample, which comprised 21 trees. This species is similar in appearance to white cypress pine (*Callitris columellaris* syn. *C. glauca*), which grows in New South Wales and parts of Queensland. It is commonly used in building construction. *C. intratropica* is slightly denser and shows a larger increase in strength on drying than the eastern species, and it has approximately the same resistance to decay and termite attack.

The strength tests on green and dry material have indicated that *C. intratropica* should be regarded as a group S4 species in the revised strength grouping system (see Newsletters Nos. 324 and 329).

D.F.P. PUBLICATION ABSTRACTS

Developments in Seasoning Practices by G. W. Wright. *Aust. Timb. J.* **32**(5). (*D.F.P. Reprint* 656.) Availability—Timber industry management and engineering (single copy only).

THIS PAPER was presented at the 1966 AusTIS Conference, and provides a comprehensive review of those aspects of the seasoning process in which significant recent developments have taken place. Its subsequent publication in the *Australian Timber Journal* has given wide coverage to the particular points it makes.

Being a review, each topic has been dealt with briefly, and the scope of the paper is probably best indicated by quoting the subject headings, which are as follows: Sorting, Stacking, and Handling; Air Seasoning; Predrying and Forced-air Drying; Kiln Drying; Special Drying Processes; Dimensional Stabilization; and Quality Control.

Design of Plywood Trim Saws by D. S. Jones. *Aust. Timb. J.* **32**(4) (*D.F.P. Reprint* 670.) Availability—Plywood and furniture industries, saw doctors.

SINCE CONDITIONS vary widely in the cutting of any material, and, especially in this case, plywood, it is probably not possible to design a plywood trim saw that will be universally suitable for all operations.

The recommendations in this paper are based on a knowledge of the fundamentals of the sawing process. Laboratory experiments planned for the future are unlikely to make any radical changes to these recommendations, but may permit them to become more specific.

After a discussion of the various factors involved in the cutting of plywood, an excellent summary incorporates 11 features shown to be desirable in a good plywood trim saw.

SHRINKAGE AND DENSITY OF AUSTRALIAN AND OTHER SOUTH-WEST PACIFIC WOODS

The value given in the first line is the species mean (i.e. the mean of tree means). In the second line the probable range for individual results is given. B.R., before reconditioning; A.R., after reconditioning; Tang., tangential; Rad., radial.

Note.—These tables will be continued in subsequent Newsletters. The introduction and first instalment appeared in August (Newsletter No. 332).

Species	Density (lb/cu ft)			Shrinkage (%)					
	Basic	Air-dry		Unit A.R.		Green to 12% Moisture Content			
						Tang.		Rad.	
		B.R.	A.R.	Tang.	Rad.	B.R.	A.R.	B.R.	A.R.
1. EUCALYPTS (*Continued*)									
GUM, SWAMP Vic.	36·2 25·7–44·1	45·8 32·7–59·6	42·6 33·2–51·1	0·32 0·24–0·40	0·20 0·13–0·26	11·3 0·0–28·6	7·3 2·3–13·3	5·1 0·3–10·4	3·3 1·2–5·3
GUM, YELLOW Vic.	50·6 37·9–65·2	62·9 48·5–78·8	60·8 47·3–76·0	0·32	0·19	6·3 2·8–10·2	4·5 3·2–6·0	2·8 0·7–4·9	2·1 1·0–3·3
IRONBARK, GREY N.S.W.	57·1 53·9–60·1	71·4 67·2–76·3	70·9 66·7–75·6	0·40 0·28–0·52	0·31 0·22–0·41	7·26 5·1–9·7	6·79 4·9–8·9	4·13 3·0–5·4	4·04 2·8–5·4
IRONBARK, GREY, QUEENSLAND Qld.	54·1 48·9–59·1	68·8 63·1–74·0	68·2 62·3–73·6	0·39 0·29–0·48	0·31 0·23–0·40	7·53 4·7–10·3	6·90 4·3–9·4	4·76 2·6–6·8	4·64 2·5–6·6
IRONBARK, RED N.S.W., Qld., Vic.	55·3 48·6–61·9	67·8 58·2–77·9	66·2 56·7–76·3	0·37 0·30–0·44	0·27 0·14–0·38	6·3 3·4–9·3	4·8 1·9–7·7	3·5 0·7–5·8	2·9 0·4–5·1
JARRAH W.A.	41·1 34·5–47·3	51·4 42·8–63·6	50·4 43·0–62·2	0·30	0·24	7·4 2·7–12·3	6·7 2·5–12·3	4·8 1·3–8·6	4·6 1·2–8·9
KAMARERE New Guinea	36·1 22·2–50·2	44·0 26·3–62·0	43·4 26·3–61·0	0·30 0·20–0·40	0·19 0·09–0·30	5·1 3·3–7·1	4·5 3·0–6·0	3·0 1·6–4·3	2·7 1·6–3·9
KARRI W.A.	43·4 39·6–47·1	56·5 50·8–62·4	55·3 49·5–61·5	0·40 0·35–0·45	0·27 0·20–0·33	9·9 6·2–13·9	8·5 4·9–12·6	4·3 2·0–6·8	4·0 1·7–6·3
MAHOGANY, RED N.S.W., Qld.	49·5 41·0–57·0	59·6 50·5–69·3	57·6 48·6–67·7	0·34 0·28–0·40	0·27 0·21–0·33	6·3 3·2–9·4	4·9 2·5–7·2	3·9 1·8–6·2	3·3 1·8–4·9
MAHOGANY, SOUTHERN N.S.W., Vic.	44·2 39·4–48·6	57·4 49·4–65·3	54·6 47·7–61·7	0·37 0·32–0·42	0·28 0·16–0·38	9·8 6·8–13·0	7·0 5·4–8·8	5·1 2·2–8·0	4·0 1·9–6·1
MAHOGANY, SWAMP Qld.	44·4	51·3 42·1–61·0	49·0 39·2–59·6	0·32	0·22	4·6	3·5	2·6	2·1
MAHOGANY, WHITE N.S.W., Qld.	49·6 44·9–54·2	59·8 51·0–68·6	58·6 49·7–67·5			5·4	4·8	2·8	2·4
MALLET, BROWN W.A.	48·1 44·2–52·0	60·8 55·9–65·8	59·2 54·4–64·1			7·1 5·8–8·4	5·5 4·1–6·9	4·4 3·3–5·5	3·6 2·6–4·7
MARRI W.A.	41·4	53·4 37·7–69·1	52·1 36·7–67·5	0·34	0·22	6·6	5·6	3·7	3·4

Species	Density (lb/cu ft)			Shrinkage (%)					
	Basic	Air-dry		Unit A.R.		Green to 12% Moisture Content			
						Tang.		Rad.	
		B.R.	A.R.	Tang.	Rad.	B.R.	A.R.	B.R.	A.R.
MESSMATE, GYMPIE Qld.	50·3 37·7–43·8	62·2 53·8–71·9	61·7 53·3–71·3	0·37 0·30–0·45	0·21 0·15–0·27	6·2 5·2–7·1	5·7 4·6–6·9	3·4 2·8–4·0	3·1 2·4–3·8
MESSMATE, NEW SOUTH WALES N.S.W.	34·4 29·9–39·6	45·5 39·2–52·9	41·8 36·0–48·2	0·30 0·24–0·37	0·20 0·14–0·26	10·0 6·2–14·6	5·1 3·7–6·4	5·7 3·1–8·4	2·9 1·9–3·7
PEPPERMINT, BROAD-LEAVED N.S.W., Vic.	38·1 32·6–44·4	50·6 44·9–57·8	46·1 39·9–53·3	0·36 0·27–0·43	0·23 0·12–0·32	11·2 4·8–19·6	5·0 2·6–8·7	5·9 2·7–8·6	2·8 1·9–3·7
PEPPERMINT, NARROW-LEAVED N.S.W., Vic.	37·0 33·2–41·8	51·3 41·3–62·8	45·4 39·0–53·2	0·36 0·29–0·42	0·23 0·16–0·30	13·2 6·5–20·5	6·2 4·4–8·3	6·3 3·6–9·5	3·2 1·7–4·9
STRINGYBARK, BROWN S.A., Vic.	38·3 30·7–44·6	52·4 39·7–60·7	49·4 35·7–58·4	0·33 0·27–0·40	0·24 0·15–0·28	10·4 6·0–14·6	6·0 3·4–8·1	5·1 1·5–7·7	3·2 1·2–4·6
STRINGYBARK, MESSMATE N.S.W., Tas., Vic.	37·4 30·4–44·9	48·0 39·9–57·1	44·5 36·5–54·0	0·36 0·23–0·44	0·23 0·12–0·33	11·3 2·9–18·7	6·3 3·6–8·8	5·1 2·3–7·6	3·3 1·8–4·9
STRINGYBARK, RED N.S.W., Vic.	43·5 38·2–48·7	56·1 48·9–64·9	51·3 44·2–60·0	0·37 0·26–0·46	0·23 0·17–0·31	9·8 5·4–15·7	4·8 2·7–8·2	5·7 3·0–8·8	3·0 1·6–4·9
STRINGYBARK, WHITE N.S.W., Qld., Vic.	40·7 34·8–46·8	53·5 46·7–61·4	50·1 43·9–57·5	0·36 0·30–0·42	0·25 0·19–0·33	10·6 4·8–17·1	6·0 3·8–10·1	5·6 1·8–9·8	3·4 1·8–5·8
STRINGYBARK, YELLOW N.S.W., Vic.	43·5 38·3–48·7	55·2 47·4–63·2	53·1 45·6–60·9	0·37 0·31–0·43	0·27 0·21–0·34	7·5 4·8–10·5	5·5 3·8–7·5	4·3 2·5–6·1	3·2 2·1–4·3
TALLOWWOOD N.S.W., Qld.	49·7 44·7–54·6	61·8 55·7–67·5	60·7 54·5–66·5	0·37 0·30–0·43	0·28 0·20–0·35	6·1 4·2–8·1	5·3 3·9–6·8	3·7 2·4–4·9	3·3 2·2–4·4
TUART W.A.	52·2 46·1–58·9	64·7 57·0–73·4	63·5 55·6–72·4	0·38 0·30–0·46	0·23 0·15–0·32	6·9 5·0–9·1	5·8 4·0–7·6	3·0 1·9–4·1	2·6 1·5–3·6
WANDOO W.A.	57·5 54·7–60·6	68·6 65·8–73·0	67·9 64·8–72·2	0·34 0·25–0·43	0·24 0·14–0·33	4·2 2·9–5·9	3·3 1·8–5·3	2·6 1·5–3·7	2·3 1·2–3·4
WOOLLYBUTT N.S.W.	50·9 45·0–56·9	66·7 59·1–75·0	63·8 56·0–72·4	0·37 0·28–0·46	0·27 0·20–0·33	10·7 6·3–15·1	8·2 5·0–11·4	5·7 4·0–7·4	4·3 2·7–6·0
YERTCHUK N.S.W., Vic.	44·3 39·5–49·6	58·6 51·3–65·9	55·1 47·3–63·3	0·38 0·31–0·45	0·28 0·23–0·34	9·1 6·5–11·8	6·0 4·2–8·0	5·7 3·2–8·0	3·7 2·4–5·2

Species	Density (lb/cu ft) Basic	Density Air-dry B.R.	Density Air-dry A.R.	Shrinkage (%) Unit A.R. Tang.	Shrinkage Unit A.R. Rad.	Green to 12% Moisture Content Tang. B.R.	Tang. A.R.	Rad. B.R.	Rad. A.R.
II. NON-EUCALYPTS									
ALDER, BROWN N.S.W., Qld.	31·9 27·1–36·7	41·8 36·0–47·4	39·6 33·8–45·6	0·39	0·19	8·8 3·0–14·2	5·7 1·3–9·9	5·2 1·4–8·3	3·4 1·2–5·4
ANISOPTERA New Guinea	30·0 26·4–35·0	36·3 31·3–43·2	36·2 31·5–42·7	0·41	0·23	5·3 3·5–7·8	5·2 3·4–7·2	2·0 0·8–3·6	2·1 0·8–3·5
ASH, CROW'S N.S.W., Qld.	49·8 40·2–53·6	59·2 49·0–64·7	58·7 48·8–64·5			4·2 2·3–5·8	4·2 2·0–6·5	3·2 1·4–4·6	3·3 0·9–5·6
ASH, HICKORY Qld.	51·9 47·3–55·6	61·4 56·8–66·6	60·9 55·6–66·3			4·4 3·2–5·6	4·1 2·8–5·5	3·2 1·6–4·9	3·0 1·3–4·6
ASH, SILVER, NORTHERN Qld.	35·0 27·5–42·0	41·9 33·1–50·6	41·7 33·0–50·2	0·31 0·21–0·40	0·21 0·19–0·24	4·8 3·4–6·2	4·7 3·0–6·3	3·1 2·0–4·3	3·1 1·8–4·3
ASH, SILVER, QUEENSLAND Qld.	32·5 26·4–37·6	40·0 31·8–46·7	39·9 31·9–46·3	0·29 0·17–0·42	0·20 0·09–0·31	5·5 3·3–7·6	5·4 3·5–7·2	3·0 1·7–4·3	3·0 1·6–4·3
ASH, SILVER, SOUTHERN N.S.W., Qld.	36·6 31·0–41·7	44·6 36·5–53·2	43·9 34·5–54·0			6·2 4·4–8·0	5·9 3·6–7·7	3·6 2·3–4·6	3·6 2·4–4·6
BEAN, BLACK Qld.	36·4 30·0–42·8	44·4 37·0–51·6	43·0 35·3–50·7	0·40	0·16 0·12–0·19	5·8 2·3–8·8	3·3 1·3–5·3	1·8 0·6–3·0	1·3 0·4–2·3
BEECH, MYRTLE Tas., Vic.	36·0 31·1–41·0	44·0 37·3–50·9	42·9 36·5–49·7	0·32 0·25–0·39	0·18 0·13–0·24	6·8 4·5–9·0	4·7 2·2–7·0	2·7 1·4–4·2	2·3 0·8–3·7
BEECH, SILKY N.S.W., Qld.	35·1 31·4–39·1	44·8 40·2–49·4	41·7 37·2–46·2	0·30 0·18–0·41	0·16 0·09–0·23	9·5 1·9–16·0	4·5 2·6–6·3	2·8 0·9–4·7	2·0 0·6–3·4
BEECH, WHITE N.S.W., Qld.	29·7 23·6–34·8	34·5 26·8–41·7	34·0 26·1–41·2	0·26	0·15	3·7 0·7–7·0	2·9 0·5–5·2	1·6 0·5–2·8	1·4 0·3–2·5
BIRCH, WHITE N.S.W., Qld.	31·8 26·0–36·7	39·5 31·7–46·0	38·4 31·0–44·8	0·33 0·17–0·48	0·17 0·04–0·28	7·0 4·5–9·7	5·3 3·3–7·8	3·1 1·5–4·8	2·6 1·0–4·1
BLACKWOOD S.A., Tas., Vic.	34·1 24·7–42·0	40·7 29·5–49·8	40·5 29·7–49·4	0·27 0·21–0·35	0·16 0·05–0·26	4·2 1·8–5·9	3·9 1·2–6·0	1·6 0·4–2·6	1·6 0·4–2·5
BOLLYWOOD N.S.W., Qld.	26·8 21·8–30·3	33·2 26·7–39·5	32·7 25·9–38·7	0·23 0·17–0·30	0·14 0·09–0·19	5·0 3·6–6·6	3·9 2·7–5·3	2·0 1·1–3·0	1·8 1·0–2·7
BOX, BRUSH N.S.W., Qld.	42·9 38·6–47·8	55·4 48·2–62·5	53·5 46·5–60·4	0·38 0·30–0·45	0·24 0·14–0·34	9·7 5·3–13·4	6·8 3·4–10·1	4·4 1·7–7·0	3·6 1·3–5·8
BOX, SWAMP N.S.W., N.T., Qld.	40·5 33·7–47·6	52·7 43·2–63·3	50·6 40·8–62·0	0·31 0·24–0·39	0·22 0·14–0·30	10·1 5·7–14·5	7·7 3·7–12·1	5·2 0·4–10·3	4·3 0·0–9·6

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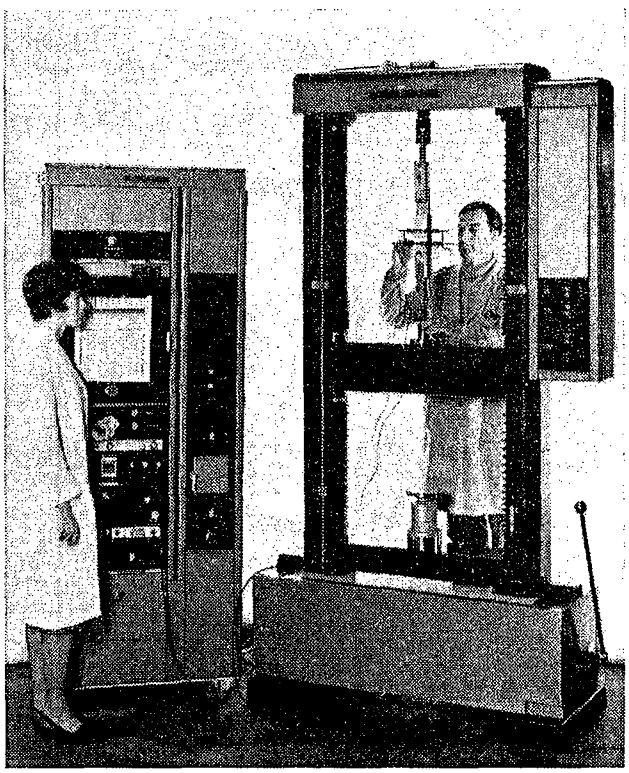
New Aid to Timber Engineering Research

RECENT RESEARCH in Australia and overseas on all kinds of timber structures and components, such as floor systems, wall panels, joints, and roof trusses, has highlighted the need for studying their behaviour under different types of loading from those customarily applied in the laboratory. It has thus been found necessary to carry out special tests in which loads are maintained for long periods, or successive cycles of loading and unloading are applied.

For example, a roof truss shows an immediate deflection under the weight of the truss and the material it supports, but as time goes on this deflection increases somewhat due to the phenomenon known as creep. During its life other loads, usually of varying magnitude and short duration, also come onto the structure, such as those caused by workmen and wind. Application of these various loadings may cause marked changes in the loads in the members and on the joints, perhaps even to the extent of a complete reversal of load for a short period. The effect of these fluctuations on the deformation of the joints needs to be known to enable an estimate of the stiffness and adequacy of the truss in service.

Machines previously available in the Timber Engineering Laboratory of this Division, although highly accurate and efficient, were not designed to carry out tests that would simulate continuous, varying, or fluctuating loadings over an extended period. For this reason an Instron testing machine was recently purchased at a cost of approximately $28,000. This machine, shown in the photograph, has a number of unique features that enable it to be used for a wide variety of tests.

In contrast to the standard type of testing machine that is hydraulically or mechanically



SHRINKAGE AND DENSITY OF AUSTRALIAN AND OTHER SOUTH-WEST PACIFIC WOODS

The value given in the first line is the species mean (i.e. the mean of tree means). In the second line the probable range for individual results is given. B.R., before reconditioning; A.R., after reconditioning; Tang., tangential; Rad., radial.

Note.—These tables will be continued in subsequent Newsletters. The introduction and first instalment appeared in August (Newsletter No. 332).

Species	Density (lb/cu ft)			Shrinkage (%)					
	Basic	Air-dry		Unit A.R.		Green to 12% Moisture Content			
						Tang.		Rad.	
		B.R.	A.R.	Tang.	Rad.	B.R.	A.R.	B.R.	A.R.
NON-EUCALYPTS (*Continued*)									
Boxwood, grey Qld.	44·6 36·2–52·1	56·0 45·6–65·3	54·6 43·2–64·7	0·38	0·29	7·2 5·0–9·5	5·3 3·1–7·2	3·9 2·8–5·0	3·2 2·2–4·1
Buttonwood Qld.	34·8 30·5–39·1	43·4 38·8–48·0	42·1 37·2–47·0	0·32	0·14	8·2 3·5–12·8	5·8 3·4–8·3	2·3 1·3–3·3	1·8 1·2–2·5
CAMPHORWOOD N.S.W., Qld.	28·9 25·5–32·6	34·8 30·0–39·6	34·8 30·1–40·2	0·26	0·16	4·8 2·2–6·9	4·2 1·5–6·4	2·3 0·3–3·8	2·3 0·5–3·9
CARABEEN, YELLOW N.S.W., Qld.	31·1 25·1–39·6	38·4 29·6–50·4	37·0 29·3–47·6	0·33	0·14	7·0 2·9–11·6	4·0 2·6–5·9	2·6 0·6–4·5	1·7 0·6–2·8
CEDAR, RED N.S.W., Qld.	24·3 18·5–31·1	27·7 21·2–36·0	27·4 21·1–35·4	0·20		4·1 1·5–7·4	2·9 2·1–4·0	2·2 0·3–4·6	1·7 1·2–2·3
CHEESEWOOD N.T.	28·8 23·5–34·4	33·8 27·6–40·4	33·7 27·6–40·2			2·8 1·3–4·8	2·7 1·4–4·4	1·6 0·2–2·9	1·6 0·2–2·9
COACHWOOD N.S.W.	30·7 24·6–34·6	38·8 30·4–44·2	37·9 29·2–43·5	0·34 0·16–0·50	0·24 0·15–0·33	8·1 5·1–11·3	6·2 3·8–8·8	4·0 1·6–5·8	3·3 1·4–4·8
ERIMA New Guinea	18·4 14·1–25·0	22·0 16·7–29·9	21·8 16·6–29·7	0·21 0·17–0·27	0·13 0·10–0·18	4·5 2·8–5·9	3·5 2·1–5·0	2·0 1·2–2·6	1·8 1·3–2·5
EVODIA, WHITE Qld.	29·1 24·8–33·2	35·4 31·0–39·8	34·8 30·2–39·3			4·9 1·9–8·2	4·2 2·2–6·4	2·4 1·0–3·8	2·1 1·0–3·2
GREENHEART, QUEENSLAND Qld.	49·9 46·3–53·1	63·0 56·3–68·7	62·5 55·4–68·7			7·3 4·9–9·3	6·7 4·2–9·0	4·4 2·6–6·0	4·2 2·3–5·9
Homalium* New Guinea	44·3	53·7	53·3	0·43	0·31	4·9	4·6	2·7	2·4
Hopea†, New Guinea New Guinea	50·8 46·9–54·8	61·7 56·4–67·1	61·7 56·5–66·8	0·36 0·23–0·48	0·25 0·08–0·43	5·4 3·4–7·4	5·4 3·4–7·3	2·5 0·9–4·2	2·5 1·3–3·7
KANUKA N.S.W., Qld., Vic.	39·2 30·8–46·6	55·6 39·9–67·7	50·5 37·4–61·1	0·37	0·21 0·12–0·28	14·2 5·6–20·1	8·0 3·8–10·8	7·1 2·8–12·0	4·1 1·7–6·2

* *Homalium foetidum.*

† *Hopea iriana.*

Species	Density (lb/cu ft)			Shrinkage (%)					
	Basic	Air-dry		Unit A.R.		Green to 12% Moisture Content			
						Tang.		Rad.	
		B.R.	A.R.	Tang.	Rad.	B.R.	A.R.	B.R.	A.R.
KAURI, QUEENSLAND, NORTH Qld.	24·6 21·5–27·5	29·1 25·5–32·7	28·8 25·4–32·4	0·18	0·14 0·01–0·27	3·4 1·5–5·3	2·7 0·6–5·1	2·2 0·6–3·9	2·1 0·5–3·8
KWILA New Guinea	43·9 38·6–47·7	51·4 44·8–55·9	51·0 44·8–55·3	0·30 0·20–0·42	0·17 0·11–0·25	2·6 1·1–4·1	2·0 0·6–3·8	1·2 0·0–2·3	1·0 0·2–1·8
LEATHERWOOD N.S.W., Tas.	36·0 32·4–40·4	46·1 40·4–54·2	44·8 39·5–52·9			9·4 7·5–12·0	8·1 6·5–10·1	4·9 2·4–7·5	4·3 2·3–6·3
MAHOGANY, BRUSH N.S.W., Qld.	31·4 27·2–36·0	39·9 33·4–46·6	39·2 33·1–45·8	0·28	0·16 0·10–0·22	7·6 4·5–11·3	6·3 4·1–9·4	3·6 1·1–6·3	3·2 1·6–5·0
MAHOGANY, ROSE N.S.W., Qld.	36·9 32·4–40·3	44·2 37·7–50·2	43·6 37·2–49·4	0·29	0·18 0·05–0·32	4·3 2·4–6·1	3·4 1·9–5·1	2·5 1·4–3·4	2·2 1·3–3·0
MAPLE, QUEENSLAND Qld.	27·6 23·4–30·6	34·7 28·4–39·8	34·1 28·1–38·8	0·25	0·15	7·2 4·6–11·2	6·0 3·6–9·9	2·9 1·9–3·7	2·8 1·9–3·6
MAPLE, ROSE N.S.W., Qld.	35·0 30·1–40·0	42·7 36·6–49·2	41·8 36·0–48·7	0·32	0·17	6·7 4·2–9·2	5·6 3·1–8·2	3·1 1·8–4·4	3·0 1·4–4·6
MAPLE, SCENTED Qld.	37·1 32·6–41·5	44·8 38·5–51·2	44·4 37·1–51·8		0·20 0·10–0·29	6·3 2·2–10·5	6·1 1·6–10·5	3·2 2·0–4·3	3·0 1·7–4·3
OAK, SILKY, NORTHERN Qld.	27·2 22·5–31·6	32·7 26·9–38·7	32·6 26·8–38·5	0·31	0·13	4·7 2·5–6·9	4·3 2·2–6·4	1·6 1·2–2·0	1·5 1·2–1·8
OAK, SILKY, SOUTHERN (*G. robusta*) N.S.W., Qld.	32·8 28·8–35·8	39·7 34·8–43·4	38·7 34·2–42·2	0·32	0·14	5·0 2·2–8·2	3·8 2·2–5·7	1·8 1·0–2·6	1·4 0·8–2·0
OAK, SILKY, SOUTHERN (*O. excelsa*) N.S.W., Qld.	31·0 26·9–34·6	38·1 33·3–42·4	37·4 31·6–42·6			6·5 4·7–8·8	5·6 4·2–7·1	2·1 1·2–3·1	1·9 1·1–2·8
OAK, TULIP, BLUSH N.S.W., Qld.	39·4 33·4–44·6	50·5 41·1–59·7	49·5 40·2–58·5	0·24	0·23	8·7 5·9–11·6	7·2 5·2–9·5	4·3 2·7–5·7	3·9 2·6–5·2
OAK, TULIP, RED Qld.	38·7 31·8–45·2	48·4 41·3–57·2	47·1 40·1–55·6			8·9 6·4–11·7	6·8 5·3–8·2	4·4 3·0–5·8	3·9 2·9–5·0
PENDA, RED Qld.	53·4 49·6–57·1	66·0 61·8–70·2	65·6 61·2–70·0	0·36	0·31	5·8 4·0–7·5	5·5 3·9–7·1	3·8 2·3–5·3	3·6 2·2–5·1
PERSIMMON, GREY N.S.W., Qld.	35·5 29·8–40·0	45·6 37·5–52·0	44·4 36·1–51·2	0·27	0·16	7·6 4·7–10·4	6·0 4·2–7·7	3·5 1·4–5·8	3·0 1·6–4·4

driven, and in which forces applied to test specimens are measured by hydraulic or lever-weighing systems, the Instron machine is basically a precision electronic and servo-mechanism system. Forces on test specimens as high as 20,000 lb or as low as 1/1000 oz may be accurately measured, and the rate of deformation of a specimen may be precisely controlled within the range of 0·0002 in. per min to 20 in. per min.

The machine may be operated manually as a conventional testing machine, but accessories enable automatic programming of test sequences such as cycling between two pre-set limits of load or deformation, or maintaining the deformation of a specimen constant or the force on it constant as it deforms under load. Once started, the machine will continue to carry out the programme for a pre-determined number of cycles or for any set period. As all information on load and deformation is automatically recorded, tests may be continued when members of staff are not on duty. The automatic recording also reduces the chance of errors in the test data.

An accessory is available for this machine to transcribe the test results onto punched tape for direct input to a computer and thus for analysis; it is hoped to install this at some future date.

OVERSEAS VISITS

DURING AUGUST and September, four officers of the Division left for extended visits to overseas research laboratories where they will work in their own specialized fields.

Mr. R. G. Pearson, Engineering Section, has accepted an invitation to be visiting professor of Wood Mechanics and Rheology at the Department of Wood Science and Technology, North Carolina State University, Raleigh, N.C., U.S.A. He will be away for 12 months.

Dr. W. M. McKenzie, Utilization Section, has accepted an appointment as associate specialist at the University of California, U.S.A., where he will work for 12 months with Professor E. Thomsen at the Forest Products Laboratory of the School of Forestry, studying basic aspects of wood cutting.

Mr. G. F. Reardon, Engineering Section, has been awarded a CSIRO Overseas Traineeship for 12 months, to work as a research student under Professor S. K. Suddarth, Purdue University, Indiana, U.S.A. He will be engaged in studies of mathematical analyses of the behaviour of timber structures with special reference to their rheological characteristics.

Mr. W. D. Woodhead, Utilization Section, will spend 12 months at the University of California, U.S.A., where he will study the insulating characteristics of wood-framed wall structures under a CSIRO Studentship.

Sections change Names

IN ORDER TO DESCRIBE more correctly the functions of three of the Division's research sections, their names were changed from the first of July. These changes do not infer any radical alteration to the organization or research programme of the Division.

The former Wood and Fibre Structure Section is now Physiology and Microstructure; Wood Chemistry, Pulp, and Paper is now Paper Science; and Timber Mechanics is now Engineering.

Concurrent with these changes, it has been decided to drop the words "Wood" or "Timber" from the names of the four sections concerned, so that the other five sections are now Physics, Preservation, Seasoning, Utilization, and Plywood and Gluing.

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Good Housekeeping and Timber Preservation

By F. A. Dale, Preservation Section

COMMERCIAL pressure treatment in Australia is now 10 years old. It has grown from a few plants to a major industry with over 90 pressure cylinders throughout the Commonwealth, treating poles, piles, fence posts, and a wide range of sawn timber from cooling tower components to oyster stakes. This expansion has been accompanied by a growing public awareness of the value of preservative treatment and its acceptance by many public authorities.

This Division can feel great satisfaction in being closely associated with the development of this industry from the beginning, and it is always very gratifying to see treated timber used to advantage in new situations. Some members of the industry and some trade associations are very active in the promotion of preservation, and many more people are now familiar with it through the widespread use of such items as treated posts and poles.

Like any other development this growth has not been free of troubles, but most of these have been overcome and an attractive and reliable product is now being produced. If public confidence in treated timber is to be maintained and increased it is most essential that the quality of treatment should match its appearance and that carelessness or oversight on the part of one or two individuals should not affect the good reputation of the industry. To this end the writer has selected a number of factors that are vital to proper treatment, some aspects of which tend to be overlooked.

Proper Drying

This is the most important requisite for proper treatment. Natural air drying is effective in most parts of Australia for most of the year but it can be relied on too much. For instance, pine posts cut in southern Australia in July are most unlikely to be dry enough for treatment in September unless suitable cover is provided.

Every plant should have some means of measuring sapwood moisture content, such as an electric resistance meter or a drying oven and a balance. This should be used on samples from every charge before treatment. At moisture contents below 25 to 30% the meter is a very useful device, but above this figure the readings should only be used as an indication and the effects of rain wetting and variable penetration of the electrodes must always be allowed for.

Perhaps the best way of assessing suitability for treatment is to treat a number of test pieces from a drying stack. If these are weighed before and after treatment both penetration and retention can be checked and a decision then made about treating the whole stack.

Fig. 1.—These post stacks are ideal except for the low ground clearance.

Rain wetting of stacks before treatment can cause high local moisture contents, which in turn can cause zones of low retention leading to early failure. Softwoods are more susceptible to this and unless given suitable treatment are also liable to blue stain and decay if they remain wet in the stack.

The treater has two alternatives in this case. He can either treat all material as soon as it is dry enough or he can put the dry material under cover. Covered drying for all material is probably uneconomic. However, cover for at least two weeks' stock is desirable to allow for redrying of rain-wet material before treatment. Covered drying space should prevent drifting rain from wetting the stacks where this is prevalent.

Drying Stock

When demand is rapidly increasing it may be difficult to obtain sufficient air-drying stock to meet it. The temptation to treat material before it is ready must be resisted as it can be a cause of early failure.

Premature failures resulting from any cause such as this can be damaging to the whole industry and to the reputation of this Division, which is actively supporting the promotion of preservative-treated timber.

Housekeeping

This is a very descriptive term covering a wide variety of factors. These include stack foundations, rubbish and weed control, drainage, yard hygiene, yard layout, and stock records.

Stack foundations should be of treated or durable timber and must raise the bottom layer of any drying stack at least 12 in., and preferably 18 in., off the ground (Fig. 1).

Rubbish and weed growth under stacks will retard drying. Ground must be kept clean and sprayed with weed killer if required. Weeds and rubbish also increase the fire risk.

Drainage is vital to proper drying. Stack foundations sink in wet ground, vehicles become stuck, and access to stacks is restricted if water lies around. This factor is often overlooked in the choice of a drying area for a treatment plant (Fig. 2).

Yard hygiene is largely a matter of rubbish removal. Bark and wood waste encourage permanent fungus and insect populations, so their removal is essential. Also, hardwoods with *Lyctus*-susceptible sapwood must be treated as soon as possible, and even then some spraying of the stacks may be necessary.

In some countries the time of cutting of softwood poles and posts is restricted because of the risk of fungal attack in autumn and winter, but the use of covered drying stacks is a much more attractive alternative for Australian conditions.

Yard layout is important even in small plants. Drying stacks set too close to each other will restrict drying and contribute to the spread of insects or fungus. The worst effect of unplanned layout is that far too much time and effort are wasted in moving material. Time and motion studies may be unpopular to some but they can make a big difference to the profitability of a treatment plant.

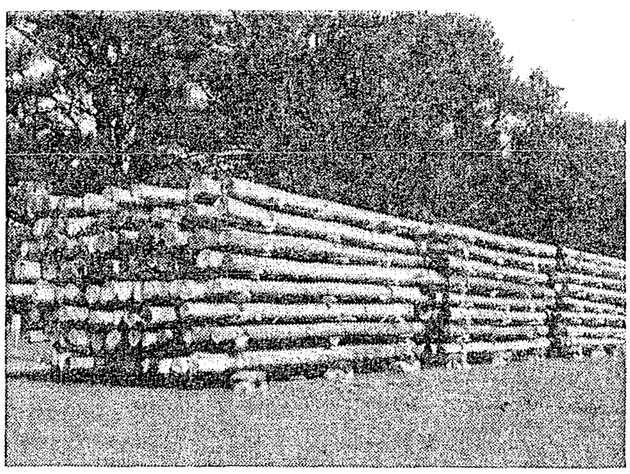

Fig. 2.—Good pole stacking, but foundations may sink in wet ground.

Stock records are not difficult to keep and without them the operator must rely on memory to identify his material. Premature treatment of green timber or insect attack and decay in old stacks may result if each stack is not clearly labelled.

Of course it is essential to exercise proper control of the treatment process itself, but this is usually checked by the preservative supplier, the customer's inspectors, or the appropriate State authority. Incorrect solution strengths or other errors in treatment can be detected and if corrected quickly are less likely to cause faulty treatment.

Although this article covers only pretreatment practice, its purpose is to remind operators of some points that can easily be overlooked. If it appears to over-emphasize the treatment of posts and poles it must be remembered that these still form the bulk of the industry's output and they are more and more in the public eye.

The Division's Annual Report—A Résumé

Part I

THE ANNUAL REPORT of the Division of Forest Products for 1965–66 was released during October. Whilst it is not possible to print the entire report in the Newsletter, readers will no doubt be interested in a summary of its main points.

General.—As announced in an earlier Newsletter, Mr. R. W. R. Muncey became Chief of the Division in March 1966, and Dr. W. E. Cohen was subsequently appointed Assistant Chief.

The Division's new building was occupied during the year by the Preservation, Seasoning, and Utilization Sections. It is largely a wooden structure, details of which were given in the Newsletter of April 1964.

The trend within the timber industry in both technical development and increasing awareness of the need for technological training has been most encouraging. The Division has been active in fostering this in many ways over the years.

During the year under review, the Division has answered some 15,000 enquiries. Whilst the majority of these have been handled immediately, there are always some that require specialist attention, thereby diverting a considerable amount of staff time from research.

Donations from wood-using industries have continued to afford valuable assistance to the Division by facilitating the acquisition of specific items of equipment and experimental material. The Plywood Association of Australia (formerly the Australian Plywood Board) has continued its support, as has the pulp and paper industry.

In October, the Division was host to a meeting of three Working Groups of Section 41 (Forest Products) of the International Union of Forestry Research Organizations. The formal meeting lasted two weeks, during which time 66 papers were presented and discussed by some 40 delegates from 16 countries.

The Division has continued to give active support to the Standards Association of Australia by representation on several Committees and particularly by assisting in the preparation of various specifications, codes of practice, and grading rules.

The policy of supporting education in the forest products field has been continued and Divisional Officers have given lectures to undergraduate and graduate students. Courses on wood technology have been prepared and the timber seasoning correspondence course has continued to provide a service to industry.

During the calendar year 1965, 49 scientific publications including four Technological Papers were issued. An Australian patent concerning improvements related to wood preserving media was also issued.

Physiology and Microstructure (formerly Wood and Fibre Structure).—Further work

Continued on page 6

SHRINKAGE AND DENSITY OF AUSTRALIAN AND OTHER SOUTH-WEST PACIFIC WOODS

The value given in the first line is the species mean (i.e. the mean of tree means). In the second line the probable range for individual results is given. B.R., before reconditioning; A.R., after reconditioning; Tang., tangential; Rad., radial.

Note.—These tables will be concluded in next month's Newsletter. The introduction and first instalment appeared in August (Newsletter No. 332).

Species	Density (lb/cu ft)			Shrinkage (%)					
		Air-dry		Unit A.R.		Green to 12% Moisture Content			
						Tang.		Rad.	
	Basic	B.R.	A.R.	Tang.	Rad.	B.R.	A.R.	B.R.	A.R.
NON-EUCALYPTS (*Continued*)									
PINE, BLACK Qld.	24·6 21·6–26·7	29·3 26·5–32·2	29·2 26·4–32·2	0·21	0·16	3·8 2·6–5·0	3·6 2·5–4·7	1·7 1·2–2·3	1·6 1·1–2·2
PINE, BUNYA Qld.	23·9 19·2–28·2	28·6 22·0–34·4	28·3 21·6–34·4	0·23 0·16–0·30	0·11 0·05–0·16	4·0 2·1–5·9	3·9 2·0–5·7	2·1 1·0–3·0	2·1 1·0–3·0
PINE, CELERY-TOP Tas.	34·2 27·1–42·6	40·3 32·0–49·6	40·2 31·6–50·4	0·19	0·12	3·4 2·3–4·8	3·1 1·6–4·8	1·6 0·7–2·5	1·6 0·5–2·7
PINE, CYPRESS, WHITE N.S.W., Qld., Vic.	35·8 30·2–42·4	42·1 35·6–50·2	41·7 34·4–47·4	0·28	0·23	2·8 1·8–4·1	2·1 0·2–4·3	2·1 1·3–3·5	2·1 1·3–3·1
PINE, HOOP Qld.	27·3 21·7–31·5	33·0 25·7–38·1	32·8 25·6–38·0	0·23 0·16–0·32	0·18 0·09–0·27	3·8 2·4–5·0	3·6 2·2–4·8	2·5 1·4–3·5	2·5 1·5–3·6
PINE, KING WILLIAM Tas.	21·5 16·3–27·9	25·5 19·6–32·4	25·5 19·1–33·4			4·0 2·8–5·2	3·7 2·5–5·2	1·5 0·8–2·3	1·7 0·7–2·8
PINE, KLINKI New Guinea	24·0 18·6–29·0	28·1 22·4–33·5	28·0 22·4–33·4	0·25 0·18–0·32	0·16 0·10–0·21	4·0 2·2–5·8	3·7 2·2–5·4	2·2 0·8–3·6	2·2 0·9–3·6
PINE*, LOBLOLLY Qld.	32·4 25·2–39·6	39·2 29·8–48·7	39·5 30·2–48·9	0·31 0·22–0·39	0·21 0·13–0·30	4·6 3·5–5·7	4·8 3·7–6·1	3·1 1·6–4·6	3·6 2·1–5·1
PINE*, MARITIME W.A.	30·6 26·5–34·8	37·2 32·0–42·5	37·2 31·9–42·6	0·25 0·19–0·32	0·18 0·14–0·21	5·0 3·7–6·4	5·0 3·7–6·3	3·0 2·0–4·0	3·1 2·1–4·0
PINE*, RADIATA Vic., S.A., W.A.	28·0 20·2–36·1	33·9 23·8–44·4	33·9 24·1–44·6	0·27 0·16–0·37	0·19 0·09–0·29	4·8 3·1–6·3	4·6 2·8–6·2	2·9 1·3–4·6	2·9 1·1–4·6
POPLAR, PINK Qld.	25·7 21·1–30·1	30·4 24·9–35·8	30·1 24·6–35·4			4·1 0·5–7·9	3·4 1·4–5·4	1·3 0·5–2·1	1·1 0·5–1·8
QUANDONG, SILVER N.S.W., Qld.	24·6 19·4–28·1	29·3 23·1–33·6	29·1 23·0–33·2	0·24 0·20–0·29	0·11 0·06–0·17	4·3 3·2–5·9	3·7 2·8–5·2	1·4 0·8–2·1	1·3 0·7–2·0
ROSEWOOD, NEW GUINEA New Guinea	31·9 24·4–38·5	36·7 28·0–44·5	36·4 27·9–44·0	0·23 0·14–0·32	0·17 0·09–0·25	1·9 1·2–2·7	1·3 0·5–2·3	1·0 0·3–1·7	0·8 0·1–1·5

* Plantation grown.

Species	Density (lb/cu ft)			Shrinkage (%)					
	Basic	Air-dry		Unit A.R.		Green to 12% Moisture Content			
						Tang.		Rad.	
		B.R.	A.R.	Tang.	Rad.	B.R.	A.R.	B.R.	A.R.
Sassafras (*Daphnandra sp.*) Qld.	30·0 25·0–35·9	37·2 30·5–45·1	36·8 30·1–44·6			7·1 4·9–9·4	6·4 3·8–8·9	2·9 1·2–4·7	2·8 1·2–4·5
SASSAFRAS (*Doryphora sassafras*) N.S.W., Qld.	30·3 25·0–34·4	36·8 29·9–42·3	36·6 29·6–42·2	0·34	0·18 0·11–0·24	5·8 4·0–7·5	5·1 3·4–7·2	2·2 1·2–3·4	2·2 1·1–3·3
SATINASH, ROSE Qld.	35·9 30·1–41·7	44·9 36·0–53·9	43·7 35·7–51·7			7·5 4·1–10·9	5·4 3·6–7·0	3·2 2·0–4·4	2·6 1·7–3·5
SATINAY Qld.	40·2 35·9–44·5	52·3 47·6–57·7	49·5 44·4–54·9	0·35 0·30–0·40	0·17 0·09–0·25	10·0 6·8–13·8	6·4 4·5–8·9	4·4 2·0–6·9	3·0 1·5–4·7
SHEOAK, RIVER Qld.	36·7	47·0	44·1		0·15	9·5 5·2–13·9	5·3 3·6–7·0	3·4 1·0–5·8	1·9 0·7–3·0
SHEOAK, ROSE N.S.W., Qld.	48·6	59·1 47·5–70·9	57·4 44·7–70·5	0·34	0·15	6·6 1·6–11·7	4·0 0·4–7·7	1·6 0·0–3·7	1·1 0·0–2·5
SILKWOOD, SILVER Qld.	26·2 15·2–33·0	32·4 20·4–40·5	32·0 20·3–39·8	0·26	0·13	4·3 2·7–5·8	3·8 2·0–5·6	2·2 1·1–3·2	2·0 1·0–3·0
SYCAMORE, SATIN Qld.	32·3 27·2–37·2	39·0 32·3–45·4	38·9 32·0–45·4	0·24 0·16–0·33	0·21 0·15–0·27	4·5 3·4–5·5	4·0 3·3–4·8	3·0 2·1–3·9	2·8 1·8–4·0
SYCAMORE, SILVER N.S.W., Qld.	31·8 25·6–36·9	39·7 31·7–46·2	39·0 30·2–45·8	0·35 0·19–0·50	0·19 0·08–0·28	7·2 5·2–9·3	6·0 4·2–7·4	3·0 1·4–4·4	2·8 1·1–4·1
TERMINALIA New Guinea	25·8 18·2–32·7	30·7 21·1–39·1	30·5 20·9–39·2	0·27 0·18–0·37	0·17 0·08–0·26	3·7 2·3–4·8	3·6 2·0–4·9	1·8 0·9–2·7	1·8 0·7–2·8
TURPENTINE N.S.W., Qld.	43·1 35·2–49·2	59·0 46·7–68·5	53·8 43·6–62·7	0·35 0·25–0·45	0·23 0·15–0·31	13·0 6·0–18·6	7·7 4·0–11·5	6·5 2·8–9·4	4·0 2·0–5·9
WALNUT, QUEENSLAND Qld.	35·6 30·2–41·0	42·6 36·7–48·6	42·3 36·3–48·3	0·32	0·19 0·12–0·27	4·6 2·1–7·1	4·0 1·9–6·2	2·1 1·3–3·0	2·1 1·2–2·9
WALNUT, YELLOW Qld.	30·4 23·6–35·8	36·5 27·9–43·2	36·0 27·7–43·0	0·27	0·17	3·8 2·6–5·2	3·6 2·5–5·0	2·1 1·2–3·0	2·0 1·1–3·0
WATTLE, HICKORY N.S.W., Vic.	37·3 24·4–46·8	44·4 27·6–56·7	44·0 27·7–55·9	0·29	0·17	3·9 0·6–7·1	3·5 0·7–6·2	1·5 0·3–2·5	1·5 0·5–2·2
WATTLE, SILVER Tas., Vic.	36·4 24·4–51·6	44·3 29·0–63·1	43·9 28·9–62·8	0·34	0·17	6·0 2·5–8·6	5·4 2·6–7·9	2·0 0·5–3·4	1·8 0·7–3·0
YELLOWWOOD N.S.W., Qld.	37·7 28·0–47·0	46·8 34·6–57·6	46·0 34·3–57·0	0·35		5·8 4·6–7·4	4·9 3·4–6·5	3·2 2·3–4·5	2·9 2·1–3·7

on the heritability of wood characteristics has indicated the form of the relationship of heritability with age for ring width, percentage late wood, average tracheid length, basic density, and incidence of grain inclination.

In an investigation of the effect of site on wood characteristics, the availability of soil moisture to the trees has been found to influence the percentage of late wood, and fluctuations in growth rate reduced the average tracheid length.

Specimens from 86 trees of *Pinus pinaster* are being assessed for wood qualities for tree breeding. Results have indicated that there is very little systematic variation of five important wood characteristics with age in the mature wood zone, and hence it should be possible to obtain a reasonable evaluation of wood quality from an examination of wood adjacent to the bark.

In spite of technical difficulties, some success has been achieved recently in an investigation of cell wall changes in collapsed wood and at the inception of fracture in wood.

Further work on the bonding of fibres in a paper sheet, including examination under the electron microscope, has resulted in clarification of the relationship between beating of the pulp and bonding.

An estimation of the porosity of the cell wall has been undertaken to assist elucidation of the path of liquids into wood. In connection with this project, a quartz fibre microbalance that is capable of weighing single fibres has been constructed.

Further investigations have been commenced on the fine structure of the cell wall to determine its influence on wood properties and also to ascertain whether some aspects can be modified advantageously during growth.

Although heartwood forms the major part of most sawn timber, there is little precise information on the manner in which it is formed and the ways in which it differs from sapwood. It is hoped to clarify some aspects of this problem by further work at present being carried out.

Work on wood extractives has been concerned with the study of the influence of the cell contents on the utilization of wood and on the behaviour of the living tree, the possible use of extractives to assist identification and characterization of eucalypts, and the formation of extractives in the tree.

Investigations on the non-cellulosic components (principally lignins) of the cell wall have been continued in order to provide a greater understanding of the nature and location of the materials removed in the pulping process.

Work on lignin has included identification of lignins in different parts of *Eucalyptus botryoides*, transformation of possible lignin precursors in *Eucalyptus* shoots, and an investigation of the influence on lignin of climate over a wide geographical range.

Paper Science (formerly Wood Chemistry, Pulp, and Paper).—The influence of fibre morphology on paper-making properties has received further attention, and the principal morphological effects are now understood well enough to predict the pulping potentiality of a timber species with reasonable confidence. Direct pulping studies are also being pursued on timbers from areas of potential economic interest.

A number of organic substances in the cambial zone of *Eucalyptus regnans* have been identified, with a view to obtaining information on metabolic processes within the stem of the living tree. The application of improved methods of summative analysis has yielded additional information on the components of the cell wall in wood of *Eucalyptus regnans*, *Pinus radiata*, *Acacia penninervis*, and *Gnetum gnomen*.

Work has been directed towards extending the range of usefulness of neutral sulphite semi-chemical pulps from both the old wood and the regrowth material from species such as *Eucalyptus obliqua*, *E. regnans*, and *E. globulus*, particularly by maintaining yield while improving strength and brightness.

Fibres are beaten during the paper-making process in order to improve the strength and other properties of the sheet. As part of a study aimed at improving the efficiency of this procedure, the effect of beating at high stock concentrations has been investigated for both eucalypt and radiata pine pulps. The eucalypt pulps show a much greater response to beating under such conditions.

The extent to which additives, applied for specific purposes to pulp at the wet end of a paper machine, are retained by the pulp fibres is an important economic consideration.

Additive retention has been studied in the systems alum–fibre–water and starch–alum–fibre–water, and significant variables determined. The possible use in paper-making of starch from the burrawang palm has been investigated.

Several sectors of the paper-making process are being studied with the long-range objective of improving product quality and rate of production. Studies are proceeding on the drainage behaviour of pulp, fibre flocculation as it affects paper formation, and the mechanical properties of fibres and paper sheets. The permeability and compressibility of wet fibre pads have been studied in relation to the lateral conformability, or plasticity, of individual fibres, which may be influenced by cell dimensions and degree of delignification.

The electrical properties of fibre surfaces are important in many aspects of paper-making, such as the retention of additives and dyestuffs, the flocculation of fine fibrous material, and drainage characteristics. Techniques for measuring surface potential have been improved and applied to a variety of problems.

The crystal structure of cellulose and other wood constituents has been studied by several physical techniques, including infrared spectroscopy, nuclear magnetic resonance, and X-ray and electron diffraction.

Physics.—Study has continued of the mechanism by which water enters the wood cell wall and causes swelling when the cell cavity is rapidly filled with water. When the wood is initially very dry, swelling of the cell wall takes place within a few seconds. However, if the wood is first conditioned to a high equilibrium moisture content before wetting, swelling may take hours or even days. A theory to account for this behaviour has been proposed. One of the main conclusions has been to show that entry of water into the cell walls is not a simple diffusion process since diffusion is faster at high than at low moisture contents. Instead, it is proposed that the rate of swelling is dependent on swelling stresses created in the cell wall by the water. At high initial moisture contents these stresses are very small and the swelling rate is correspondingly slow. The effects of cell wall thickness, species differences, temperature, and type of liquid have been studied. This work may have important implications in such diverse fields as preservative treatment, the application of soluble glass and other materials to wood surfaces, and the behaviour of stressed wood under changing moisture content conditions.

Creep observations have continued at monthly intervals on 50 beams of scantling size kept under load for the past 10 years, and the effect of seasonal changes has been determined.

While considerable attention has been given in the past to the maximum load wood can support without failing, little is known about the fracture process itself, including the location in the structure where fracture is first initiated, the propagation of cracks through the material, and the conditions favouring failure in certain directions. These aspects are being studied to obtain a better understanding and, eventually, control, both in utilization and in cutting.

A small-scale test of the effect of preservatives on the electrical conductivity of spotted gum (*E. maculata*) has been completed. The main conclusions are that treatment with a proprietary waterborne preservative increases the equilibrium moisture content by about 0·75% and the electrical conductivity of the sapwood by 1·5 times at about 16% moisture content and by 4 times at 60% moisture content.

The Preservation, Seasoning, Engineering, Utilization, and Plywood and Gluing Sections will be covered in the next issue of the Newsletter.

DONATIONS

The following donations were received by the Division during September:

A.C.I. Ltd.	$100.00
Kauri Timber Co. Ltd.	$400.00

Materials

Austral Engineering Supplies Pty. Ltd., N.S.W.
Special cam for automatic saw sharpener .. .. approx. $17.00

Fishers Korumburra Pty. Ltd.
80 untreated fence posts approx. $18.00

Freespan Pty. Ltd.
2 roof trusses .. .. approx. $44.00

Natural Durability Ratings

By N. Tamblyn,
Officer-in-Charge, Preservation Section

IN NEWSLETTER NO. 324 (November 1965), a table was published showing various properties of the more important structural timbers used in Australia. In one column of this table a natural durability rating was given according to a system used by this Division for many years to express approximate relative resistance to a combined decay and termite hazard.

Our attention has been drawn to the need for some further explanation of this durability classification, of its limitations, and of the need for care in its interpretation.

Before any explanation is made, it should be emphasized that no classification can hope to be precise where it deals with a naturally variable material such as wood exposed to a wide range of hazards. Actually for any timber species, durability may vary quite widely from tree to tree and also within the tree, the outer heartwood often being considerably more durable than the wood near the centre. Hazards also vary greatly from place to place and identical use involving exposure or ground contact at Melbourne, Alice Springs, and Darwin cannot be expected to produce identical results. The hazard also varies greatly with the type of use, and timbers such as Douglas fir, mountain ash, silky oak, etc. that have low durability in the ground may give excellent service in window joinery or other semi-protected use. Also, where there is a marked difference between the decay and the termite resistance of a timber, its service life can be very dependent on the relative severity of these hazards.

The rating system for natural durability used by this Division refers to the expected performance of *heartwood when used in ground contact*. This is an average expectation for average quality commercial timber under average temperate conditions, which may be regarded as approximately the average of Australian capital city climates. It should be noted particularly that moderate or low durability in ground contact does not indicate unsuitability for other uses where the hazard is lower. However, it does indicate that these timbers cannot be expected to give long life if subjected to any severe conditions of service.

When applied to heartwood in ground contact, such as a sawn fence post without preservative treatment, the four durability classes recognized have approximately the following meanings.

Class 1.—Timbers of the highest natural durability which may be expected to resist both decay and termite attack for at least 25 years and sometimes 50 years.

Class 2.—Timbers of high natural durability which may be expected to have a life of about 15 to 25 years.

Class 3.—Timbers of only moderate durability which may be expected to have a life of about 8 to 15 years.

Class 4.—Timbers of low durability which may last from about 1 to 8 years. These timbers have about the same durability as untreated sapwood, which is generally regarded as Class 4, irrespective of species.

SCAFFOLD PLANKS

IN RECENT YEARS timber merchants in Australia have experienced increasing difficulty in obtaining timber for the manufacture of scaffold planks. This has been caused by the increased demand in Australia for Douglas fir, and by reduced supplies of higher quality material of this species from Canada and the United States.

The Division, therefore, has started a project to ascertain whether local plantation-grown softwoods, such as radiata pine and hoop pine, are suitable for this application.

In the past, scaffold planks have been single boards, air-dried to a suitable moisture content and sawn to size. In the present experimental study, small sections (3×2 in. and 4×2 in.) of kiln-dried pine have been laminated along their length with a waterproof adhesive to form a small number of individual boards. Treatment with a water-repellent wood preservative has been given to extend the service life under rigorous exterior conditions.

Strength tests have been carried out on planks of various thicknesses, and weathering tests are now in progress to assess the effect of exposure. It is hoped that service trials will be undertaken in the near future.

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The Division's Annual Report—A Résumé
Part II

Preservation

FIELD TESTING of wood preservatives has continued to be a major project. The large test at eight sites extending from New Guinea to Victoria and including over 6000 test stakes has been inspected for the first time. This has shown that the sites were well chosen and that the new inspection procedure is satisfactory.

Tests of treated sleepers and poles in Queensland were also inspected. The north Queensland pole test has indicated that commercial preservatives can provide satisfactory protection against the giant northern termite (*Mastotermes*) if used in sufficient amounts in pressure treatments.

Further marine borer tests are planned to examine the effect of timber species as a result of anomalous results from the present test.

The fire resistance of round fence posts treated with copper–chrome–arsenic preservatives has been criticized following the severe fires in Victoria in 1965. A survey is being made to determine whether this criticism is justified, and experimental work aimed at improving fire resistance is being carried out.

The effectiveness of boron compounds as preservatives against termites is being further examined in field tests where leaching is prevented under conditions simulating use in buildings. A survey of the incidence of termite attack in Melbourne and suburbs is still in progress. It has already proved valuable in advising builders and architects of the precautions necessary in various localities.

Improvement in the termiticidal properties of creosote is desirable under certain circumstances, and, to meet this requirement, work has continued on the incorporation of arsenic trioxide in Australian creosotes. It has been found that the arsenic is well distributed in the wood treated with arsenical creosote and that it is very resistant to leaching.

Studies of the factors affecting penetration of preservatives into wood have continued, with emphasis on the retention and distribution of creosote in the sapwood of some eucalypt pole timbers.

As much of the exterior and marine-grade plywood in Australia is made from relatively non-durable species, further attention has been given to development of a fixed preservative suitable for dip-diffusion treatment of green veneer.

Accelerated testing of preservatives by laboratory bioassay techniques has continued to be an important project, and further work has been done on the organo-tin preservatives.

It has now been confirmed that the fungus *Fomitopsis annosa* is present in Australia on hoop pine stumps in both Queensland and northern New South Wales.

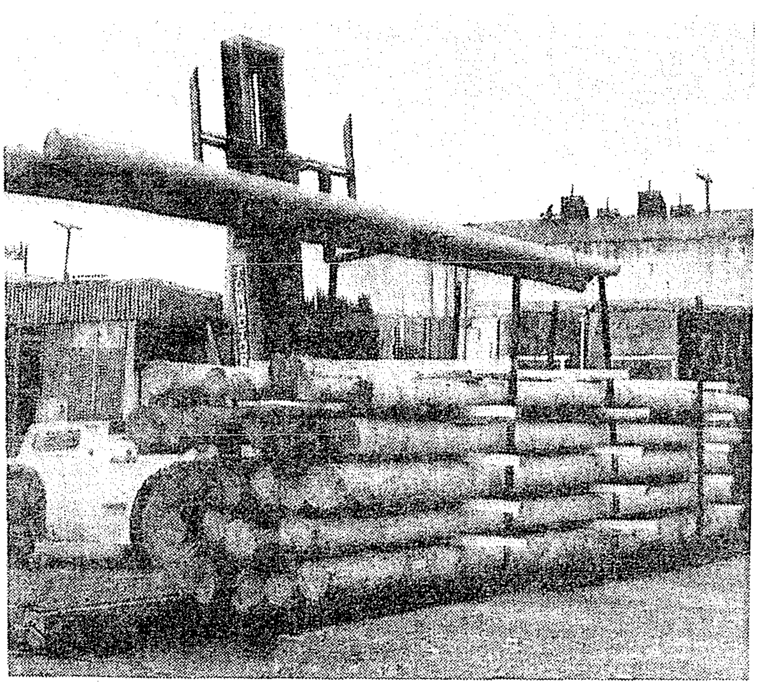
Tests of *Lyctus*-susceptible timbers used in plywood in which the glue line had been treated with a preservative have now been in progress for 20 years, and have confirmed the effectiveness of this form of protection.

Engineering (formerly Timber Mechanics)

Determination of the mechanical properties of timbers has continued, some 80 New Guinea species, 25 Fiji species, and 7 British Solomon Islands species having been tested during the year. The information on the New Guinea species has been published as a Technological Paper of the Division. Testing of immature messmate stringybark (*Eucalyptus obliqua*) from Tasmania has also been carried out as part of a study of the conversion and utilization of this material.

There is considerable interest by industry in design data for the use of timber in general structural work, and many enquiries in this field have been answered. A proposed new strength grouping of structural timbers has been published, based on the much greater fund of knowledge of the properties of Australian timbers than was available 30 years ago when the original strength-grouping system was introduced.

Much time has been devoted to the preparation of tables of allowable spans for structural members in timber buildings. This work is in connection with a Code of Practice for Light Timber Framing being prepared by a committee of the Australian Standards Association. This work has been facilitated by the use of a computer.



30-Ft radiata pine poles assembled for an experiment on accelerated drying at high temperature in a commercial kiln.

Efforts to define the relationship between load and deformation in a nailed joint under short-duration loading have proved successful. A basic load–deformation curve, independent of species and nail diameter, has been described in an empirical form for joints in compression or tension.

A comprehensive investigation of the characteristics of metal-toothed plate connectors in Australian timbers has been commenced, as also have long-duration loading tests of trusses fabricated, using these toothed plate connectors. The object is to develop a satisfactory procedure for analysing and designing these structural units, with due allowance for the effect of deformation of the joints and members on the total truss deflection.

A study is being made of the influence of the size of gum pockets and incidence of gum veins on the bending and shear strength of scantlings of messmate stringybark, to decide whether some relaxation of the grading rules relating to these defects is justified.

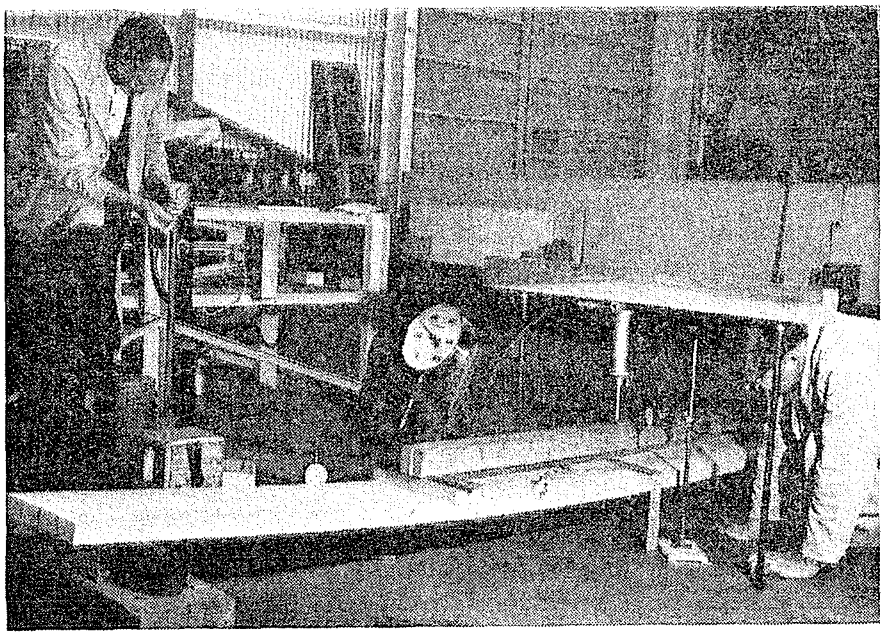
A number of experiments have been made on plywood to examine the influence of a variety of defects on the structural performance of this material.

In a cooperative project with the Commonwealth Experimental Building Station, the effect of fire on large timbers is being investigated. Of particular interest is the strength of the unburnt core portion remaining after a structural member has been subjected to fire.

Seasoning

Investigations on the air seasoning of sawn timbers have been continued, with the dual aims of establishing basic design criteria for air-seasoning yards and improving industry practices. Conservative estimates suggest that major savings in stock requirements, capital investment, and drying cost should result. The project consists of two parts, viz. yard studies on stacks of commercial size, and laboratory studies on scale-model stacks under simulated field conditions in the Division's low-speed wind tunnel.

Field tests were also commenced to determine the suitability of plastic stack coverings during air seasoning, their effect on the dried quality of protected sawn boards, their comparative life, and the economics of one-service ("throw-away") *versus* multiple-service thicknesses.



Proof-testing laminated radiata pine scaffold planks. Laminating tends to upgrade building-grade pine for this exacting use.

The drying of round timbers has always proved a problem with a number of Australian species, and has rendered otherwise excellent material unacceptable for this purpose due to excessive drying degrade. Studies have commenced on pole timbers of karri (*Eucalyptus diversicolor*), manna gum (*E. viminalis*), alpine ash (*E. delegatensis*), and mountain ash (*E. regnans*), and other studies are planned for blackbutt (*E. pilularis*) and rose gum (*E. grandis*). Results so far suggest that a boultonizing treatment will not only dry these difficult timbers to good final quality, but will also complete this process in a fraction of the time required by air drying.

Field exposure tests have also been continued on 80 air-dried and boultonized, untreated, and preservative-treated karri, mountain ash, alpine ash, and manna gum poles to determine susceptibility to after-treatment splitting in service. Those boultonized or creosote-treated showed little deterioration, whereas the untreated controls showed severe barrel splitting.

The kiln drying of sawn timber has been further investigated, with particular reference to presteaming to accelerate drying methods and to improve drying behaviour, the determination of kiln schedules, and the control of checking — an increasing cause of impaired productivity and excessive cost to industry.

Improvement of dimensional stability of wood is an important continuing project, and further work on collapse and recovery has been carried out, particularly with regard to the mechanism of reconditioning and recovery.

In order to provide a better understanding of the seasoning process, work has been resumed on the fundamental aspects of the movement of moisture in wood.

The equilibrium moisture content project, the purpose of which has been to establish a correlation between the equilibrium moisture content of Australian timbers and the associated microclimate — so that the moisture content reached by seasoned wood in service anywhere in Australia or Papua–New Guinea can be predicted solely from meteorological data — has been completed. The data have been combined into a reference manual.

Plywood and Gluing

The Plywood Association of Australia (formerly Australian Plywood Board) has continued to subsidize the work of the Section. Extensive assistance has been given to the Association in the formulation of a Standard for Constructional Grade Plywood and in efforts to facilitate establishment of industry quality control.

Peeling trials of 12 important species from the British Solomon Islands Protectorate indicated that the majority were potentially suitable for veneer manufacture.

Cinematographic and microscopic studies of veneer formation provided further elucidation of veneer roughness phenomena in parallel-to-the-grain cutting situations and demonstrated the function of the nosebar in controlling roughness.

Studies of the corrosive wear on veneer knives have indicated that, with some species, corrosion can be a dominant cause of knife wear. Knife-edge recession was reduced by maintaining the knife at a negative potential, as high as 60 volts in one case, with respect to the nosebar.

Further work has been done on tannin–formaldehyde adhesives. Studies of phenol–formaldehyde resin and glue formulation in relation to bonding veneer of a high-density eucalypt species have shown that within the formulations used, a range of conditions can be established for optimum bond quality with this species. Drying studies have included work on reconditioning of ash-eucalypt veneers with saturated steam by heat treatment alone, and in a high-frequency field, redrying of plywood treated with copper–chrome–arsenic preservatives and longitudinal shrinkage in veneers. Limited tests were done using surface electrodes for veneer moisture content determination in conjunction with commercial resistance meters.

Other projects include stability studies of plywood panels, particularly in relation to flush doors, dryer control using thermister elements, veneer compression during hot pressing, and fire resistance of plywood (in collaboration with the Commonwealth Experimental Building Station).

Utilization

The problem of utilization of immature regrowth eucalyptus forest in various parts of southern Australia is one of increasing urgency. The utilization potential of this class of material is currently being studied in Tasmania, and data obtained so far are being applied to the prediction of value of sawn timber from different log quality groups. Similar work is planned in Victoria.

Further assistance has been given to industry in the design of sawmills and moulding plants and in recommendations for improvements to existing mills. Additional information on the behaviour of items of sawmilling equipment under various conditions was also obtained and advice on such equipment passed on to industry.

Work on saws and sawing has included a field study of the performance of swage-set circular saws cutting radiata pine, assistance concerning production of circular saws for portable tools, assessment of the potential value of twin-band saws for Australian conditions, and a project aimed at improving the trimming of plywood with circular saws.

Basic cutting research has continued and a relation has been developed between edge bluntness and cutting force. A study of the friction between wood and tool materials has indicated that most species of wood which do not have a high content of greasy extractives show closely similar frictional behaviour in sliding on metals of practical roughness. Further work has also been carried out on the corrosive wear of steel cutting edges.

The effect of tip thickness of finger joints on strength has been extended to include the influence of the side slope. Work on the finger jointing of green timber has been concentrated on experiments to investigate the influence of initial moisture content on drying time of finger joints in the electric flash dryer.

Weathering tests on painted and unpainted finger joints made with PVA adhesive have been continued, panels now having been exposed for up to four years.

Technical advice was given to committees preparing standards for timber and manufactured timber products.

Course for Sawmill Executives

DURING early November, the Division conducted a course on Equipment and Practices in the Sawmilling Industry.

Designed to draw attention to improved techniques and equipment for timber production, the course was attended by 34 executives of sawmilling companies throughout Australia.

During the first week, the group had three days of lectures at the Division and one day trip to Victorian mills, after which they proceeded on a 2500-mile tour to inspect mills in eastern Victoria and southern New South Wales.

Due to the tremendous interest in this topic, it is proposed to conduct another course early in 1967.

PLANT GUMS

By C. M. Stewart, Paper Science Section

THE WORD "gum" has been used, in a general sense, to describe any of various materials which exude to the outside of plants. Many eucalypt trees exude so-called gums of a red to dark reddish brown colour — hence their designation as "gum" trees. The material exuded is in fact a kino which is composed of tannin-like substances. For example, Botany Bay kino (known also as red gum or eucalypt gum) has been collected for many years from river red gum trees (*Eucalyptus camaldulensis*, syn. *E. rostrata*) and from trees of several other eucalypt species; the kino has been used as a base for lozenges. In view of the above considerations, and of the definition of gums given below, the term "gum tree" is really a misnomer.

In the more specific sense, gum is defined, in Webster's Dictionary, as "any of numerous colloidal polysaccharide substances that are gelatinous when moist but harden on drying, that are exuded by plants or extracted from them by solvents and either soluble in or swelling up with water, and that are salts of complex organic acids yielding hexuronic acids and aldoses on hydrolysis". Certain gums yield either only aldoses (e.g. guar gum) or only hexuronic acids (e.g. alginic acid) during acid hydrolysis. The above specific definition applies to the gums that are described in this article.

Plant gums have been utilized for many centuries. For example, gum arabic (also known as gum acacia), the exudation from one or more species of the genus *Acacia*, has been used as an article of commerce for more than 4000 years and is now consumed at an annual rate in excess of 50,000 tons.

In Australia, small quantities of gums have been collected and marketed for more than 100 years. Many of the gums collected were wattle (*Acacia*) gums, which are usually rather dark in colour, astringent in flavour, and not completely soluble in water. These undesirable properties and the ever-increasing cost of collection have eliminated most wattle gums from commercial consideration. However, if the quality of a gum is sufficiently good, its collection may be economically feasible; thus, during recent years, manna gum has been collected in limited quantities from *Acacia microbotrya* trees of Western Australia, and has been sold for up to $600 per ton. Today, manna gum is collected from residual areas of trees on private property and along road verges. Before settlement the trees were plentiful throughout the wheat belt, especially in a zone from Toodyay to Katanning where the rainfall is from 16 to 22 in. a year.

In general, gums are exuded by trees grown under adverse conditions brought about by excessive heat and lack of moisture, the actual exudation often being associated with insect and other wounds. It is thought by some investigators that gum exudation is a means of providing a sealant to protect injured portions of the plant against the entry of air, fungi, or bacteria. The sugar units incorporated in the gum are often similar to those that are normally produced by high metabolic activity during the biosynthesis of the polysaccharides which are laid down in the initial walls of growing cells.

Originally, the Sudanese collectors of gum arabic obtained gum tears from natural exudations. However, about 60 years ago the collectors obtained large increases in yields of gum as a result of artificial wounding (tapping) of *Acacia* trees. The wounding is done soon after the beginning of the dry season when the leaves show signs of withering. The collectors use a small axe to make a horizontal cut, about 1½ in. wide, through the bark. Wounds 2 to 4 ft long are formed by peeling off strips of bark both above and below the axe cut. During a period of 1 to 2 months, the gum exudes slowly to form tears (½ to 3 in. in diameter) which gradually dry and harden. Sometimes the gum tears are bleached by exposure to the sun for several weeks.

Most Australian gums have been collected as tears formed from natural exudations. Artificial wounding of suitable plantation-grown species of *Acacia* and other plants may provide economic yields of gums in Australia, especially if the soil moisture content is controlled by means of irrigation. However, much experimentation would be necessary before the establishment of a gum production project on a sound economic basis.

Acacia microbotrya (badjong or manna wattle), *A. saligna* (western wreath wattle), and *A. penninervis* (hickory wattle) yield light-coloured gums, which, like gum arabic, have a bland and mucilaginous taste and are completely soluble in water. *Flindersia maculosa* (leopardwood) and Tasmanian *Acacia dealbata* (silver wattle) give tasteless, light-coloured, water-soluble gums. *Brachychiton populneum* (kurrajong) yields a light-coloured, tasteless, and partly soluble gum that is similar to karaya gum from India. *Acacia deanei* (Deane's wattle), *A. mearnsii* (black wattle), and *Owenia acidula* (emu apple or gruie) produce dark-coloured gums that are partly soluble in water. The gums of *Acacia harpophylla* (brigalow) and *A. pycnantha* (golden wattle) are water-soluble but have an astringent taste due to the inclusion of tannins. The first six gums listed above may possibly have some future commercial usefulness.

Gums are used in the manufacture of adhesives, beverages, confectionery, cosmetics, drilling fluids, emulsions, food products, inks, paper, pharmaceuticals, photographic materials, textiles, and many other items. Guar gum production would probably be worth while in Australia; the gum, which has extensive use in the paper and other industries, is milled from the seed of *Cyamopsis tetragonolobus* or *C. psoraloides*. This legume grows to a height of about 2 ft and is suited to large-scale cultivation. It is grown for the economic production of guar gum in south-western U.S.A. The guar beans must be harvested before any rain falls after the first frost. Many synthetic "gums" are now being produced and, to some extent, are tending to replace the natural plant gums.

The coastal waters of Australia are a source of useful products. During past years, certain Phaeophyceae (brown seaweeds) have attained some economic importance. For example, potash has been produced from *Macrocystis* and *Ecklonia* species in Tasmania, and alginates (plant gums composed almost entirely of base units of two hexuronic acids, namely, mannuronic and guluronic acids) of good quality have been made from *Macrocystis* in Tasmania and from *Ecklonia* in New South Wales.

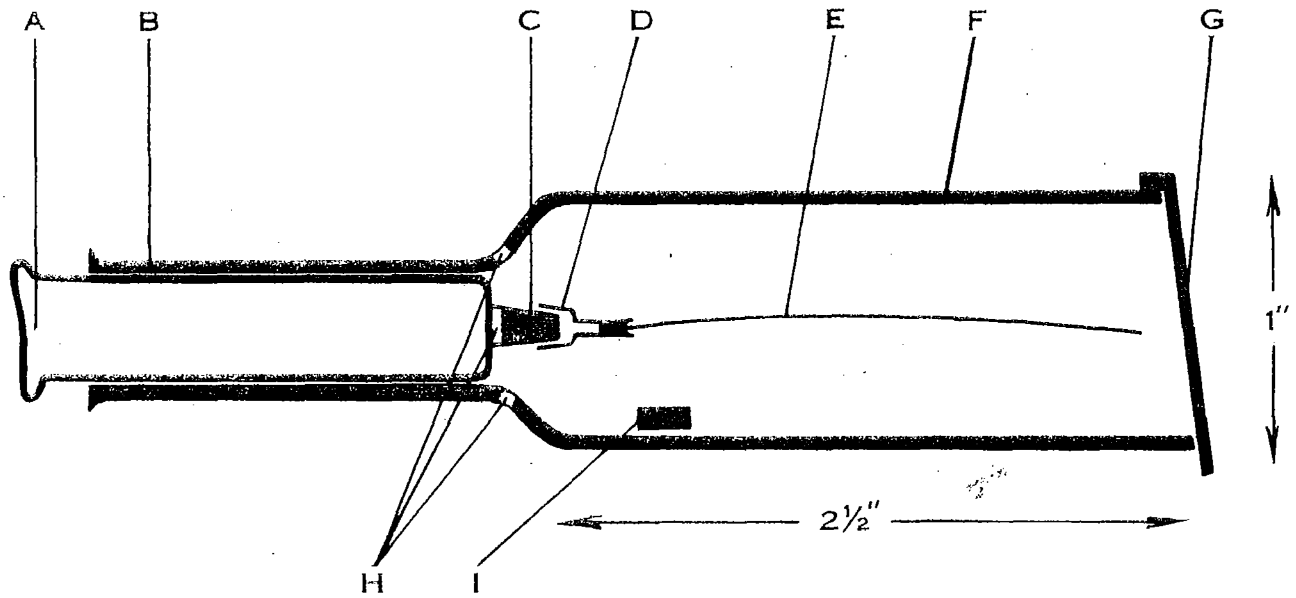
During the past few years, an alginate industry, based mainly on the giant kelp (*Macrocystis pyrifera*) that thrives in the waters around Tasmania, has been established. The kelp grows to the ocean surface and those portions of the plants which are contained within the upper few feet of water are harvested at suitable intervals. The alginic acid is extracted from the seaweed by an aqueous alkaline solution and then processed into products suitable for industrial use.

A Sensitive Microbalance for Weighing Single Fibres

By D. S. Skene, Physiology and Microstructure Section

The porosity of the cell wall is a major factor influencing the seasoning and preservative treatment of wood, and is, therefore, a matter of wide interest amongst wood technologists. The densities of the components of the cell wall are known quite accurately, thus cell wall porosity can be calculated from its density. Determining density involves making two measurements — weight and volume — and it was decided to use two methods of "weighing" the cell wall, one being an optical method using polarized light, and the other weighing individual wood fibres on a specially constructed microbalance.

The balance is similar to one designed by O. H. Lowry, of Washington University Medical School, and its construction and action are aptly described by the term "fish pole" balance. It consists of a thin quartz hair firmly fixed at one end. The material to be weighed is placed on the other end and its weight is determined by measuring the deflection of the hair with a microscope. The use of the balance, therefore, falls into three parts — construction, measurement of hair deflection, and calibration.



Section through the completed microbalance.
A, *Glass plunger*, B, *glass barrel*, C, *glass needle mount, all from a hypodermic syringe;* D, *hypodermic needle, cut off short;* E, *quartz hair — mounted in needle* (D), *using sealing wax;* F, *case of glass tubing* (*aluminized internally*)*;* G, *clear glass lid, fits ground end of case;* H, *parts glued with epoxy resin;* I, *pellet of radioactive material.*

Construction

The quartz hairs were made by heating the middle of a quartz rod to white heat and pulling the ends apart very quickly. This draws out a fine hair, and in this instance a piece about 0·002 in. in diameter (slightly finer than a human hair) and about 2½ in. long was selected.

The rest of the balance consists of a case to protect the hair from draughts, and a mount to hold the hair in position. The complete balance is illustrated in the diagram. The case consists of a glass tube, the inside of which is aluminized, and contains a small amount of radioactive material to prevent the build-up of electric charges which might otherwise occur. One end of the case is covered by a removable glass lid through which the hair is observed, and the other consists of a mount for the hair.

The mount for the hair was made from an all-glass hypodermic syringe with interchangeable parts, modified as shown. This method of mounting has two advantages: different sizes of hair can be readily interchanged; and a hair can be put into a convenient position by bending the needle in which it is held and by moving the piston.

Measurement of Fibre Deflection

Deflection of the quartz hair could be measured to a precision of 0·0015 mm (0·00006 in.) using a microscope. Precision of this order requires a firm mounting, and this was achieved by turning the arm of the microscope to a horizontal position and clamping the microbalance horizontally in place of the stage.

Calibration

The microbalance was calibrated using a colorimetric method in which small crystals of fluorescein were placed on the hair and the deflection was measured. The fluorescein was then dissolved in a small quantity of 1% sodium carbonate solution and the amount of light it absorbed was measured accurately using a spectrophotometer. These results were then compared with a series of solutions of which the strengths were known accurately, and the final result was a graph showing the deflection of the hair against weight of material placed on it. The deflection was of the order of 0·610 mm/μg*, and the balance performed satisfactorily for the range of fibre weights involved, namely 0·04–0·1 μg.

* 1 μg = 1 millionth of a gramme.

SHRINKAGE AND DENSITY OF AUSTRALIAN AND OTHER SOUTH-WEST PACIFIC WOODS

(Final instalment)

Species	Country of Origin	Density (lb/cu ft)			Shrinkage (%)					
		Basic	Air-dry		Unit A.R.		Green to 12% Moisture Content			
							Tang.		Rad.	
			B.R.	A.R.	Tang.	Rad.	B.R.	A.R.	B.R.	A.R.
III. SPECIES IMPORTED INTO AUSTRALIA*										
ASH, JAPANESE	Japan				0·31†	0·17				
BALTIC, RED	N. Europe		30				4·4		2·1	
BALTIC, WHITE	N. Europe						8·1‡		4·0	
Beech, Japanese	Japan				0·41†	0·18				
CEDAR, WESTERN, RED	U.S.A.		22				2·2		1·1	
FIR, DOUGLAS (COAST)	U.S.A.		34				7·6		5·0	
Hemlock, Chinese	Taiwan	27·8 22·3–33·2	32·8 25·8–39·8	32·8 25·8–39·8	0·29 0·23–0·35	0·16 0·07–0·25	3·4 1·8–5·1	3·2 1·3–5·2	1·9 0·5–3·2	2·1 0·9–3·3
Jelutong	Malaysia		29				1·5		1·0	
KAPUR	Malaysia		49				5·3		2·6	
KAURI, FIJIAN	Fiji	28·2 22·5–33·9	33·9 26·5–41·4	33·9 26·5–41·3	0·25 0·18–0·32	0·19 0·09–0·28	4·1 3·1–5·2	4·0 3·1–4·8	2·7 1·3–4·1	2·8 1·6–4·1
MAHOGANY, AFRICAN	W. Africa		31				2·5		1·8	
MERANTI, RED	Malaysia	32·5	40·3	38·7	0·30	0·17	7·7	4·4	2·2	1·8
OAK, JAPANESE	Japan				0·35†	0·19				
PINE, PARANA	Brazil, Argentina		35				7·9		4·0	
Pine, patula	S. Africa, Kenya		23				5·3		2·3	
PINE, SUGAR	U.S.A.		25				3·4		1·8	
REDWOOD	U.S.A.		28				2·2		1·3	
RIMU	N.Z.		37				4·1		2·2	
SAPELE	W. Africa		40				3·3		2·1	
Seraya, white	Malaysia, Borneo	28·4	34·2	33·5	0·30	0·18	5·1	3·6	1·9	1·6
TEAK	Burma, India		43				2·2		1·2	
Walnut, African	W. Africa		34				3·3		1·7	

* These species are taken from various sources and are believed to be the best available. They are not, however, in most cases, based on tests carried out in this laboratory.

† Before reconditioning. ‡ Green to oven-dry.

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