CSIRO

Forest Products Newsletter

DIVISION OF FOREST PRODUCTS, CSIRO, P.O. BOX 310, SOUTH MELBOURNE, S.C.5, VICTORIA

REGISTERED IN AUSTRALIA FOR TRANSMISSION BY POST AS A PERIODICAL

NUMBER 337 JANUARY–FEBRUARY 1967

1967##337

Bonding High Density Wood Species with Resorcinol Formaldehyde Adhesives

By J. W. Gottstein and K. F. Plomley, Plywood and Gluing Section

STRONG, RELIABLE, waterproof bonds using low temperature setting, non-creeping adhesives are difficult to obtain in high density species, yet such bonds are highly desirable for laminated construction work in medium and high density hardwoods where thin laminations could avoid many constructional and seasoning difficulties.

The work reported below is of an exploratory nature only, but indicates a simple method by which more reliable bonds can be made. Further investigation is necessary, especially in development of working techniques, but the exploratory work at this stage seems worth reporting because it may be of immediate value in some applications.

The effects of varying adhesive formulation, priming of the wood surfaces with low solids resins, surface "grooving" and sanding, moisture content, assembly time, and other variables were studied in the bonding of several high density species, using resorcinol formaldehyde adhesives. The species used were spotted gum, blackbutt, karri, and gum-topped box.

In the first experiment the effects of grooving the gluing surfaces, of priming with low solids (20%) resin, and of certain glue formulation variations were examined. Lap joints 1 in. × 1 in. were made from sawn karri specimens $4\frac{1}{2}$ in. × 1 in. × $\frac{1}{8}$ in. The glue was spread on both components and a closed assembly time of 15 min was used throughout.

The test results showed that of the factors examined "grooving" was the most important and gave a very considerable improvement in failing load and wood failure of grooved specimens compared with ungrooved controls. Under one set of conditions using a laboratory resin formulation and where other factors were near optimum, the failing loads (lb) and wood failure (%) of grooved and ungrooved specimens were 978–65 and 691–5 respectively at gluing pressures of 150 lb/sq in and 859–85 and 601–5 at 75 lb/sq in pressure. Priming with low solids resin and varying the glue formulation gave improved bond quality also, but to a smaller extent than grooving.

In a second experiment with lap joints, the effects of sanding (medium-fine F2 paper) and grooving were compared using blackbutt, spotted gum, and gum-topped box and a commercial resorcinol formaldehyde adhesive. The results (Table 1) again show that much higher bond strength and wood failure were achieved with grooved compared with

Table 1

Treatment of Wood Surfaces	Blackbutt	Spotted Gum	Gum-topped Box
Not treated	402—0*		
Sanded both surfaces	531—0	571—0	585—0
Grooved one surface, not treated the other	602—10		
Grooved one surface, sanded the other	729—45		
Grooved both surfaces	785—75	967—85	916—80

* Failing load (lb) and wood failure (%).

ungrooved specimens. Sanding produced only a comparatively small increase in failing load.

In both experiments the grooves were made manually in the direction of the grain on a machined (planed) wood surface by using a thread "chaser" of 48 threads per in. Whitworth form. The chaser cut was repeated until full thread depth was obtained. This thread form groove is very different in shape from the form produced by the old "toothing" plane knife and gives greater bond area. The grooving used ensures better glue retention and may affect the rigidity of the surface. In these tests the thread cuts were not quite straight and, in general, the thread forms meshed only occasionally.

A further test was carried out with blackbutt and spotted gum specimens conditioned to 5% moisture content and grooved with 20 threads per in. The specimens were grooved with a milling cutter to Whitworth thread form and, as a check on the possibility of inactivation (case hardening) during the grooving operation, the surfaces of half the grooved specimens were carefully scraped by hand.

Table 2

Treatment of Wood Surfaces	Blackbutt	Spotted Gum
Grooved	888—71*	980—69
Grooved and scraped	854—72	1007—64

* Failing load (lb) and wood failure (%).

The glue, a commercial resorcinol formaldehyde, was spread on both components. After a closed assembly time of 15 min the specimens were pressed at 75 lb/sq in and left under pressure in a 5% e.m.c. room (temperature 38°C) for 4 days.

The test results (Table 2) again show high failing loads and wood failures with both species. There was no significant difference between specimens which were grooved and scraped and those which were grooved only, indicating no inactivation during groove milling.

In this experiment the grooves were cut so that the coarse thread forms "meshed" when the glue-spread surfaces were brought together. As this condition would not generally occur in practice, the effect of "unmeshed" grooves was examined. To ensure that they did not mesh, the grooves (20 per in.) were cut at an angle of 2° to the long axis of blackbutt specimens so that when assembled the grooves on opposite surfaces crossed at an angle of 4°. The glue and gluing conditions were as before.

The mean failing load using the coarse (20 per in.) grooving with meshing of 9 specimens was 684 lb and wood failure was 59%. This result is somewhat lower than was obtained before with grooved specimens of this species, but it is far better than that obtained with sanded and unsanded specimens. The lower values are possibly attributable to the thicker glue lines.

Table 3

Treatment of Wood Surfaces	Blackbutt	Spotted Gum
Ungrooved	62—0*	1670—0
Grooved	1900—14	2595—25

* Failing load (lb) and wood failure (%). Mean of 6 blocks.

Finally, block shear tests were carried out with blackbutt and spotted gum. Specimens 2 in. $\times$ 2 in. $\times$ $\frac{1}{2}$ in. were conditioned at 5% e.m.c. Half were grooved by hand with a 48 T.P.I. chaser and the remainder were left ungrooved as controls. The glue and gluing conditions were the same as before and the manually cut grooves were more or less parallel but not intermeshing. Test results are given in Table 3. Bond strength was much higher in the grooved than in the ungrooved specimens. Although the wood failures of the grooved specimens are not as high as those obtained before with these two species, the failing loads are particularly high and very close to those of unjointed blocks of the two species.

Bonds were also made with the grain of the specimens at right angles and with 48 grooves to the inch, and comparable improvements in joint strength and wood failure were obtained. Joints of various widths with grain (and grooves) at right angles are being submitted to humidity cycling. There are indications that the hygroscopic forces developed during severe moisture-content cycling in glue joints with the grain in the plane of the joints at right angles in these dense species may lead to failure in service.

Summarizing these results, fine grooving of the gluing surfaces in the grain directions has been shown to give very considerable improvement in failing load and wood failure with a number of high density species when bonded with resorcinol formaldehyde adhesives. On the other hand sanding produced only a comparatively small increase in failing load. There does not appear to be any surface inactivation when the grooving is done with a milling cutter, nor is it necessary for the grooves on the two surfaces to "mesh" when fine thread forms are used. Both 20 and 48 threads per in. Whitworth form, the finer thread form being the more tolerant, appear satisfactory, but the optimum grooving has not yet been established.

In addition to grooving, moisture content control also appears to be important, and some improvement is achieved by varying the glue formulation and gluing conditions. However, further work is needed to establish the relative importance of these several factors.

Wood Structure and the Electron Microscope

By G. W. Davies, Physiology and Microstructure Section

SINCE THE INVENTION of the microscope towards the end of the sixteenth century, workers in many fields have used its powers to assist in resolving problems involving all scientific disciplines. Botanists, particularly those studying descriptive anatomy, found the microscope to be of inestimable value, so that it was only a matter of course for microscopy to be the principal tool of early wood anatomists.

Naturally the instrument itself was altered considerably as techniques of optical and mechanical design progressed, so that the modern light microscope will magnify up to 2000 times. Parallel to these advances, the wood anatomist also had the advantages of improved sectioning, fixing, embedding, and staining techniques. As each of these ancillary factors improved with time, so the need for a greater knowledge of the nature of the cell wall grew, and the anatomist found that he needed still greater magnifications to investigate the finer points of cell-wall structure. The great breakthrough came with the invention of the electron microscope in 1932.

The Electron Microscope

The biggest single feature of the electron microscope is the enormous improvement in resolving power over any other form of microscopy. Resolving power or resolution of a microscope means the ability to distinguish separately two points that are very close together.

Electron beams have wave motion like light beams and they can be bent and focused by electromagnetic lenses just as light beams are by optical lenses. However, because of the very much shorter wavelength of the electron beam its resolving power is far greater than that of the light beam, hence much higher magnifications are possible.

Since the electron beam is invisible to the eye, the eyepiece of the light microscope is replaced by a fluorescent screen in the electron microscope. Details of the object

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being magnified may then be examined visually on the screen or photographed directly by removing the screen.

The electron microscope therefore consists basically of a source of electrons (electron gun), electromagnetic lenses to channel the electron beam through the specimen, a fluorescent viewing screen, and a photographic attachment.

Preparation of Material

The preparation of material into a form suitable for viewing in the electron microscope calls for considerable skill and patience, and in some cases is exceedingly difficult. The main prerequisite is that the material be exceptionally thin to allow the passage of electrons. It must also be stable in a vacuum and resistant to electron bombardment. After specimens have been picked up on specially prepared grids, they may be viewed directly in the electron microscope or may first be "shadowed".

"Shadowing" consists of evaporating a heavy metal such as platinum onto the surface of the specimen at an angle. This has the advantage of increasing contrast so that the geometrical relief of the surface is much more apparent (Fig. 1).

There are three ways in which a specimen may be prepared for viewing—direct observation, surface replication, and sectioning.

In direct observation the specimen must be first disintegrated into minute fragments, so this method has great limitations. For example, if parts of a wood fibre wall are to be examined, thin sections of wood are cut, placed in water, and then disintegrated for some time in a homogenizer. The suspension is then allowed to stand until all visible particles have sunk. A tiny drop of the apparently clear supernatant liquid is then placed on a grid and examined in the hope that minute pieces of cell-wall layers will be present. This is clearly a hit-or-miss method, but quite good results can be obtained with patience and perseverance.

Surface replication, as the name implies, limits observations to surface phenomena. A section or chip of wood is pressed tightly against a block of thermoplastic material and heated. An impression of the surface of the

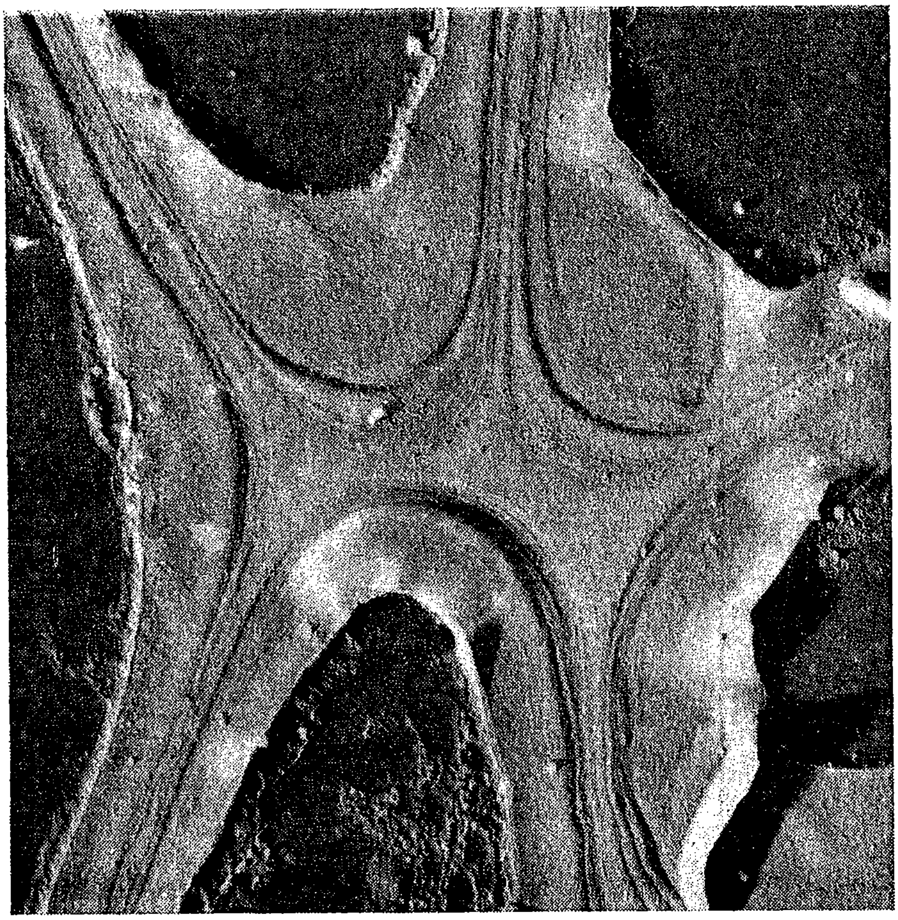


Fig. 1.—Electron micrograph of a thin section of Eucalyptus regnans *showing the cell-wall layers at a corner between five cells. This section has been shadowed with a heavy metal.* ×5000.

wood is produced on the plastic surface and the woody material is then carefully removed. This replica is shadowed with metal and carbon, then the plastic material is dissolved away, leaving a very thin metal–carbon layer which is not only a faithful reproduction of the wood surface, but which is also shadowed for contrast as described earlier. Pieces of replica, 1 mm square, are then picked up on grids and can be examined in the electron microscope. Actually, only a surface impression of the material is seen, which gives no indication of what the structural features below the surface are. For this reason the method has limitations.

Surface replication has one major advantage over direct observation in that parts of the surface can be selected for examination, and much of the early research into the nature of cell-wall layers was done in this way.

Section-cutting by mechanical means has been done for many years. The instrument used is called a microtome. It works on the principle of commercial bread slicers, i.e. slices of desired thickness can be cut off and the specimen block is raised automatically so that the next slice will be of the same pre-set thickness.

Sections from mechanical microtomes can be cut as thin as about 4 microns (0·004 mm), but such sections are about 400 times too thick for electron-microscope examination. It is only in recent years that suitable ultra-microtomes have been devised that will cut sections as thin as 0·01 micron (0·00001 mm or 1/2,500,000 of an inch). The cutting is done with glass or diamond knives and the specimen block is fed forwards by thermal expansion of the block holder. The pieces of material used must be very small and in order to hold them in a suitable clamp they must first be embedded in a plastic material. Epoxy resins have been found to be very suitable for this purpose. The specimens used can be pre-stained if required, or, after mounting on grids, the plastic can be dissolved out and the specimen then shadowed with metal as described earlier.

This technique of ultra-thin sectioning opened up new fields to the electron microscopist, making it possible to examine the fine structure of the cell wall across its entire thickness. Also, suitable fixatives were found so that the cell contents, or cytoplasm, could be "fixed" or permanently preserved in a condition closely approximating to that of the living material. As may well be imagined, these new methods have been of tremendous value in all fields of research.

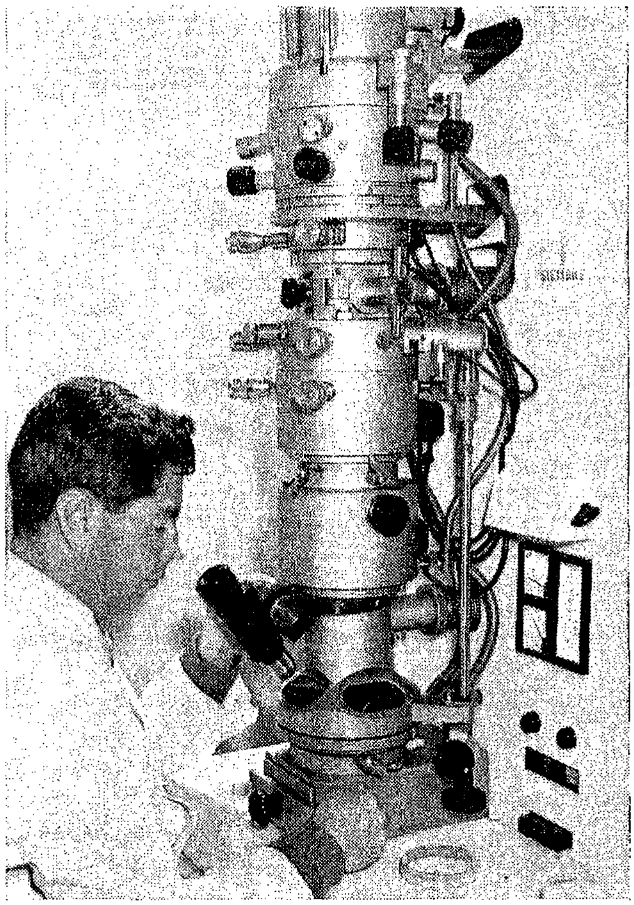


Fig. 2.—The Division's electron microscope. The specimen is inserted near the top of the instrument and is viewed through the telescope at the base. The camera is below the viewing screen.

Role of the Electron Microscope in the Division's Research

The Division has had two electron microscopes and much of the early work on lignification and cell-wall structure was done with the original instrument using replica and direct observation techniques. Since the installation of a Siemens Elmiskop (Fig. 2) about seven years ago, further advances have been made in the above fields and our knowledge of numerous anatomical features has been improved by the ability to cut ultra-thin sections on Siro-flex ultra-microtomes.

Many topics of interest to industry have also been investigated. Using the knowledge gained from the fundamental studies mentioned above, it has been possible to carry out research into pulp and paper properties, timber fracture, plywood gluing, liquid penetration into wood, tannin formation, mycorrhizal associations, and other related fields.

It must be realized, of course, that the high resolution of the electron microscope is far from being the complete answer to all the above problems. In the field of lignification, for example, the knowledge of chemists is of absolute importance in the interpretation of electron micrographs, because it is essential to know the possible shapes, sizes, and arrangements of lignin particles before many of the visible features of lignified and de-lignified wood can be explained. The main advantage of the instrument is that we are now able to see objects approaching macro-molecular size, and to use this visible evidence in conjunction with physical and chemical evidence in the formation of hypotheses to account for the structure and function of both animate and inanimate objects.

PRE-FREEZING AS A DRYING TREATMENT

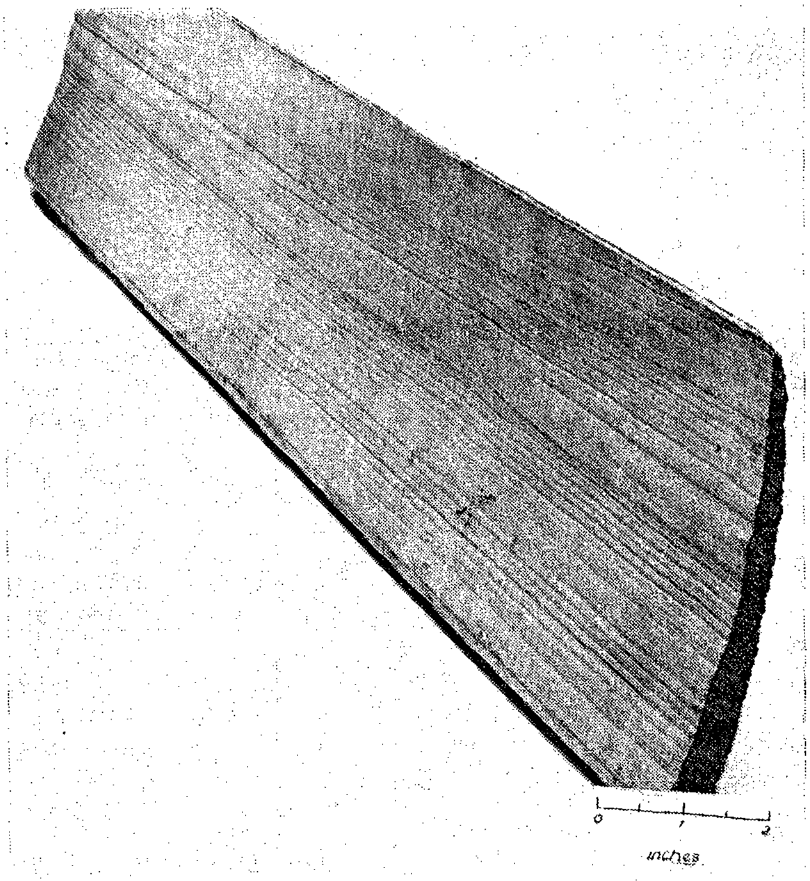
By G. W. Wright, Seasoning Section

COLLAPSE is widely known in Australia as a wood phenomenon that adversely affects the shrinkage and shape of many important hardwoods during drying. It is also known to affect impermeable timbers in which the amount of water (sap) present is extremely high for the species; and further, that it is because of this that certain tension forces develop in the water system of the wood of these timbers during the early stages of drying. It is also recognized that these forces—which are of the same nature as those that pull kerosene up the wick of a lamp—act on the cell walls of the wood, and often become so great as to exceed the cell-wall strength. In this case the cell walls crumple together in a way that becomes apparent as external collapse, usually recognizable as a marked corrugation or deformation of the wood surfaces.

It is perhaps less well known that the collapsing forces sometimes cause the wood to check during drying. These visible checks usually develop first in the early wood of growth rings just under the wood surface, but often extend inwards to develop a form of honeycombing. When such timber is machined to produce flooring or joinery, such checks become exposed as cracks and small splits at the timber surfaces, and become a common form of degrade. Sometimes they are not especially apparent in "appearance grade" timbers until they have been fitted into position in a structure, when final treatments such as staining and polishing may make them obvious.

The reconditioning process has proved of tremendous benefit as a means of removing most collapse during the later stages of seasoning—estimates suggest that its measur-

Condition of Samples	Pre-freezing Temperature (°F)	Total Volumetric Shrinkage in Drying to 12% m.c. (% of original green size): Before Reconditioning at 12% m.c.	Total Volumetric Shrinkage in Drying to 12% m.c. (% of original green size): After Reconditioning at 12% m.c.	Apparent Collapse Present Before Reconditioning (% of original green size)
Unfrozen control	—	31	12	19
Pre-frozen test samples	32	25	12	13
	−5	23	12	11
	−109	20	11	9
	−317	Sample cracked severely during pre-freezing		



Visible collapse in a section of a weatherboard (not reconditioned).

able economic value approximates at least $3,000,000 per annum to the Australian timber industry—but the process cannot remove any checks that have formed. Usually reconditioning will close such checks, but they remain as lines of wood failure as described above.

Present technical knowledge, then, has advanced to the stage of providing a means of removing collapse after it has occurred, *but not of preventing either its occurrence in the first place or the checking which sometimes accompanies it.*

For some years the development of an economic method to prevent collapse has been an objective in some of the seasoning research of this Division, and work has proceeded along a number of lines of possible reward. Approaches investigated have included the nucleation of the water system in green wood with carbon dioxide, to reduce the intensity of the causative liquid tension forces, the induction of liquids of low surface tension into the wood before drying is commenced, and others, as reported from time to time in the annual reports of the Division.

One of the more effective of the methods examined* has been to pre-freeze the timber concerned while in the green condition as a prelude to normal seasoning. Pre-freezing temperatures used were 32°, −5°, −109°F (using dry ice as the cooling medium), and −317°F (using liquid air), after which the pre-frozen timber was kiln dried, together with non-frozen matched controls, under a kiln-drying schedule deliberately chosen to encourage collapse. This was done so there would be no question as to the development of collapse-inducing forces within the water system of the timber being tested. The timber chosen was mountain ash (*Eucalyptus regnans*), a highly collapse-susceptible ash-type eucalypt used widely in south-east Australia as a general utility timber for flooring, joinery, containers, light framing purposes, and for many other uses.

When drying was completed, the results obtained showed that pre-freezing did modify noticeably the drying behaviour of the wood. The extent of this is shown in the accompanying table.

* Division of Forest Products, CSIRO.—Annual Report 1958–59.

At the conclusion of drying both the control and pre-frozen samples were then steam reconditioned. The effect was to reduce the total of normal shrinkage *plus* such collapse as was still present to a common level at between 11 and 12% of the green volume of all specimens, irrespective of whether they were pre-frozen or not.

On the basis that collapse in the non-frozen timber amounted to some 19% of the original green volume of the timber as it dried to 12% moisture content, the data suggest that by pre-freezing at −5°F subsequent collapse was reduced by some 40%, and that by pre-freezing at about −110°F collapse was reduced by about 50%.

These results were confirmed by further studies in which alpine ash (*Eucalyptus delegatensis*) was pre-frozen at a temperature of −4°F and then either air dried or kiln dried. In both cases collapse was also reduced by over 40%.

The table shows that pre-freezing alone is not as effective as reconditioning in achieving a sawn product free of collapse; it is also clear, however, that pre-freezing very considerably reduces the intensity of collapse development during the early stages of drying, and that this could well avert the risk of related checking at that stage.

As far as is known, no information is available as to the cost of pre-freezing as a treatment for seasoning purposes. Crude estimates by the author suggest it could be of the order of some 60 cents per 100 super ft, on the basis of a refrigeration plant capable of holding some 25,000 super ft and pre-freezing two charges per day (24 hr) to a temperature of about −5°F; this rough cost estimate includes the cost of overheads and handling. It would drop if a pre-freezing time of less than, say, 8 hours were acceptable.

Aspects of this research will be further investigated.

Sad News from Overseas

IT WAS WITH DEEP REGRET that we heard of the death, on 19th December, of Dr. Edward G. Locke, distinguished research administrator and Director, since 1959, of the United States Forest Products Laboratory at Madison, Wisconsin.

Dr. Locke, accompanied by Mrs. Locke, spent two weeks at this Division in 1965, in his capacity of Chairman of Section 41, Forest Products, of the International Union of Forestry Research Organizations. The conference attracted some 40 delegates from 16 countries, and during his stay in Melbourne, Dr. Locke made many new friends and also renewed many old acquaintances among the delegates.

We share, with those at the United States Forest Products Laboratory, a feeling of deep loss at his passing.

DECEMBER also brought more sad news from America. This came in a report of the death of veteran wood physicist and seasoning specialist, Harry D. Tiemann, on 18th November, at the age of 91 years.

In 1920, Mr. Tiemann came to Australia to deliver the first course for seasoning kiln operators ever to be given in this country. During the 1930s, he was responsible for training Australian scientists sent to the United States Forest Products Laboratory at Madison, Wis., on studentships. Since then he always maintained a friendly and generous interest in Australia and Australian science. For many years after the foundation of the Forest Products Laboratory at Madison, he was the kiln drying engineer there, and his published papers are still the "bible" of every practical man who is concerned with the drying of timber.

The Division of Forest Products has always been proud of its association with this eminent scientist and engineer, and considers it an honour that Mr. Tiemann, despite his great age and failing eyesight, was an active correspondent with members of the staff right up to the time of his death.

Printed by CSIRO, Melbourne

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REGISTERED IN AUSTRALIA FOR TRANSMISSION BY POST AS A PERIODICAL

NUMBER 338 MARCH 1967

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Assessment of Raw Materials for Pulp Manufacture

By A. J. Watson, Paper Science Section

MOST OF THE WORLD'S supply of paper-making fibres is obtained from wood. Until the last few decades all pulpwood was obtained from a limited number of softwood species grown in the Northern Hemisphere. Wood supplies were satisfactory and only those species were used which experience had shown to be well suited for pulping and paper-making. The rapid expansion in the consumption of paper and paper products over the past 20–30 years has greatly increased the demands for pulpwood, and this, in turn, has directed attention to species previously considered unsuitable for the manufacture of pulp and paper. Modifications to the conventional pulping process and the development of new techniques have contributed to this wider utilization, but there are still many species that are not suitable for use by the pulp and paper industry.

This problem has been of major interest to Australia, where hardwoods predominate amongst the native timbers. It is not surprising, therefore, that this country was one of the first to look to the hardwoods as a possible source of fibre for paper-making, and a major industry based on our native eucalypt forests has now been developed. However, experience has shown that only a limited number of these species can be utilized by the pulp and paper industry.

How can we assess the paper-making characteristics of any wood species? To obtain precise information it is necessary to conduct laboratory and pilot-plant investigations and actually make and test paper from the wood under examination. However, a general assessment can be made from a knowledge of the fibre characteristics, wood density, and chemical composition of the wood.

Fibre Properties

The basic paper-making units are the tracheids of softwoods and the fibres of hardwoods. In paper-making the term "fibre" is applied to both these elements. The fibres are obtained as separate entities or as small bundles by subjecting the wood to chemical or mechanical treatments or by a combined chemical–mechanical treatment. The individual fibres are long thin tubular structures with tapered ends, 50 to 100 times as long as their external diameter. Fibres obtained from softwoods are usually 2·5–4·0 mm long and + 0·2–0·4 μ in diameter*; hardwood fibres are much shorter, generally about 1·0 mm and + 0·15–0·4 μ in diameter. The thickness of the cell wall also varies widely between different species.

Investigations have shown that the fibre length has a major influence on tearing strength, long fibres giving a paper with a high tearing resistance. If high tearing strength is required the paper must contain a high percentage of long-fibred (softwood) pulp.

* 1 μ = 0·001 mm or 0·0004 in.

+ 0.02mm – 0.04mm

0. 015mm – 0.04mm

The other strength properties generally considered in assessing paper quality (tensile and bursting strengths and folding endurance) are affected mainly by the way in which the individual fibres are bonded together in the paper sheet. The degree of fibre bonding depends largely on the flexibility and compressibility of the individual fibres. Fibre flexibility, in turn, is governed by the diameter and wall thickness of these fibres.

There is a high order of correlation between the cell-wall thickness and the basic density of the wood. In general, it can be assumed that dense woods will yield pulps with thick-walled fibres. The converse is not necessarily true, because low basic density may be due to the presence of large amounts of non-fibrous elements (vessels, ray cells, etc.). Basic density can be measured much more readily than cell-wall thickness and fibre diameter and, providing due consideration is given to the amounts of vessels, ray cells, etc. that may be present, it is the simplest guide to the paper-making characteristics of the species.

Chemical Properties

Wood may be divided into several chemical entities, the most important being cellulose, hemicelluloses, lignin, and extractives. The cellulose and the hemicelluloses are the main fibre constituents; the lignin occurs mainly as an encrusting material in which the fibres are embedded, rather like the concrete in a reinforced concrete structure, while the extractives may occur throughout the wood substance.

Chemical pulps, i.e. those produced by reducing the wood to fibres by appropriate chemical treatments, consist mainly of cellulose and the more resistant hemicelluloses. It is desirable, therefore, that pulpwood should be high in these particular components. A low lignin content will also contribute to a better yield of pulp.

The amount of the extractives can be of major importance. The extractives make no contribution to the paper-making components, and their presence will always lead to reduction in pulp yield per ton of wood. They also interfere with some pulping processes, increase the consumption of cooking chemicals, and may cause difficulties in the pulp screening and washing processes and in the chemical recovery plant. Old, over-mature trees are usually much higher in extractives than young regrowth trees of the same species.

These comments apply also to semi-chemical pulps, i.e. those produced by softening the wood by chemical treatments and completing the fibre separation by mechanical means. Mechanical pulps, which, as the name implies, are made by reducing the wood to a fibrous form by mechanical treatments, are particularly influenced by the extractives in wood that can affect the colour and the paper-making characteristics of the pulp.

Selection of Pulpwood

The main requirements for pulpwood, whether from hardwoods or softwoods, are that it should be relatively free from decay and in the low to medium-low basic density range (not more than 40–45 lb/cu ft and preferably less than 30 lb/cu ft), and that it should not contain large amounts of extraneous substances (gum pockets, kino veins, etc.). If thinnings are being used extensively, some reduction in tearing strength when compared with mature wood must be expected because of the preponderance of short fibres in the juvenile wood. The wood should not contain large amounts of reaction wood and the cellulose content should be as high as possible.

Light-coloured wood is desirable and is essential if the wood is to be used for the manufacture of mechanical pulp.

Various other considerations, based largely on economic factors, have to be taken into account in assessing the suitability of various species as potential sources of pulpwood. Pulp mills are large, heavily capitalized units which cost many millions of dollars to build. Economic operation demands, except in special cases, that the output should not be less than 50,000 tons of pulp a year. The minimum requirements would be 100,000 to 200,000 tons of air-dry wood per year depending on the pulping process employed. It is clear that not only is it necessary to have wood with the desired morphological and chemical properties, but the wood must be available in large quantities over a long period. In addition to wood supplies, a pulp mill requires large quantities of fresh water, fuel, and power, and it must be served by a good transport system. Provision must also be made for the removal of effluents (waste materials), which vary in quantity and type depending on the pulping process.

Computers Aid Forest Products Research

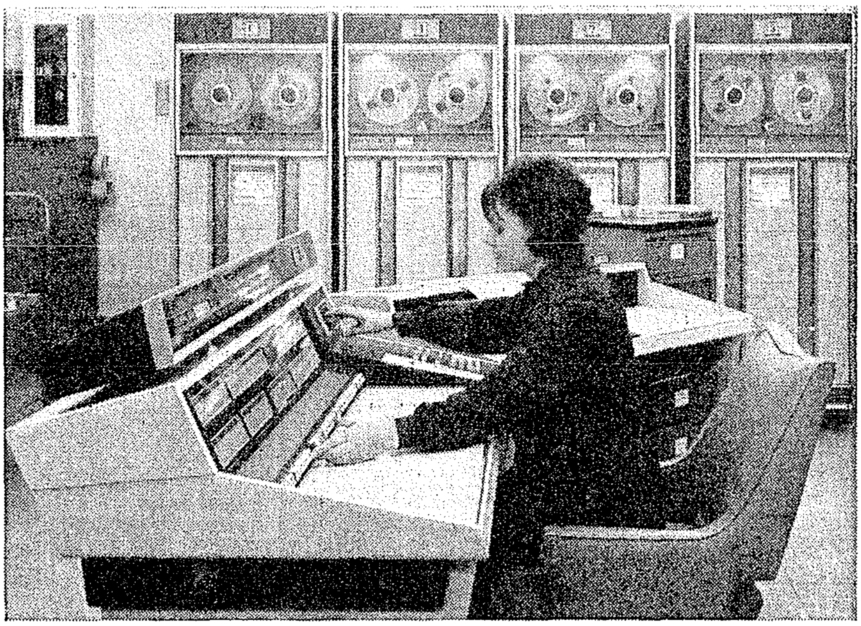
By Anne Ryan, Engineering Section

THE ELECTRONIC DIGITAL COMPUTER is rapidly becoming an almost commonplace adjunct to research in practically every field of wood technology, from the investigation of the molecular structure of wood constituents to timber engineering design. The computer's usefulness lies in its ability to store large quantities of information and to carry out long and, if needed, complex sequences of mathematical operations at high speed and produce accurate results. Also, because a high-speed printing device is usually used in conjunction with the computer, tabulated information can be produced quickly in a neat, readable form. In the analysis and presentation of the results of mechanical tests on timber species, the printing of tables by the computer is leading to considerable savings in both time and money.

Until recently, the analysis of the results of standard mechanical tests on Australian and other timbers was carried out by hand on desk calculating machines. The test results were first transcribed onto special sheets and then the species mean and other statistics for each property were computed. For any one species represented by five trees or more, generally 32 properties of the timber are measured, and for each property five pieces of statistical information are computed and recorded. Checking to detect errors required the independent recalculation of each of the 160 statistics. Publication of data derived from the test results required the tedious and time-consuming preparation of handwritten tables and the typing of these for the printer. Intensive checking of transcription was necessary at every stage from the original species analysis sheets to the final galley proofs. Hence the preparation of results for tabular publications of the Division such as Technological Papers Nos. 25 and 41, on the mechanical properties of Australian and New Guinea timbers, was a very lengthy process.

For processing by one of CSIRO's electronic computers, the test results are transferred from data sheets to punched cards, the punching of which must be checked. These cards, together with a programme of instructions, are fed into the computer, which not only carries out all the required analyses but also prints the information in any form required, including final tables for publication. The computer actually turns out in seconds what previously took days and sometimes many weeks to achieve.

Also, by using the same punched cards and simply providing the machine with another set of instructions, a wide variety of studies of the original test results such as the relationship between various strength properties and between strength and density can be made.



CSIRO has a number of computers in various States. This one, located at Clayton, Vic., is used by the Division of Forest Products.

Formerly, when done by hand machine, this meant the laborious retabulation by hand of the original test data every time a new study was required.

The processing of strength data is one of the simpler applications of the computer in the Division's work, and it has been referred to only as an example of how the modern computer is helping to save time and money by eliminating many tedious and time-consuming hand operations. No doubt subsequent articles in this Newsletter will refer more and more frequently to the assistance provided by the computers in a wide variety of investigations carried out by the Division.

D.F.P. PUBLICATION ABSTRACTS

Moisture Content Predictions for Eight Seasoned Timbers under Sheltered Outdoor Conditions in Australia and New Guinea by R. Finighan. Div. For. Prod. Technol. Pap. No. 44. *Availability.*—Timber industry.

Considerable difficulty is often experienced with wood products made from seasoned timber, owing to swelling or shrinking after manufacturing or installation. This occurs because wood is a hygroscopic material that takes up or gives off moisture until it reaches an equilibrium with its environment. Where a quality product is required, it is necessary, therefore, to season timber to a moisture content suitable to the conditions of use. Under normal conditions wood seldom reaches a true equilibrium with the atmosphere because both temperature and humidity are continually changing. However, by taking moisture-content measurements over an extended period it is possible to determine the seasonal variation and mean value for any particular locality. The mean value obtained represents the preferred utilization moisture content for the area.

This procedure obviously involves a large amount of work if e.m.c. values are required over a wide area or range of conditions, and various attempts have been made to overcome this problem by relating e.m.c. values to their associated climatic conditions. These attempts have been only partly successful in the past because of the limited amount of data available. During a Forest Products Research Conference at Melbourne, in 1956, attended by representatives of the various State Forestry Departments, it was decided to conduct a comprehensive wood moisture content survey for all the major timber-using areas. Specimens of various species were exposed at selected localities throughout Australia and New Guinea, and it was hoped that the data obtained would enable the prediction of moisture contents for all other localities.

The large volume of data has now been processed, and moisture content predictions for 108 localities in Australia and New Guinea are published in this paper. Values are tabulated for eight commonly used species in three thicknesses, viz. $\frac{1}{4}$, $\frac{3}{4}$, and $1\frac{3}{4}$ in. They apply to sheltered outdoor conditions, but may be readily converted to indoor conditions through a relationship, given in the paper, which was established by means of a survey of indoor values made concurrently with the outdoor study at a number of localities.

DONATIONS

The following donations have been received recently by the Division:

Anson's Bay Timber Co., Tas.	$50.00
Perfectus Airscrew Pty. Ltd., Newport, Vic.	$25.00
Phosphate Co-op. Co. of Australia, Geelong, Vic.	$25.00
Radiata Pine Association, S.A.	$500.00
Timber Development Association (S.A. Branch)	$400.00
Timber Development Council of Australia, Sydney	$35.00

Materials

H. Beecham & Co. Ltd., Spotswood, Vic. Timber for experimental purposes .. .. .. approx. $10.00

Printed by CSIRO, Melbourne

CSIRO
Forest Products Newsletter
DIVISION OF FOREST PRODUCTS, CSIRO, P.O. BOX 310, SOUTH MELBOURNE, S.C.5, VICTORIA
REGISTERED IN AUSTRALIA FOR TRANSMISSION BY POST AS A PERIODICAL

NUMBER 339 APRIL 1967

1967##339

Boultonizing—A Promising Seasoning Method for Poles of Some Eucalypts

By J. E. Barnacle and F. J. Christensen, Seasoning Section

What is Boultonizing?

The Boulton process or "boultonizing" is a well-established method of accelerating the drying of green timber, particularly large-section timbers such as poles or railway sleepers, before preservation treatment. Essentially, it consists of heating green timber in a liquid such as creosote or petroleum oil while maintaining a partial vacuum in the drying chamber (treating cylinder). Because of this partial vacuum the boiling point of water is lowered; thus, water may be evaporated (boiled) quite rapidly from the wood even at temperatures below 212°F—the boiling point of water at normal atmospheric pressure.

The process was first patented in England in 1879 and in the United States of America in 1881, but it has not been widely adopted by the timber-treating industry in any country except the United States, where more than 40 boultonizing plants are operating.

Research into Boultonizing

In the research field, considerable interest has been shown in boultonizing in both Canada and Japan, where some detailed studies of the process have been carried out. In Canada, boultonizing has also been investigated as a possible means of improving the subsequent preservative treatment of western hemlock (*Tsuga heterophylla*), which is normally difficult to treat.

In this Division, work on boultonizing dates mainly from 1958, when green incised sleepers of the virtually impermeable species brush box (*Tristania conferta*) were dried by this process in an attempt to improve the retention and penetration of creosote during subsequent high pressure (1000 lb/sq in) preservative treatment. Boultonizing has also been used here to accelerate the drying rate and improve the dried quality of sleepers of mountain ash (*Eucalyptus regnans*) and white stringybark (*E. scabra*), and sleepers and pole sections of messmate stringybark (*E. obliqua*) and manna gum (*E. viminalis*). Although some measure of success was achieved with each of these objectives, results were not exceptional.

Of greatest potential interest, however, are the most recent studies carried out on poles of the free-splitting Western Australian species, karri (*E. diversicolor*), which has a mean air-dry density of approximately 56 lb/cu ft. These studies have shown that boultonizing will not only dry the sapwood of this species very rapidly, but will also reduce the severity of checking to such an extent that karri—which has not been usable as a pole timber because of excessive seasoning degrade—can now be considered for this

Fig. 1.—Air-dried karri specimen showing extremely severe end split and adjacent barrel checks.

end use. This break-through climaxed a series of drying studies in which the following seasoning treatments were tried without success: air seasoning, with and without cover, under summer and winter conditions; chemical pretreatments using sodium chloride and sodium chloride–urea solutions; kiln drying under very mild conditions; and steam and vacuum drying. The results of these studies had indicated that karri was clearly the most difficult pole timber this Division had dried* and that some other special seasoning method was necessary. Generally, it could be said that pole sections of karri dried by the above methods developed long and deep barrel checks and severe to extremely severe end splits (Fig. 1). Where a chemical pretreatment was used, the number of barrel checks was greatly reduced but the few that did occur were extremely severe, sometimes being more than 1 in. wide with individual checks up to 8 ft long. In chemically pretreated *full-length* poles, however, a number of these checks occurred with their ends overlapping. As a result the effective length of the barrel check could be more than 20 ft.

Boultonized karri pole sections, on the other hand, developed an acceptable checking pattern with numerous fine barrel checks (usually $\frac{1}{32}$ to $\frac{1}{8}$ in. wide) distributed over the entire surface (Fig. 2). Where a number of overgrown branch stems occurred in a pole section, barrel checks tended to be fewer in number and longer and wider than usual, but they were still within acceptable limits. End splits and checks varied from zero to approximately 2 ft in length, i.e. an amount that could be allowed for at time of cutting. Moisture contents of between 3 and 10% were obtained in the outer $\frac{1}{2}$ in. of sapwood after a total drying time of only 9 hr. It is considered that such a low outer sapwood moisture content—which could never be achieved by air drying—would greatly reduce the possibility of karri poles splitting in service after preservative treatment, despite the severity of the exposure conditions that are likely to be encountered in Western Australia.

This could be particularly favourable for poles of karri because (*a*) the radial cleavage strength of the species is reduced markedly as it dries; (*b*) the heartwood is typically resistant to normal pressure treatment and is not durable against termites and decay fungi; and (*c*) practically the entire area of Western Australia (where the species would be used as a pole timber) has a high termite hazard.

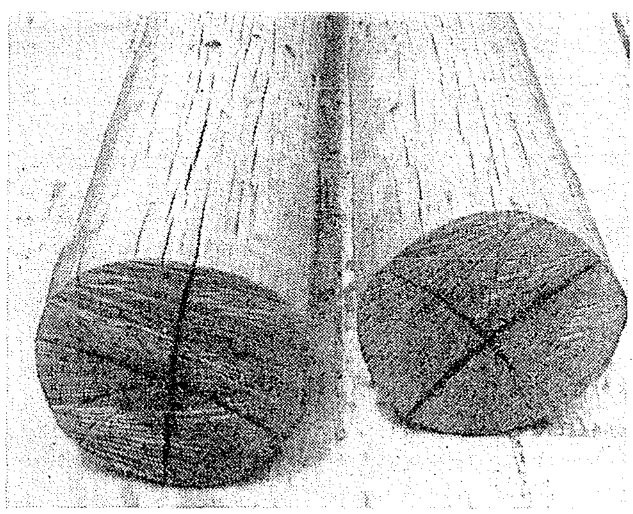


Fig. 2.—Controlled checking and splitting in boultonized karri pole sections.

*Pole drying studies carried out to date have included material from the following species: messmate stringybark (*E. obliqua*), manna gum (*E. viminalis*), mountain ash (*E. regnans*), alpine ash (*E. delegatensis*), spotted gum (*E. maculata*), and radiata pine (*Pinus radiata*).

During the boultonizing of karri pole sections creosote was absorbed by the sapwood, and this was probably assisted by the diffuse checking pattern that developed as the sapwood dried. Retentions of 8 to 9 lb of creosote/cu ft of sapwood (i.e. approximately 75% of the current specified minimum retention of 12 lb/cu ft) have frequently been obtained during the boultonizing of pole sections with sapwood thicknesses of about 1 in.

Despite the problem of sludge formation in the creosote, which is still being investigated, the results achieved to date indicate that, for karri at least, boultonizing could prove to be a valuable aid to the pole preservation industry in Western Australia, not only by reducing the time required to dry the sapwood of pole timber but also by controlling degrade during drying.

Because of the degrade control achieved by boultonizing, it should now be possible to use the considerable resources of large pole timbers that are available in the karri forests. This is particularly important because Western Australia has only two species, namely jarrah and karri, which are available in quantity as *large* pole timbers, and until now it has not been possible to consider karri because of excessive seasoning degrade.

ADDITIVES IN PAPER-MAKING

By A. W. McKenzie, Paper Science Section

PROPERLY PREPARED WOOD fibres are a remarkably versatile raw material and after appropriate treatment can be used either alone or in blends with other suitable types of wood fibre to produce papers with a wide range of properties. However, not all the properties that are necessary for many grades of paper are inherent in wood fibres, and they must therefore be obtained by the addition of other materials. These materials are collectively known as additives. In addition, the normal mechanical treatment used to develop the full potential of the fibres for paper-making purposes (generally termed beating or refining), in some cases will also develop characteristics that will render the resulting sheet of paper less desirable for its intended purpose. Under such circumstances, a compromise with respect to the extent of beating can sometimes be reached, but if this is not possible, it again becomes necessary to resort to the use of additives either to augment a property that has not been fully developed or to remedy a deficiency that has been brought about by the need for prolonged beating.

There are three main methods by which additives are applied in paper-making: wet-end or "beater" addition, where the additive is mixed with the fibre before the sheet is formed; size-press addition, where the partly dried paper is run between rolls that force a solution or suspension of additive into the body of the paper; and coating, in which a layer of additive in suspension is spread over the paper surface. At the present time, additive research in this Division is confined primarily to the wet-end type of addition, which is commonly used to incorporate into the paper sheet such materials as starch (for improved strength), pigments (for better opacity and some colour effects), and synthetic resins (for the production of wet strength). Many other types of additive are used and these have merely been given as examples.

The first essential feature of any wet-end additive is that it should be retained in the sheet. As the average diameter of most of the additive particles used is about one twenty-five-thousandth of an inch, and the holes in the wire mesh on which the paper is originally formed are about one hundred times as big, this is not a simple matter. It is made even more difficult by the fact that both fibre and additive can only be present in very small quantities in the water that is run onto the machine wire. A typical furnish might contain 5 parts fibre, 0·5 parts additive, and 1000 parts water, which means that most of the additive that is not firmly attached to the fibre will be washed through the wire and lost. Work being carried out in the Division and elsewhere suggests that adhesion of the very small additive particles to the pulp fibres can be brought about by controlling the electrical potential of the surfaces involved. Most surfaces, when immersed in water, will develop a small potential (usually 10–50 mV), the sign of which depends on the chemical nature of the surface. A large number of the additives used in paper-making will develop a negative charge and, as pulp fibres are also negatively charged, the like charges repel each other and adhesion is difficult to achieve. However, certain polymers and also alum under appropriate conditions can alter the surface of the fibre, and eliminate this repulsion. Adhesion can then occur. These materials can also act as linking agents between particle and fibre and further increase the adhesive strength. In some cases it is also possible to modify the surface of the additive by chemical methods so that fibre-additive adhesion is markedly improved. It is believed that with the additional knowledge obtained as a result of these investigations, it will be possible to design and use additives, particularly those of a synthetic nature, more effectively and so eliminate much of the wastage that now occurs.

Once the additive has been successfully retained in the sheet, it becomes necessary to consider how effectively it performs its intended function. A knowledge of the mechanisms involved and of the changes that take place during the retention process can again provide information to aid in the preparation of additives that will produce more efficiently those properties that are lacking in the untreated paper. Studies of this type have been carried out in the Division with the object of obtaining more information on the behaviour of wheat starch. This has been necessary because only a limited amount of work has been reported overseas on the mechanisms by which starch acts to give a stronger sheet, and, furthermore, this work has been carried out with either corn or potato starch, which are the common industrial starches in the U.S.A. and Europe respectively. The results obtained have shown that any modification or genetic selection of starch for use as a wet-end additive should be for the purpose of improving (i) the swelling characteristics of the starch granule and hence its ability to flow under pressure; (ii) the film-forming properties and thus the strength of the starch layer between the individual fibres; and (iii) the adhesive properties and consequently the strength of the bond at the starch–fibre interface.

Future work in this field will be concerned with the effect on the paper of varying the means of obtaining retention. In some cases, in addition to the adhesion of additive particles to the fibres in the stock suspension, additive particles will also tend to adhere to each other. This is generally undesirable, as the larger aggregates so formed are more susceptible to being washed off the fibres to which they are adhering during the process of forming the paper sheet on the machine. It has also been observed that, at least in the case of pigments, the formation of these aggregates can markedly reduce the effect produced by a given amount of additive. For these reasons, it seems that a better knowledge of the causes and effects of this type of aggregate formation is the next step on the road towards tailor-made paper.

CORRIGENDUM

FOREST PRODUCTS NEWSLETTER No. 338, March 1967

Page 1, column 2 under Fibre Properties, lines 13 and 15:

for 0·2–0·4 μ in diameter
and 0·15–0·4 μ in diameter
read 0·02 mm–0·04 mm in diameter
and 0·015 mm–0·04 mm in diameter.

Printed by CSIRO, Melbourne

CSIRO
Forest Products Newsletter
DIVISION OF FOREST PRODUCTS, CSIRO, P.O. BOX 310, SOUTH MELBOURNE, S.C.5, VICTORIA
REGISTERED IN AUSTRALIA FOR TRANSMISSION BY POST AS A PERIODICAL

NUMBER 340 MAY 1967

1967##340

LIGNIN

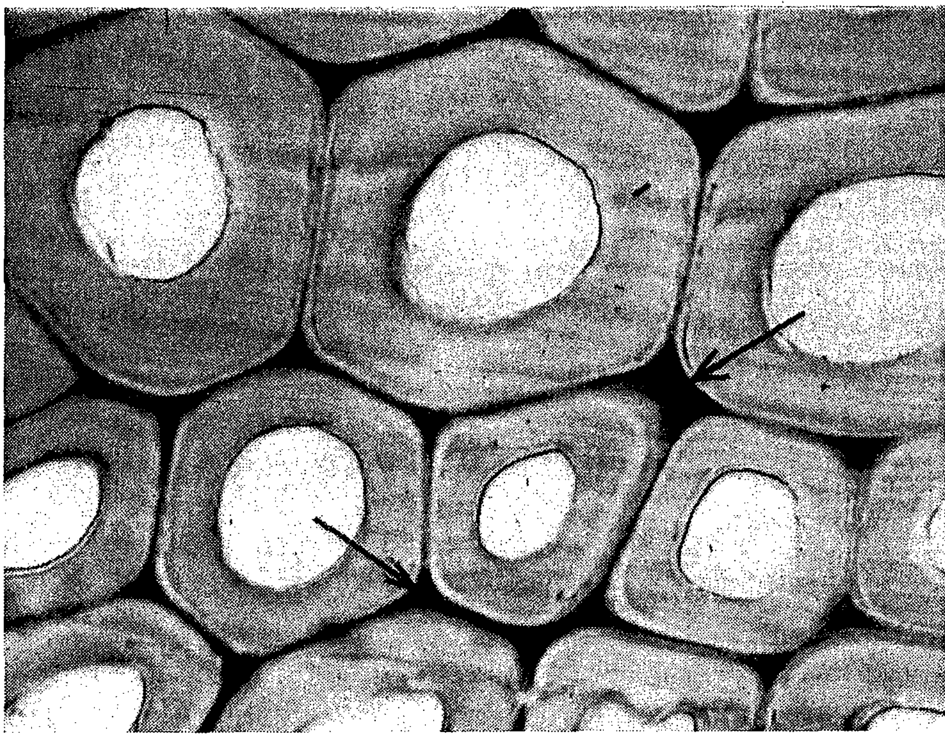
By D. E. Bland, Physiology and Microstructure Section

An ultraviolet photomicrograph of a transverse section of wood shows the fibres in cross section with black layers between them. This substance shows as black in an ultraviolet photograph because, in contrast to the other components of the wood, it has the property of strongly absorbing ultraviolet radiation. This substance is named lignin, and a superficial examination of an ultraviolet photograph suggests that it occurs only as a cementing material between the fibres. More detailed examination shows that it is not confined to such a layer between the fibres but also penetrates the fibre walls to a considerable extent; in fact careful investigation of its distribution shows more than half to be in the walls.

Chemical analysis shows that wood contains 20 to 30% of lignin, although certain abnormal woods may have lignin contents outside this range. These analyses depend on the action of acids which, under the right conditions, break down the polysaccharides of the wood to soluble sugars and leave the lignin as an insoluble, chemically rather inert non-reactive residue. This residue is altered so much that it gives little indication of the nature of the lignin in the wood. Numerous attempts have been made to separate unchanged lignin from the other wood constituents so that detailed chemical examination would give a true picture of the lignin as it occurs in the wood. In recent years it has been found that extremely fine grinding of wood in vibratory ball mills greatly assists in the extraction of an unchanged lignin. Investigation of lignins from a wide range of woody plants has established that the basic structural unit of all lignins is the phenylpropane "skeleton".

Numerous different modifications of this basic unit occur in lignins, and they are linked together in many different ways to form the lignins of different plants. Much information on how differently modified phenylpropane derivatives combine to form lignin has been deduced from experiments with model systems by observing how they combine to form artificial lignins and the properties of these lignins.

Pulping of wood chips for paper-making consists essentially of treatment with chemicals to remove the lignin by dissolving it away from between the fibres, thus liberating them in a state in which they are capable of being made into a sheet of paper. In recent years semi-chemical pulping processes have been developed. In these processes a relatively mild chemical treatment of the chips is followed by mechanical disintegration. Most of the lignin remains in the pulp but the chemical treatment has been sufficient to sever chemical bonds between the lignin and the polysaccharides of the fibre, thus permit-



Ultraviolet photomicrograph of transverse section of Eucalyptus regnans. *Arrows show lignin (black areas) between fibres.*

ting separation of the fibres without undue damage.

Despite the development of semi-chemical processes, pulps prepared by chemical pulping processes are still widely used, more particularly for higher grades of paper. As a result, large quantities of waste liquor containing lignin are produced, thus creating one of the world's greatest industrial waste problems. In some cases the liquor is utilized by concentrating to the point where the lignin and other dissolved solids can sustain combustion. The heat of combustion is used for steam raising and the pulping chemicals can be recovered from the ash.

Numerous uses have been proposed for industrial waste lignins. These include use as a filler in rubber for motor tyres, in water purification, in plastics, as an extender in adhesives, as a source of activated carbon, and in improvement of the water retention and humus content of soil. Lignosulphonic acid, which may be separated from the waste liquor of the sulphite pulping process, finds use as a dispersing agent in ceramic mixes and in concrete. Additives for drilling muds are prepared from sulphite waste liquor.

As lignin is basically a phenylpropane polymer it is theoretically possible to use it as a starting-point for the preparation of many different chemical substances. In this connection, however, it must be remembered that it would have to compete with two other large-scale sources of chemicals, coal and oil. It is therefore unlikely that this would be economical except where lignin is a more suitable source of the particular chemical in question. This is so in at least one case: vanillin, the active material in artificial essence of vanilla, is prepared from softwood lignosulphonic acid. However, the consumption of lignin for this purpose is a minute fraction of the available raw material.

The possibilities of lignin as a chemical raw material may be illustrated by some other examples. Recent Japanese pilot-scale hydrogenation of lignin has succeeded in obtaining good yields of *p*-cresol, a raw material for chemicals, dyes, and plastics. Dimethylsulphoxide, a powerful solvent, can be made from lignin. This substance showed great promise as a drug but its use was suspended because of doubts about side effects. One of the oxidation products of eucalypt lignin is syringaldehyde. It has recently been shown that, starting from this substance, the hallucinogenic drug mescaline can be synthesized. Polyester fibres can be prepared starting from chemicals derived from lignin.

The work of the Division of Forest Products has been concerned mainly with eucalypt lignin. It was discovered early in the work that methods of analysis employed for softwoods gave entirely erroneous results when applied to some eucalypt woods. Suitably modified methods were developed but, although these methods gave a measure of the total amount of lignin present in eucalypt wood, they gave no information on the precise nature of the lignin. Isolation and purification of eucalypt lignin by careful exclusion of extractives and lignin decomposition products has enabled chemical examination of eucalypt lignin to be carried out. Like all lignins it is composed of phenylpropane units; commonly half of these bear one methoxyl group and half of them two methoxyl groups. The principal chemically reactive groups of it are phenolic, primary alcohol, and carbonyl groups. In one in about every fifty of the phenylpropane units a grouping is present which is responsible for an important colour reaction of lignin, the phloroglucinol reaction, which is commonly employed by botanists to locate lignin in wood sections.

Eucalypt lignin is not identical throughout the genus. The number of units bearing one and two methoxyl groups differs over a considerable range from species to species. A recent survey of lignin from tropical and temperate zone species showed that the methoxyl content of the tropical zone eucalypts was lower in all specimens examined.

Many problems in the utilization of eucalypt timbers are traceable to the presence of tension wood. The composition of this wood differs from that of normal wood, the ratio of lignin to polysaccharide fraction being much lower. The opposite is the case with the compression wood of softwoods, in which the ratio of lignin to polysaccharides is higher than normal. The properties of these woods are related, among other things, to the amount, distribution, and peculiarities of the lignin.

In order to understand fully the function, distribution, and relation to wood properties, it is necessary to know the steps by which the phenylpropane derivatives that make up eucalypt lignin are formed in the living tree and built into the lignin polymer. This is being investigated with the help of radio tracer techniques.

D.F.P. PUBLICATION ABSTRACTS

Mechanical Properties of 81 New Guinea Timbers by E. Bolza and N. H. Kloot. Div. For. Prod. Technol. Pap. No. 41. Availability.—Wood technologists.

SINCE 1945, in cooperation with the Department of Forests of the Territory of Papua and New Guinea, mechanical and other tests have been carried out on Territory species to determine which are likely to provide timber suitable for structural purposes.

This paper presents the laboratory test values of the mechanical properties of 81 species, but is intended primarily to provide wood technologists with basic information. A limited number of copies only are available to members of the timber trade who have immediate need for this information.

The Incorporation of Arsenic in Creosote and Wood Tar Material to increase Termiticidal Effectiveness by R. Johanson. *Inst. of Wood Sci. J.*, Oct. 1964. (*D.F.P. Reprint 604.*) Availability.—Wood preservation industry and pole-using authorities.

THE VERY HIGH termite hazard in some areas of Australia has indicated the possible merit in fortifying with a suitable termiticide the creosote commonly used for pole preservation.

This paper reports the results of an investigation into the capacity of creosotes to dissolve or react with arsenic trioxide. It was found that the amounts of As_2O_3 that could be incorporated into the various creosotes were sufficient for fortification for areas of high hazard. At a conventional retention of 10 lb creosote/cu ft of wood, the concentration of As_2O_3 obtained would be at least three times the amount required to protect specimens in laboratory compulsion tests.

The Incidence and Distribution of Termite Attack in Melbourne and Environs by C. D. Howick. *Quant. Surv.*, 1966, **13**(4). (*D.F.P. Reprint 682.*) Availability.—Specialist interests and industries concerned.

EARLY IN 1964, a survey was commenced to determine the incidence of termite attack in Melbourne and environs. The need for such a survey was indicated by the large number of enquiries received by the Division concerning termite attack and the widely differing and often erroneous views as to the occurrence of termites in the area. The purpose of the survey was to plot known termite infestations on a map so that any areas of relatively high hazard could be recognized. This paper gives an indication of the results of the survey, and is accompanied by a termite distribution map of Melbourne and suburbs.

Contributions from the Division of Forest Products, CSIRO, to U.N. Conference on Application of Science and Technology for the Benefit of the Less Developed Areas (UNCSAT), Geneva, 1963. Div. For. Prod. Technol. Pap. No. 46. Availability.—Specialist interests in the field of tropical research and development.

THIS PUBLICATION is made up of six papers as presented to the UNCSAT Conference held at Geneva in February 1963. They have been collected in this form to make the complete papers more readily available. The following are very brief summaries of the papers:

Developing the structural use of native timbers: important technological factors by J. D. Boyd.

Sampling procedures, strength grouping of timbers, grading of structural timbers, factors affecting structural utilization of native timbers, and experimental procedures and records are discussed.

The behaviour of paper products under extreme climatic conditions by H. G. Higgins and A. J. Watson.

The relationship between climate and economic development, with reference to the manufacture and use of paper, is briefly outlined and the use of paper in less-developed areas is discussed. The effects of humidity and temperature on paper, restrictions on use under extreme conditions, and treatment to extend utilization are all discussed in some detail.

Tannin formaldehyde adhesives by K. F. Plomley.

Mangrove, wattle, and radiata pine bark extracts react readily with formaldehyde to form resins. These can be used to provide a relatively cheap waterproof adhesive for plywood and as a bonding agent for particle board. This paper briefly describes the experimental work and exploratory tests carried out with these materials.

Preservation of hardwood building timbers with special reference to tropical countries by N. Tamblyn.

In most tropical countries there is a need to increase the durability of building timbers. With proper preservative treatment, timber structures can be made to last indefinitely. Such treatment is an important step in raising housing standards and in utilizing the less durable timbers that typically occur in tropical forests. This paper defines the hazards and details suitable methods of treatment.

Timber utilization with special reference to sawing techniques and utilization of waste by R. F. Turnbull.

Timber utilization in undeveloped countries can be planned for local requirements or to enhance the economy by supplying materials for industrial development and export. At all levels, conversion should be as efficient as possible and utilization of native species should be promoted on a sound technological basis. This paper discusses the subject from the sawmill to final utilization.

Timber seasoning practices for conditions of high humidity in tropical areas by G. W. Wright.

In this paper an outline of the problems associated with timber-drying in tropical areas is given and basic recommendations are made concerning methods and equipment to produce properly dried timber.

Printed by CSIRO, Melbourne

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Forest Products Newsletter

DIVISION OF FOREST PRODUCTS, CSIRO, P.O. BOX 310, SOUTH MELBOURNE, S.C.5, VICTORIA

REGISTERED IN AUSTRALIA FOR TRANSMISSION BY POST AS A PERIODICAL

NUMBER 341 JUNE 1967

1967##341

Marine Borer Tests with Pressure-treated Timber

By J. Beesley, Preservation Section

In its search for reliable treatments to protect timber against the attack of marine organisms, the Division established a test of preservative-treated timber in four Australian ports in the summer of 1959–60. The scope of this test and details of the installation were described in "A marine borer test in Australian waters" by J. E. Barnacle, Newsletter No. 262, April 1960.

Now that these specimens have been exposed to attack by marine organisms for approximately six years, it is obvious that:

- The best treatment in the test is the group of sawn radiata pine specimens impregnated with fixed waterborne preservatives (these were proprietary preservatives of the metal–chrome–arsenic type commercially available in Australia) to a nominal retention of 1·75 lb/cu ft. The performance of this group of specimens is markedly superior to that of untreated turpentine (*Syncarpia glomulifera*, a species renowned for its natural resistance to attack by marine borers) and rather better than that of any of the other groups of treated specimens in the test.

- The performance of round eucalypt (*E. macrorrhyncha*) specimens impregnated with approximately 20 lb/cu ft of Australian K55 creosote oil is also superior to that of untreated turpentine heartwood, but is not quite as good as that of the pine specimens impregnated with the metal–chrome–arsenic (CCA) preservatives.

- The test failed to show any material difference in performance between (*a*) the untreated heartwood of turpentine, (*b*) round eucalypt specimens impregnated with the same loading of CCA preservative as proved so successful in pine, and (*c*) pine specimens impregnated with about 20 lb/cu ft of creosote oil.

There was some evidence of these trends during the earlier part of the test but they were not clearly recognized at first because of the differences in hazard at the four sites and because of the inherent properties of the eucalypt species chosen.

One test site, in the Brisbane River, was so far upstream that it was virtually free from marine fouling, and the only marine organism to attack the specimens was the teredine borer *Nausitora queenslandica*. At Port Hedland, W.A., also, practically all attack was due to teredine borers, but in Sydney Harbour and at Kwinana, W.A., both crustacean borers and teredine borers attacked some of the test specimens. It is noteworthy that very little crustacean attack was found in any of the eucalypt specimens at either Sydney or Kwinana and that such attack as did occur

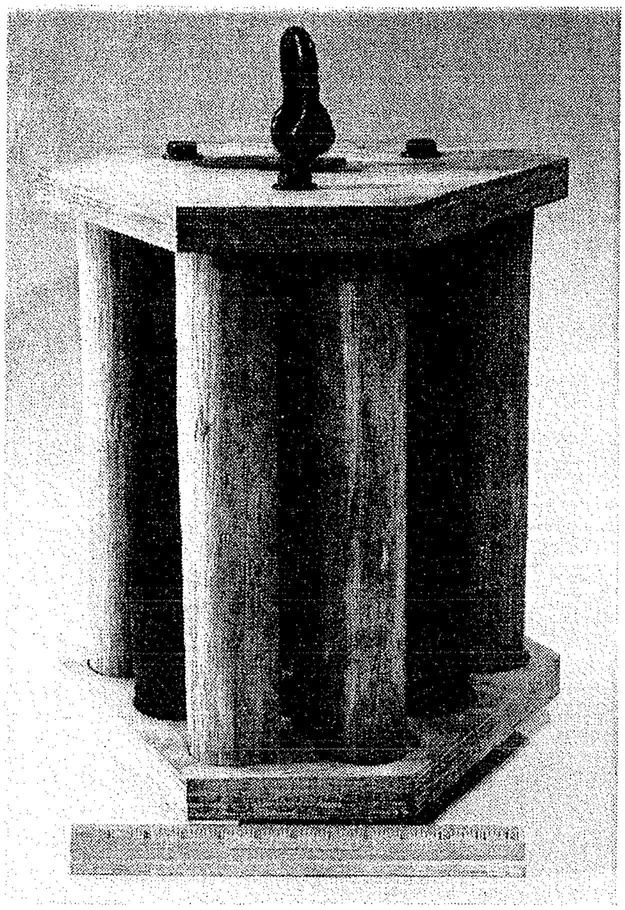


Fig. 1.—Assembled test frame.

was limited to the eucalypt specimens impregnated with the CCA preservatives. With the pine specimens, the position was reversed in these two ports. No crustacean attack was discovered in the pine specimens treated with CCA preservatives but relatively heavy attack (sometimes amounting to complete destruction) occurred in the pine specimens impregnated with creosote oil. This contrasts markedly with the high resistance of these specimens to teredine attack.

Arrangements have now been completed to install a new and more comprehensive test of impregnated timber specimens during the winter of 1967. It is hoped that this new test will throw some light on the reasons for the difference in performance of CCA preservatives in eucalypts and *P. radiata*. It is also anticipated that the new test will give reliable information on differences in hazard between the various ports chosen as test sites around the Australian coast and in the Territory of Papua and New Guinea.

In this new test, 44 test frames similar to that shown in Figure 1 will be exposed, under conditions of full salinity, at seven Australian ports, namely, Carnarvon, Port Hedland, Darwin, Weipa (Cape York), Cairns, Gladstone, and Sydney, and at Lae, Rabaul, and Port Moresby in the Territory of Papua and New Guinea.

Each frame is made up of two *P. radiata* plywood end pieces, impregnated with 2 lb/cu ft of a commercial CCA preservative followed by a second impregnation with creosote oil, and held together by three galvanized bolts coated with a coal tar–epoxy resin. An eye bolt passes through both end plates so that the weight of the assembly can be supported on a square washer.

Twelve recesses, each $\frac{5}{8}$ in. deep and 3 in. in diameter, have been machined into the face of each end plate as shown in Figure 2. These recesses are to provide a safe anchorage for the test specimens so that the end grain will be protected from exposure to the sea and attack by marine organisms. One or two of the recesses have been taken right through the plywood to provide access for bait specimens as explained later. Each test specimen was sealed into the recesses with an epoxy caulking compound after the end had been sealed with three coats of an epoxy enamel.

In order to avoid the possibility of prejudicing the results of the test by selecting a species that had some inherent peculiarity or resistance to attack by one or other of the two major groups of wood-destroying marine organisms, the specimens used in this test were natural rounds, less than 3 in. in diameter, of *P. radiata*, spotted gum (*E. maculata*), and messmate stringybark (*E. obliqua*). In addition, a piece of turpentine heartwood, sawn to an octagonal section just under 3 in. across, was included in each test frame for direct comparison with the treated timbers.

The three preservatives used in this test were Australian creosote oil, conforming to the revised Australian Standard AS K55 (1965), and two waterborne salts approximating in their composition to different commercial CCA preservatives.

The test specimens were impregnated in

36 in. lengths and the preservative retentions obtained were reasonably close to the required nominal retentions of 2 lb/cu ft for the waterborne preservatives and 20 lb/cu ft for the creosote.

After impregnation, the specimens were dried before a 15 in. test piece was taken from each end of the treated length. These two pieces were regarded as being identical. The remaining piece, from the centre of the treated length, and approximately 6 in. long, was retained for chemical analysis. The results of these analyses will be used to determine the progressive loss of preservative from the test specimens during the period of exposure.

In order that the treated specimens might be exposed to the maximum hazard, they were randomly arranged in the outer recesses of the test frames and the turpentine specimen was uniformly placed in one of the internal recesses.

By using the turpentine specimen as an index, each recess could be given a number so that the position and serial number of each test piece could be recorded during assembly. Hence, regardless of the amount of deterioration that might occur during the test, each test piece will be readily identifiable.

The frames were identified by a serial number burned into the exposed face of the upper end plate. The same number was deeply engraved on the reverse face of a clear acrylic label $\frac{1}{4}$ in. thick. This label was positioned over the burned number, so as to protect it from erosion by fouling growths, and held in place by two of the tensioning bolts used to hold the frames together.

After assembly, the frames were distributed between the test sites by random selection. Five frames were allotted to each Australian port, while three frames were available for use at each of the three sites in the Territory of Papua and New Guinea.

Apart from routine inspections to ensure that the chains and bolts securing the frames are in good order, the frames will be left undisturbed for at least two years after installation. A few months before the frames are to be examined for deterioration in the test specimens, a "bait" will be added so that, at the time of the assessment, a piece of susceptible timber freshly attacked will be available as a measure of the existing hazard and as a source of animals for identification purposes.

The Division is particularly grateful to the following Departments, Boards, and Companies who have generously agreed to co-operate in this test and assist with the installation and maintenance of the specimens: the Public Works Department and Forests Department of Western Australia (Carnarvon and Port Hedland); the Northern Territory Port Authority (Darwin); the Commonwealth Aluminium Corporation Ltd. (Weipa); the Cairns Harbour Board, the Gladstone Harbour Board, and the Queensland Department of Forestry (Cairns and Gladstone); the New South Wales Forestry Commission, the Division of Wood Technology, and the Maritime Services Board (Sydney). In the Territory of Papua and New Guinea, the Forests Department has undertaken responsibility for supervising the test.

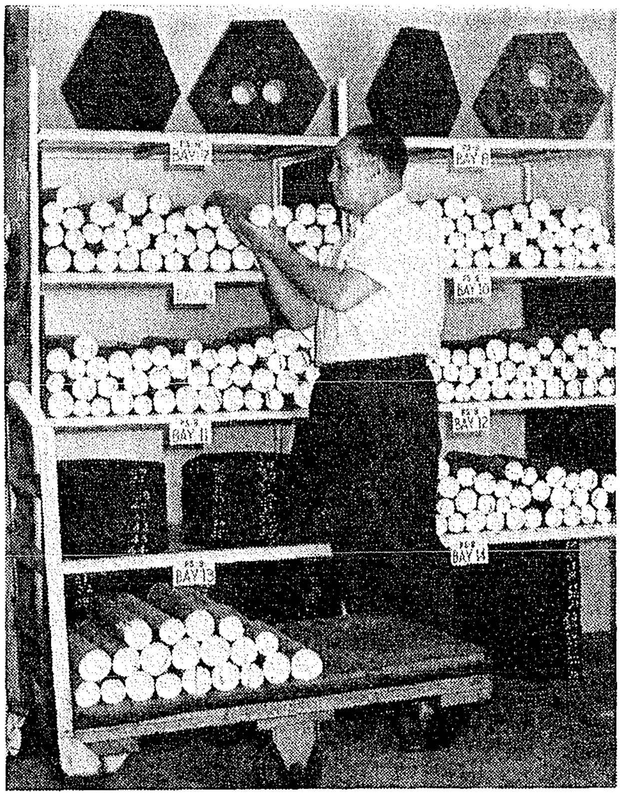


Fig. 2.—Test material ready for assembly into test frames. Note arrangement of recesses in plywood end plates.

Strictly for the Birds

By J. K. Chamier, State Electricity Commission, Vic., and F. A. Dale, Preservation Section

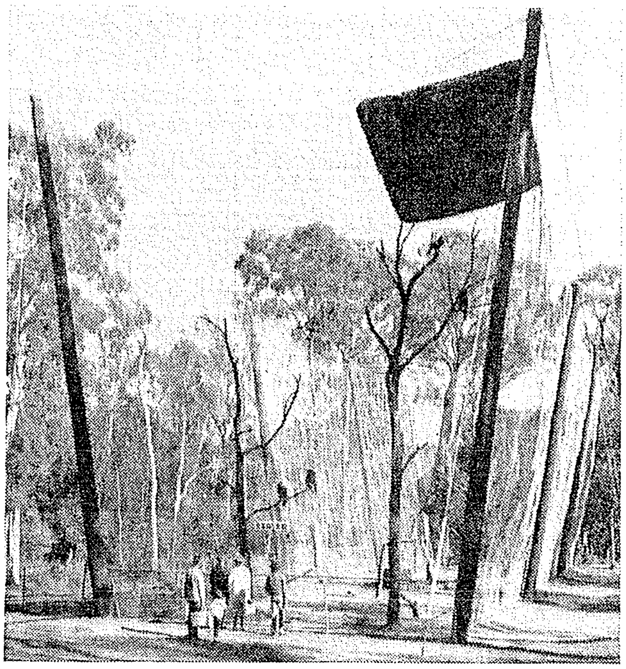
SINCE THE INTRODUCTION of pressure preservation treatments in Australia ten years ago, the Division of Forest Products and others have been advocating the use of treated round timbers in structures such as bridges, farm buildings, warehouses, and advertising signs, where light weight, low cost, and ease of erection offer real advantages in the design of durable, efficient, and attractive structures.

Although this form of building is well established in the United States of America, and pressure-treated transmission poles are now widely used throughout Australia, engineers and architects here have been slow to adopt pole construction.

Recently, a unique opportunity arose to demonstrate the advantages of poles in a large structure. The management of the Sir Colin MacKenzie Sanctuary at Healesville, Vic., had to replace a large enclosure for wedge-tailed eagles. The new enclosure had to be free of internal framing, permitting uninterrupted flight and allowing a clear view of the birds. It also needed to be durable, robust, attractive, and not expensive. A pole-supported cable structure seemed to be the logical answer and the management agreed.

The new enclosure, designed by the authors, consists of eight pressure-creosoted hardwood poles forming a box, as shown in the photograph. The base of the box is 125 ft × 30 ft and the poles slope outwards at an angle of 8° from the vertical so that their tops form a rectangle 155 ft × 50 ft. The four corner poles are 55 ft long × 18 in. ground-line diameter and the four intermediates are 45 ft long × 15 in. diameter. They are set 8 ft in the ground and their tops are connected by catenary cables consisting of seven strands of 12-gauge galvanized high-tensile steel. The tops of the poles are tied to 5 ft × 15 in. diameter "dead-men" in the ground by guys consisting of 19 strands of 14-gauge. These guys also slope at 8° from the vertical. The corner poles have two guys each, consisting of two cables of the above construction. Preformed grips were used for fastening the guys.

Ringlock fencing is tied to the catenary cables to form the roof, while the sides are



covered with rabbit netting hanging from the catenaries and tied to horizontal strands of 8-gauge fencing wire fastened to the poles at 10-ft intervals. This netting is protected at ground level by 4 ft of chain wire on pipe supports. Reinforced holes are provided in the netting to allow photographers a clear view.

The poles, cables, and netting were erected with standard equipment by a contractor experienced in the building of transmission lines, while site work and fencing was done by staff of the Sanctuary.

Total cost of the enclosure including site preparation was $4700, which is less than half the maximum allowed for.

The enclosure has already received much favourable comment. Ten eagles can be accommodated and the large open space permits them great freedom of flight. The poles blend in well with the surrounding trees, and had a suitable black wire been available for the covering the effect would have been even more attractive.

The management of the Sanctuary must be congratulated on their decision to build the first large structure of this kind in Australia. There is no reason why it should not be the first of many.

Printed by CSIRO, Melbourne

CSIRO
Forest Products Newsletter
DIVISION OF FOREST PRODUCTS, CSIRO, P.O. BOX 310, SOUTH MELBOURNE, S.C.5, VICTORIA
REGISTERED IN AUSTRALIA FOR TRANSMISSION BY POST AS A PERIODICAL

NUMBER 342 JULY 1967

1967##342

Kiln Drying of *Pinus Radiata* Poles and Posts

By F. J. Christensen and J. E. Barnacle, Seasoning Section

CURRENT DEMAND for transmission poles in Australia stands at about 250,000 per annum, including both new installations and replacements. Approximately half are used for telecommunications, and the remainder by various power authorities in the States. Supply difficulties have already arisen, particularly for power distribution poles from native hardwoods.

The Australia-wide plantation programme is leading to an increased availability of poles in softwood species. Although present consumption of preservative-treated softwood poles is relatively small, it seems certain to increase because of their good drying behaviour, ease of treatment with either creosote or waterborne preservatives, and the savings in freight costs arising from their relatively low density when dried.

While poles of *Pinus radiata* air dry readily with negligible degrade, both before and after treatment with waterborne preservatives, poor natural drying conditions at certain times of the year can adversely affect the continuity of production of treated poles and increase the possibility of decay during drying. For these reasons, the Division has investigated the drying of *P. radiata* poles and posts at high temperatures and considered the design of suitable driers. The redrying of treated poles was also examined in view of their tendency to dry more slowly than from the green condition. All experimental work was carried out at the Dartmoor Pine Mills Ltd., where a commercial kiln, handling facilities, and a supply of poles and posts were made freely available over a period of almost a month.

Poles

A total of 175 *P. radiata* poles, ranging from 24 to 42 in. butt girth under bark and 30 ft long, were dried in an internal-fan cross-circulation kiln with an effective stack cross-section of 9 ft 6 in. square. Prior to drying at temperatures of 200–230°F and with 50–75°F wet-bulb depressions, poles for each charge were felled and block-stacked until ready for debarking.

Stacks were assembled with a fork lift truck and were made 9 poles high and 6–10 poles wide, depending on pole diameter. They were supported on lengths of steel rail. Vertical steel supports, clamped to both ends of three of the supporting rails and tensioned with chains, were used to restrain poles in the stacks, particularly when moved in and out of the kiln on a conventional transfer truck with motorized hydraulic lifting system (Fig. 1). A stronger restraining frame is recommended for industrial use.

Green moisture content values for the outer 2 in. of sapwood ranged from 65 to 90% for the smaller diameter poles and 80 to 110% for the larger ones.

The poles in two runs were dried in open-piled stacks having adjacent layers separated by 4 in. × 3 in. bearers; in another run, poles were virtually block-stacked (close-piled) with only 2 in. × 1 in. strips between layers. Air velocities through these types of stacks were 200–400 ft/min and about 100 ft/min respectively.

Results

In general, drying was more even and faster with 4 in. × 3 in. separating bearers. However, after drying for approximately 72 hr, all poles appeared sufficiently dry for preservative treatment, i.e. the moisture content at a depth of 2 in. from the surface did not exceed 30%. Most of the smaller-diameter poles were adequately dry after 48 hr.

Drying degrade was well within acceptable limits although a small amount of cut-back was required at the top of some poles. A complete absence of any drying degrade was noted for a number of poles in the close-piled stack. The typical condition of poles immediately after kiln drying at temperatures up to 230°F is shown in Figure 2.

Treated Poles

Forty-eight poles drawn from all runs were treated for 2 hr with a copper–chrome–arsenic preservative by the full-cell method at a pressure of 200 lb/in^2; normal sapwood retentions were obtained. During treatment, the moisture content of both the sapwood and heartwood increased substantially above green values.

The treated poles were redried in an open-piled stack at kiln temperatures varying from 215 to 225°F and wet-bulb depressions ranging from 55 to 65°F; after 96 hr the moisture content 2 in. from the surface was still about 50%. The principal factor responsible for this apparently slower drying was the greater amount of moisture present in the treated poles: rate of loss of moisture from poles during kiln drying was substantially the same for both green and treated material.

Posts

A test parcel of some 150 posts, 3–5 in. top diameter under bark, was dried in both open-piled and close-piled stacks. At kiln temperatures of 200–210°F and wet-bulb depressions of 50–60°F, the open-piled posts dried to an average moisture content of less than 20% in 36 hr, while the close-piled material only dried to 50–60% in this time. Drying degrade remained well within acceptable limits.

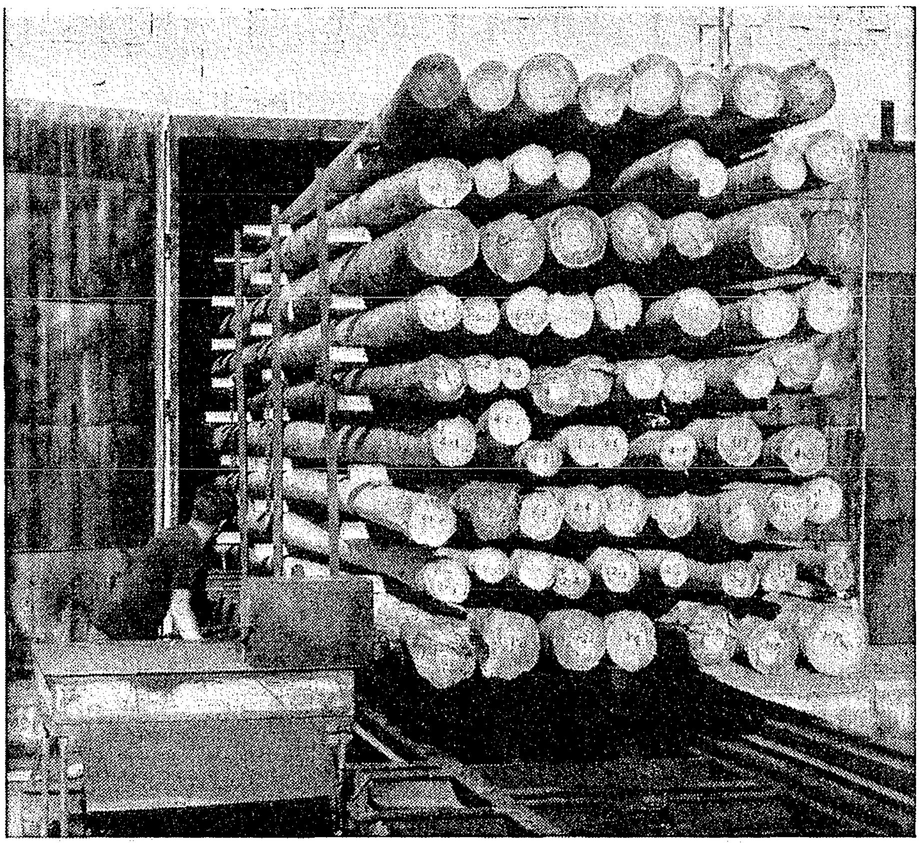


Fig. 1.—Loading an open-piled stack of P. radiata *poles into the kiln for high-temperature drying.*

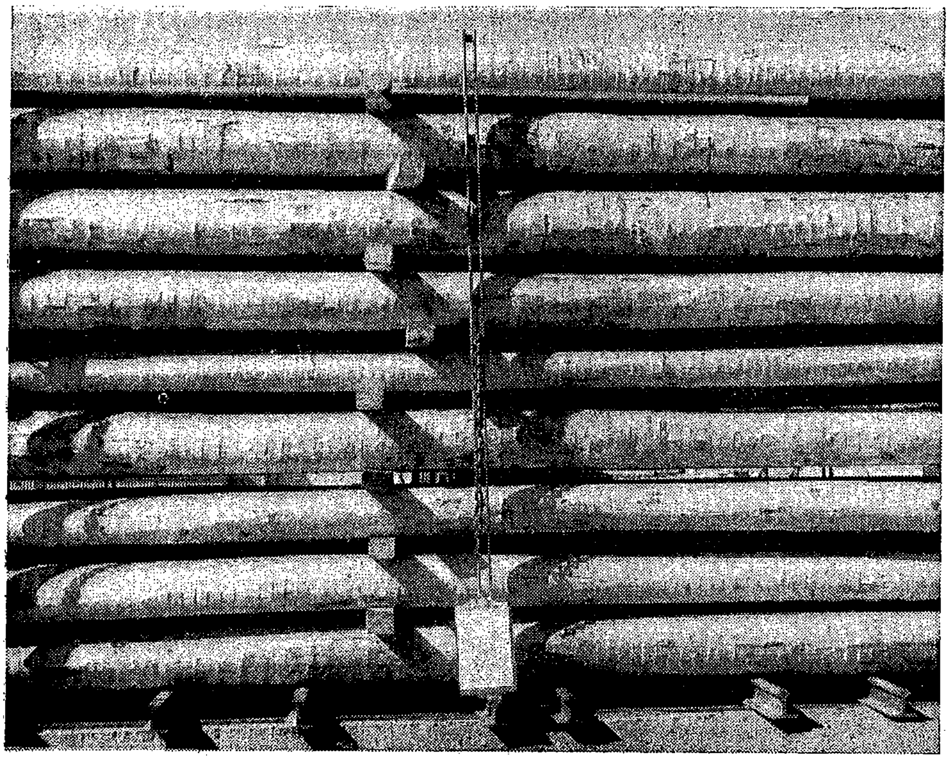


Fig. 2.—Typical appearance of P. radiata *poles after drying for 81 hr at temperatures of up to 230°F.*

Conclusions

This experiment has established that *P. radiata* poles can be satisfactorily dried from the green condition in 2 to 3 days in a commercial kiln operated at high temperatures and low equilibrium moisture content conditions; open- and close-piled methods of stacking appear to have little effect on the rate and quality of drying. Under similar drying conditions, open-piled posts dried to a treatable moisture content in less than 36 hr. The redrying of poles treated with waterborne preservative was slower than drying from the green condition to the same moisture content, principally because of the extra moisture present. The commercial application of high-temperature kiln drying to *P. radiata* poles and posts will depend on economic considerations.

Termite Attack in the Northern Territory

ABOUT 12 MONTHS AGO, an officer of this Division and an officer from the CSIRO Division of Entomology, Canberra, visited Darwin at the request of the Commonwealth Department of Works, in order to advise on methods of reducing the incidence of termite attack in departmental buildings in Darwin and the Northern Territory.

These officers presented their recommendations to the Department in the form of a report dealing with the nature of the termite hazard in Darwin and the Northern Territory, outlining the principles of termite-proof construction and concluding with detailed recommendations for the prevention of termite attack in buildings of various types.

The authors recognized that the substance of this report could be useful to architects and builders operating in the Northern Territory and, probably, most other parts of Australia where subterranean termites are a serious hazard. As a result, the Commonwealth Department of Works has given permission to release the report (with minor amendments) for general distribution. Architects and builders may obtain copies by application to this Division.

This report makes reference to, but does not replace, two Australian Standards, namely, AS CA43(1966)—Soil Treatment for Protection of Buildings against Subterranean Termites — and AS CA50(1967) — Physical Barriers used in the Protection of Buildings against Subterranean Termites. These Standards should be used in conjunction with the report.

Dr. W. E. Cohen Retires

DR. W. E. COHEN, Assistant Chief of the Division, retired on 28 June after 40 years' service with CSIRO. He was a foundation member of the Division, and in 1931 became Officer-in-Charge of the Wood Chemistry Section (now Paper Science Section), but his interest in this field extends back to 1927, when he was one of a team working on the pulping of *Pinus radiata* at the Botany Mill of Australian Paper Manufacturers Ltd., and later Officer-in-Charge of Tannin Extract Investigations in Perth, W.A., from 1928–30. He is the author of over 70 papers covering many aspects of the chemistry of wood, pulping of wood, and production of paper, and in 1936 was awarded the degree of D.Sc. for his published work in this field by the University of Western Australia.

Dr. Cohen has been abroad on various occasions. In 1935 he was awarded a Commonwealth Fund (now Harkness) Service Fellowship and spent a total of two years at the University of Wisconsin, the United States Forest Products Laboratory, Madison, and the Forest Products Research Laboratory, Princes Risborough, England; in 1946 he was a member of a scientific mission to Japan, where he spent some 9 months; in 1949 he attended conferences in Brussels and Helsinki; in 1951 he was invited to attend the 75th Anniversary meeting of the American Chemical Society; in 1952 he was a consultant on pulp and paper to F.A.O., Rome; in 1957 he received a Fulbright Award under which he spent 12 months at the United States Forest Products Laboratory at Madison, and the Institute of Paper Chemistry at Appleton, Wis., studying dimensional stabilization of paper.

Dr. Cohen is a Fellow of the Royal Australian Chemical Institute and is now an Honorary Member of Appita (Australian and New Zealand Pulp and Paper Industries Technical Association), having been a foundation member and former president of that Association.

A farewell dinner for Dr. Cohen, attended by over 130 past and present members of the staff of the Division and representatives of the pulp and paper industry, was held in Melbourne on 26 June.

D.F.P. PUBLICATION ABSTRACTS

Predrying in Australia by L. J. Brennan, K. W. Fricke, W. G. Kauman, and G. W. Wright. *Aust. Timb. J.* **32**(11). (*D.F.P. Reprint* 686.) *Availability*.—Timber industry.

THIS PAPER was originally presented at the 6th All-Australian Timber Congress in September 1966. It reviews the development of predryers and their introduction to the industry, and also gives a general picture of the design and construction of these units. The application of predryers and comparative establishment and drying costs are also discussed in some detail.

***Hylotrupes bajulus*: Its Incidence in Australia and a Survey of its Habits** by C. D. Howick. Div. For. Prod. Technol. Pap. No. 47. *Availability*.—Preservation and pest control industries, forest authorities, and specialist interests.

Hylotrupes bajulus, one of the world's most destructive softwood borers, is not indigenous to Australia but has on occasions been introduced into the country in softwood timber received from overseas. Its presence in some several thousand precut softwood houses imported from Europe in the late 1940s has focused attention on the risk of its becoming established in Australia. The situation in individual Australian States as at 1965 is summarized.

To develop a sound basis for recommendations, the Division of Forest Products circulated a questionnaire concerning the habits of the insect to specialist entomologists in countries where *Hylotrupes* has become established. This paper presents the substance of the replies received.

Printed by CSIRO, Melbourne

CSIRO

Forest Products Newsletter

DIVISION OF FOREST PRODUCTS, CSIRO, P.O. BOX 310, SOUTH MELBOURNE, S.C.5, VICTORIA

REGISTERED IN AUSTRALIA FOR TRANSMISSION BY POST AS A PERIODICAL

NUMBER 343 AUGUST 1967

1967##343

The Structure of Cellulose and Other Carbohydrates

By B. J. Poppleton, Paper Science Section

ON A DRIVE through any area in which trees are planted in a regular fashion, most people at one time or another have noted how the separation between rows appears to depend on the direction from which the plantation is viewed. This situation is sketched in Figure 1, where it is seen that the rows viewed from A are more widely spaced than the rows viewed from B. An astute observer would also note that as the row spacings decrease so the distances between trees become greater. This is clear if the two dotted portions, one along A and the other along B, are compared.

This everyday observation is a useful analogy with which to explain some work at present being undertaken by the Division, with the collaboration of the CSIRO Division of Chemical Physics, on the structure of materials such as cellulose and other carbohydrates. The techniques of crystal structure analysis by X-ray and electron diffraction that are being used were developed in the early years of this century. Since that time they have been instrumental in providing extensive knowledge of the solid state. Structures that have been resolved with their use range from common salt to extremely complex organic molecules such as the protein haemoglobin.

In most solid materials of which we have experience, the atoms and molecules are ordered in a regular way. The extent of the order, of course, can vary over a wide range as also can the size of the regions in which this order is found. An example of the latter is sugar, of which the crystal size commonly varies from coffee crystals to icing sugar. In such crystals the molecules are arranged in a regular way, as in the example in Figure 1, except that instead of being in a plane they are arranged according to a three-dimensional pattern, perhaps more like oranges packed in a crate. It is worth noting at this point that there are 230 ways, and only 230, in which

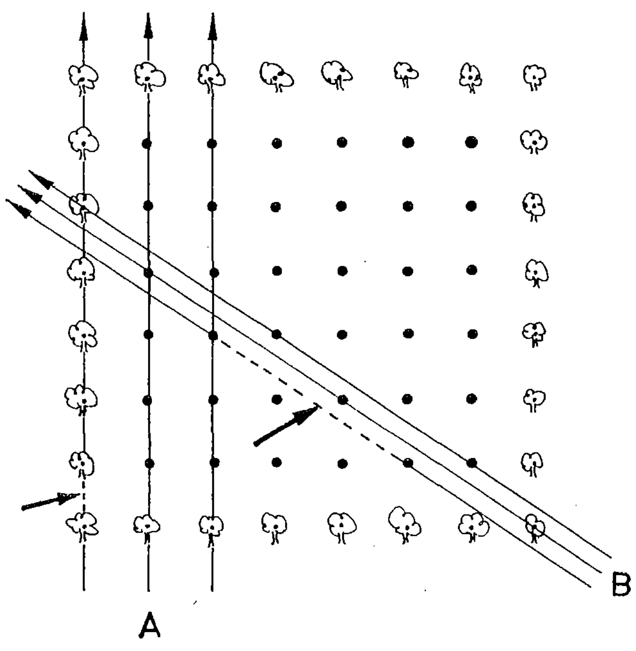


Fig. 1.—Two views across a plantation with trees at regular spacings.

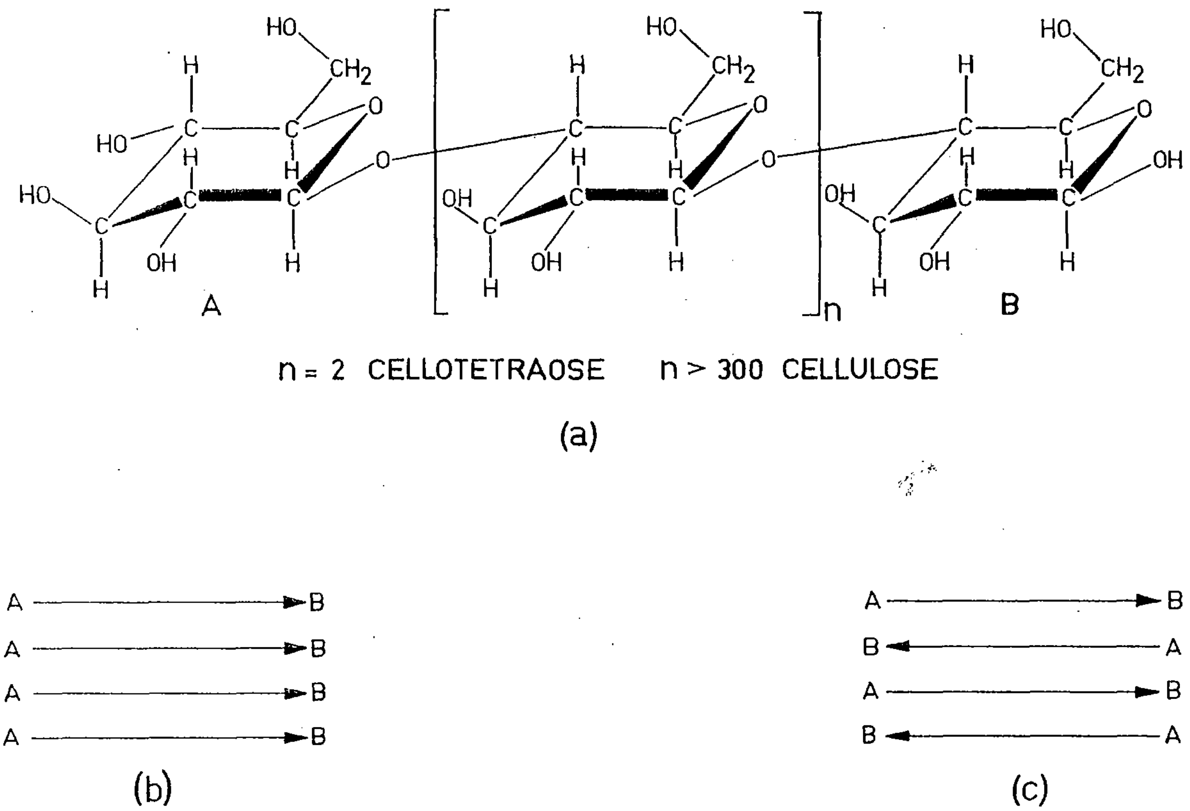


Fig. 2.—Cellulose.

molecules can be packed together to form a repetitive pattern that will fill space completely.

When a small crystal of a material such as sugar is placed in a beam of X-rays, it is found that the incoming beam is split into a number of subsidiary beams that emerge from the crystal in different but characteristic directions. What is occurring is that the planes of atoms that make up the crystal are acting as tiny mirrors to the incoming beam. Each set of parallel planes reflects in a direction that is characteristic of that set of planes.

From the characteristic directions of the emergent beams is obtained the size of the crystal's smallest repeating unit, which is most often formed of two or four molecules. From the intensity or relative brightness of the emergent beam it is possible then to deduce, in many instances, the shape and fine structure of the molecules of which the crystal is composed. In terms of the analogy mentioned above this can be expressed by saying that the direction of an emergent beam is the direction in which the plantation is viewed. If the plantation is looked at in a sufficient number of directions and the spacing between rows along each direction is recorded, the regular pattern in which the trees are set can be determined. The intensity (brightness) of the emergent beams in this case would then be a measure of how densely populated are the rows of trees in those particular directions.

In practice, for a small molecule such as sugar, information along 1000 of these directions is collected by measuring the intensity of each reflection. The next stage is to find a structure that yields a set of theoretically calculated intensities that agrees to within 10% of the observed set. It is only when such agreement is obtained that the correct structure has been found.

Unfortunately, the step of deducing a structure from the intensities is never straightforward: there are two major difficulties to overcome. Firstly, it must be decided with which planes in the crystal a particular reflection is to be associated. Secondly, direct observation provides only half the information necessary for a complete picture. Thus, from the intensity can be calculated a quantity (the structure factor) that is peculiar to a set of atomic planes, but to know where the atoms are placed it must be determined whether the quantity is positive or negative.* It would not be feasible to test all possibilities even with the fastest computers, as the number is astronomically large—for 1000 reflections this would be 1 followed by 300 zeros. Indirect methods must be used, and, although a number are available, none guarantees a solution to the problem.

This then is a brief outline of the steps and principles involved in a crystal structure determination from X-ray diffraction data.† With this background, some mention can now be made of the projects being undertaken in the Division by means of this technique.

The chemist has firmly established that cellulose is a long chain compound of β-glucose linked as shown in Figure 2(*a*). Although its chemical structure has been known for some time, no satisfactory description has been advanced as yet of the way the molecules are arranged in the solid. It can be seen from Figure 2(*a*) that the two ends of the molecule are not identical; one of the questions to be answered is whether or not the molecular chains are parallel, i.e. are the neighbouring chains arranged as in Figures 2(*b*) or 2(*c*).

Unfortunately, any structural study of natural cellulose, or even regenerated cellulose, is beset with considerable experimental difficulties. As a means of by-passing these difficulties the series of compounds containing an increasing number of β-glucose residues is being studied: a series with n of Figure 2(*a*) ranging from 0 to 4. The straight chain compound with $n=2$ (cellotetraose) has a number of properties (e.g. a critical part of its infrared spectrum) which suggest that it can be studied as an idealized form of cellulose II, or regenerated cellulose. In this material adjoining molecules actually run parallel to each other, i.e. the situation is as illustrated in Figure 2(*b*), but to date it has not been possible to establish whether this is also true of cellulose. This aspect is being studied further.

* Strictly speaking this is true only for centrosymmetric structures. For non-centrosymmetric structures the possibilities are infinite, as the structure factor is a complex quantity.

† The same description would also apply if the incident beam was composed of electrons or neutrons.

Other compounds being investigated include the simple carbohydrates and their derivatives. The interest in these compounds arises because they are the building blocks from which a number of naturally occurring polymers are assembled. By studying them it is hoped to gain information on the shape and flexibility of the molecules, which has bearing on the way they are packed in the solid, and the nature of the binding forces that hold the solid together.

With a clear understanding of such phenomena it may eventually be possible to suggest ways whereby the properties of the polymers may be tailored to suit particular requirements.

NEW ASSISTANT CHIEF

FOLLOWING THE RETIREMENT in June of Dr. W. E. Cohen, Dr. W. G. Kauman has been appointed Assistant Chief of the Division of Forest Products.

Walter G. Kauman, who is now 44, joined the Division in 1948, as a Laboratory Assistant in the Seasoning Section. Part-time study at the Melbourne Technical College gained him the Associateship Diploma in Applied Science in 1951, followed in 1952 by a B.Sc. in Physics from the University of Melbourne, with first-class honours and the Dixson Scholarship. Four years later, he was granted a CSIRO Studentship to study chemical physics under Professor I. Prigogine, at the Université Libre de Bruxelles, and in 1959, he became "Docteur en Sciences" with "grande distinction".

He is interested in transport phenomena and cell collapse in wood, and in the application of research results to industry, and his contributions have gained him an international reputation.

From 1962 until early 1965, Dr. Kauman was seconded to the Food and Agriculture Organization of the United Nations, to participate in a project in Chile. He established research facilities in the Instituto Forestal in Santiago, and coordinated research programmes in wood technology in five Chilean universities. He was also visiting professor at the Universidad Austral in Valdivia.

On his return to Australia, Dr. Kauman again took up his work in the Seasoning Section of the Division. In August 1966, he was appointed Acting Officer-in-Charge of Utilization, and since then has divided his time between the two sections.

He is the author of more than 30 papers, the majority on transport phenomena and theoretical problems associated with the drying of wood. Dr. Kauman is fluent in French, Spanish, and German.

DONATIONS

The following donations have been received recently by the Division:

Bowen & Pomeroy Pty. Ltd., North Melbourne	$50.00
Cellulose Aust. Ltd., S.A.	$100.00
Feiglin & Son, Nunawading, Vic.	$21.00
Hyne & Son, Maryborough, Qld.	$200.00
Timber Preservers' Association of Australia, S.A.	$50.00

Materials

Myrtleford Pine Preservation Pty. Ltd., Vic. Posts	approx. $25.00
Mrs. J. Davidson, East Hawthorn, Vic. Moisture meter	approx. $40.00

Visit to South America

MR. MERVYN W. PAGE, Experimental Officer of the Division's Utilization Group, left on 16 July on a 4-month round-the-world mission.

Earlier this year, the Australian Sawmilling and Related Equipment Manufacturers' Association approached the Commonwealth Department of Trade and Industry with a request to conduct a survey mission of the timber industry on the west coast of South America, and nominated Mr. M. W. Page to carry out this survey. The Division agreed to make Mr. Page available, and he will travel to Colombia, Ecuador, Peru, and Chile on behalf of the Department of Trade. He was also invited by the United States Forest Service to stop over at Hawaii for three days to help solve problems in the utilization of plantation-grown eucalypts. Additional brief stop-overs are scheduled in Mexico, Guatemala, Argentina, Uruguay, and Brazil.

While travelling to and from South America, Mr. Page will look at research centres and industrial plants on the west coast of the United States and in various European countries.

Printed by CSIRO, Melbourne

CSIRO

Forest Products Newsletter

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

REGISTERED IN AUSTRALIA FOR TRANSMISSION BY POST AS A PERIODICAL

NUMBER 344 SEPTEMBER 1967

1967##344

Obituary

GEORGE WILLIAM WRIGHT

WE deeply regret to inform our readers of the death of Mr. G. W. Wright, who passed away on 27th August at the age of 56, after a brief illness.

George Wright graduated in mechanical engineering from the University of Western Australia, and started his career in 1933 as Assistant Utilization Officer with the W.A. Forests Department. In 1936 he came to Victoria to join the Seasoning Section of the CSIRO Division of Forest Products and began his long and distinguished association with the Australian timber seasoning industry, an association that was to last until his untimely death. He has been fully responsible for the Division's work in this field since 1939, and in 1942 was appointed Officer-in-Charge of the Seasoning Section.

George Wright's contribution to timber seasoning is unique. It was under his guidance that seasoning research achieved the satisfactory drying of many difficult Australian timbers whose acceptance for high-class applications has been of great benefit to the national economy. His work and that of his staff on the principles of drying, the development of new types of driers, and the economics of seasoning, are held in high regard in industry, and it is largely to his credit that the seasoning position in Australia is so soundly based. The award of the M.E. degree from the University of Western Australia in 1949 recognized the profound academic knowledge of engineering science that lay behind G. W. Wright's very practical contributions.

His work achieved for him a high technical and personal reputation in the international sphere. During a world tour in 1949, he was Australian delegate to an FAO Conference on Mechanical Wood Technology held in Geneva, and in 1962, he attended the 8th British Commonwealth Forestry Conference in East Africa.

For more than 12 years he was convenor of the Timber Seasoning Corresponding Committee of the British Commonwealth Forestry Conference, and his advice was sought by colleagues and seasoning engineers from all over the world.

Mr. Wright's achievements are reflected

in more than 50 papers on the seasoning and utilization of timber. He was greatly sought after as a contributor to research and industrial conferences, where his clear exposition of both fundamental principles and practical problems of timber seasoning will long be remembered by all who were associated with him.

Radiata Pine as a House-framing Timber

By H. Kloot, Engineering Section

FROM ENQUIRIES, and sometimes complaints, received by the Division from time to time, it appears that doubt still exists in some quarters as to the suitability of radiata pine as a framing timber in domestic construction. In spite of the explanatory matter published in recent years to clarify the position, there seems to be a continuing feeling of uncertainty, in Victoria particularly, owing to the classification of green radiata pine as "below *D*" strength group in Pamphlet No. 112. This pamphlet is the sole reference in the Victorian Uniform Building Regulations to the allowable sizes of members in timber buildings and construction.

The following notes are intended not only to provide an unequivocal statement of the technical position regarding the use of radiata pine as a framing timber but also to draw attention to the more recent recommendations as to appropriate member sizes, particularly for studs.

Radiata Pine and Pamphlet No. 112

When Pamphlet No. 112 was first published by the Division in 1941, and even by the time it was revised in 1952, radiata pine scantlings for framed construction were not marketed in the dry condition to any extent, if at all. The reference to the timber as being of *below D* strength group applied, as with all the other species listed in the pamphlet, to its use in the green condition. That classification for green material remains substantially correct.* However, *it does not constitute a limitation on the use of radiata pine scantlings in the dry condition* when selected to the grading rules as set out in SAA Interim 377, Interim Grading Rules for Sawn Radiata Pine for Use as Light Framing Material, published by the Standards Association in 1959. In fact, the scope clause of this Interim Standard makes it quite clear that timber graded in accordance with its rules is to be regarded as being of strength group *D* for the purposes of using not only Pamphlet No. 112 but also the Timber Engineering Design Handbook, and Australian Standard AS O56 which is similar in context to Pamphlet No. 112.

There should be no doubt, therefore, that Pamphlet No. 112 does not limit the use of dry radiata pine scantlings graded according to SAA Interim 377. Unfortunately, no steps have been taken to have the Victorian Uniform Building Regulations amended to clarify this issue, and there has been a tendency amongst a few building surveyors to abide by what appears to be the strict letter of the law and interpret Pamphlet No. 112 as virtually excluding the use of radiata pine scantlings. It is hoped that by the time this article is printed, a firm declaration (clarifying the position regarding the use of dry radiata pine for building scantlings in Victoria) will have been given by the Uniform Building Regulations Committee.

Radiata Pine and Douglas Fir

Douglas fir (Oregon) and radiata pine, both being softwoods and readily available, are often compared in their use as framing timbers. An article dealing with this comparison was published in Newsletter No. 295. This article, copies of which may be obtained on request, makes the position regarding the comparative sizes of framing members in the two species abundantly clear, and requires no further amplification here.

However, when the article was published

* Although a change has been made to the strength grouping system as a whole (Newsletters Nos. 324 and 329), the position of radiata pine relative to other species has not been significantly altered.

the interim grading rules for Douglas fir (AS O106–1966) had not been prepared; therefore, a further point may be made. It was stated in the article that radiata pine scantlings in the green condition would perform the same functions as unseasoned Douglas fir of the same nominal sizes, providing they were *of the same grade* and *cut full to size*. However, the grading rules for radiata pine (SAA Interim 377) and for Douglas fir (AS O106) do not provide strictly comparable grades. It may be taken, however, that dry radiata pine cut full to size and graded to SAA Interim 377 is more than comparable with unseasoned Douglas fir of select merchantable grade as defined in AS O106.

Radiata Pine and the Draft Code of Practice

Many people, particularly in the timber industry, will be aware that a draft of a Code of Practice for Construction in Light Timber Framing has recently been issued by the Standards Association for public comment. When completed and finally promulgated, this Code, intended for Australia-wide application, will completely supersede Pamphlet No. 112 so far as recommendations of this Division are concerned. It will incorporate in its final form all the latest technical advice on the use of timber as a structural material that this Division, as an authority in this field in Australia, has been able to provide.

The draft Code provides for the use of $4 \times 1\frac{1}{2}$-in. dry radiata pine studs, whereas Pamphlet No. 112 allows only 4×2-in. studs in a group *D* timber. It is the Division's considered opinion that these dry $4 \times 1\frac{1}{2}$-in. studs may be used satisfactorily either at 18-in. or 24-in. spacing for single storey houses of traditional construction, whether tiled or sheeted. It is also considered that this size of stud is sufficient to carry trusses up to a 32-ft span if the roof is of iron or asbestos cement, but not tiles. On this question of stud sizes, it is interesting to note that the current Commonwealth Savings Bank Specifications for brick veneer and timber dwellings also specify $4 \times 1\frac{1}{2}$-in. studs in dry radiata pine.

Radiata pine is far too important to the timber economy of Australia for there to be any doubt about its satisfactory performance when properly seasoned, properly selected, and properly used. It is hoped that these notes will assist in removing any ambiguity as to the suitability of this species as a framing material.

In conclusion, it is perhaps timely to comment on the applicability of Pamphlet No. 112 as a whole. From one or two recent enquiries, it seems that a few people have the mistaken impression that it has already been superseded and is therefore no longer valid. Pamphlet No. 112, second edition published in 1952, is still the basis of Chapter 25 of the Victorian Uniform Building Regulations and retains the same legal standing now as it had when the regulations were first promulgated. As far as this Division is aware, it will continue to have this standing until such time as the new Code of Practice is not only completed but is substituted for Pamphlet No. 112 in the Uniform Building Regulations.

FINISHING OF FURNITURE TIMBERS

ALTHOUGH most of the enquiries received by the Division on the subject of natural timber finishes concern finishes for external use, it has come to our attention recently that some manufacturers are having difficulty in obtaining satisfactory natural finishes on timber for internal uses, such as furniture. In these cases, the difficulties reported concern poor bonding between the various components of the finish.

It is well known that in some cases the timber itself can be the cause of poor adhesion, particularly when the moisture content is excessive or the extractives content is high. However, the range of stains, toners, sealers, and lacquers now commercially available is extremely varied, and it is becoming increasingly important to ensure that the finished components are mutually compatible. If this is not done, flaking, peeling, and crazing of the finish can result. The most convenient method of preventing this is to obtain all components from the range provided by a single manufacturer and to follow his recommendations as to the most suitable choice of materials within this range. By following this procedure satisfactory results should be more readily obtained and much unnecessary wastage and expense avoided.

CONFERENCES

The 13th Forest Products Research Conference was held at the Division from 7 to 11 August.

Delegates were from all State Forestry Departments, the Forestry and Timber Bureau, Territory of Papua–New Guinea, the Forest Research Institute, New Zealand, and the Australian National University and University of Melbourne Forestry Departments.

In addition to reviewing the research activities of the various organizations represented, the Conference discussed many investigations and topics of vital concern to the development of forest utilization in its broadest sense.

Four officers represented the Division at the 3rd Australian Building Research Congress, held at Monash University (Melbourne) from 14–17 August. The Congress was organized by the Division of Building Research, CSIRO, and presented recent developments in the science, technology, and practice of building.

D.F.P. PUBLICATION ABSTRACTS

Experimental Analysis of Saw Tooth Stresses and Deflection by D. S. Jones, B. T. Hawkins, and E. McArthur. *Forest Prod. J.* **16**(11). (*D.F.P. Reprint 653.*) *Availability*.—Research workers.

STUDIES of the stresses occurring in saw teeth due to lateral load were made using both brittle lacquer and photo-elastic techniques. The results of these studies were combined with estimates of stresses due to normal and parallel forces to determine the optimum saw tooth shape.

As a result of these studies, a saw tooth with a gullet rounded from a point close to the top of the tooth is considered to have excellent stress distribution and stiffness, and is now being generally recommended to the Australian sawmilling and woodworking industries.

The Effect of Phenols on the Evaluation of Creosote and Petroleum Oil Admixtures by R. Johanson. *J. Inst. Wood Sci.*, 1966, **17**. (*D.F.P. Reprint 647.*) *Availability*.—Research workers and industries concerned.

THE AMOUNT of petroleum oil in creosote–petroleum mixtures can be estimated if triethylene glycol (TEG)-insolubles are first determined on the original materials. Vertical-retort creosotes have high phenolic contents and low TEG-insolubles. Removing phenols from these creosotes produces anomalous products with high TEG-insoluble values, but on addition of phenols these values return to normal. Transfer of phenols from creosote to petroleum oil reduces the insoluble fraction in the petroleum oil.

The removal of phenols from creosote with the accompanying effect on TEG-insolubles could mean a serious loss of preservative effectiveness.

A Simple Method for the Estimation of Copper–Chrome–Arsenic Wood Preservative in Poles by P. Rudman. Div. For. Prod. Technol. Pap. No. 45. *Availability*.—Wood preservation industry and analytical chemists.

THIS PAPER reports the investigation into a simple rapid method for the determination of copper–chrome–arsenic salt retention in preservative-treated wooden poles.

The salt is determined by weighing the ashed treated wood and correcting for the wood ash and changes in salt nature. A simplified method of carrying out the calculation is explained, and it is considered that such an estimation could be used in conjunction with results-type specifications. It is not intended that this method should replace determinations of individual elements in cases where this is possible or desirable, but rather that it should be used for an initial screening of the acceptability of salt-treated poles.

Printed by CSIRO, Melbourne

CSIRO

Forest Products Newsletter

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

REGISTERED IN AUSTRALIA FOR TRANSMISSION BY POST AS A PERIODICAL

NUMBER 345 OCTOBER 1967

1967##345

More Research on Utilization

MORE AND MORE, the timber industry is turning to modern production methods to meet growing competition and the need for greater productivity. For many years, the Division has built up research results on the problems now confronting industry, and today many firms are reaping the benefit of this earlier work.

However, the application of new methods brings new problems. More sophisticated equipment requires more sophisticated technical knowledge, new materials require new techniques, and changing market conditions require up-to-date management practices. Utilization research, traditionally concerned with individual conversion processes such as sawmilling, machining, and drying, must therefore be expanded to provide solutions to the new problems that will inevitably arise in the future.

This need for expansion of the research effort is reflected in the Division's current research programme, which contemplates an integrated approach to all phases of the conversion process—from trees to products required by the Australian economy. The integrated approach implies studies of production methods and equipment in relation to the basic properties of the timber as well as to the economic return achieved by the industry. It will require even closer coordination than hitherto between research teams concerned with the various aspects of mechanical conversion.

In the Division's traditional organization, the Sections most concerned with mechanical conversion processes were Utilization, Seasoning, and Plywood and Gluing. The departure for London last year of Mr. R. F. Turnbull, Officer-in-Charge of Utilization (Newsletter No. 332), and the recent untimely death of Mr. G. W. Wright, Officer-in-Charge of Seasoning (Newsletter No. 344), have deprived these groups of two of their most experienced officers. To achieve the integration of the various aspects of conversion required by the research programme, it has therefore been decided to place the activities of these three Sections under the overall leadership of Mr. J. W. Gottstein. Under him, the senior officers of Utilization, Seasoning, and Plywood and Gluing will be responsible for the work of their groups.

The combination of the Sections into one team will facilitate formation of *ad hoc* research groups to tackle particular tasks which cut across the boundaries of the traditional subjects, and will enable officers to maintain their close contact with the increasingly multi-sided production problems of the practical timberman.

The new conversion team will continue all the important research projects of the constituent Sections. At the same time, new work will be started, as indicated above, to meet the changing needs of the forest products industries.

Readers will be kept up to date on the research work in this field in future articles.

Assessing the Pulping Potential of Western Australian Timbers

By F. H. Phillips, Paper Science Section

THE NEED for increased utilization of timbers from the forest areas of the south-west of Western Australia has been apparent for some time. Such an increase, necessary for reasons related to both forest economics and forest management, could be achieved if a wood pulping industry based on local raw materials were established in the area. In the past, pulping and paper-making tests have been made on some of these timbers; in fact, some of the earliest pulping experiments in this country were carried out in Western Australia in 1918, initially on karri (*Eucalyptus diversicolor*) saplings, and then on other samples of karri and jarrah (*E. marginata*). Later studies in 1920–21, on the soda pulping of the principal eucalypts in immature form, also included Western Australian woods along with timbers from other States.

A detailed assessment of the pulping and paper-making properties of the three main eucalypt species, jarrah, karri, and marri (*E. calophylla*) from forest areas in the south-west of the State, has now been carried out at the Division of Forest Products. It has been estimated that the wood resources of this area could meet the needs of a large pulp mill without interfering with the present or future needs of existing industries.

Although Western Australia has no natural softwoods, pine plantations are being established. Thus, in addition to the hardwoods, increasing quantities of long-fibred species, particularly thinnings of *Pinus pinaster* (maritime pine), will become available as further plantations are established and as existing plantations reach an age suitable for thinning. For this reason *P. pinaster* was included in this investigation.

The wood samples used for this work were representative of the raw material that on present indications would be available to supply a pulp mill in the area. In all, over 200 different specimens were used, comprising (i) normal forest improvement thinnings of marri, karri, and jarrah (25–30 years old) collected at random from Pemberton and in the Pimelia district and including butt, centre, and crown logs from each tree sampled; (ii) butt, centre, and top logs from small (7 ft g.b.h.), medium (10 ft g.b.h.), and large (15 ft g.b.h.) trees of mature marri (estimated ages 130–400 years); (iii) karri and jarrah sawmill waste collected at random over a 3–5-week period from mills considered as potential suppliers to a pulp mill; and (iv) butt logs of *P. pinaster* thinnings (6–8$\frac{1}{4}$ in. diam. under bark) from a plantation at Pemberton.

A general assessment of the paper-making characteristics of these woods may be obtained from a knowledge of their fibre characteristics, wood density, and chemical composition, as indicated in a previous article (Newsletter No. 338). However, in this instance more detailed information was required and pulping and paper-making tests were carried out. When making such an assessment consideration must be given to numerous factors, but the procedure is at least simplified if either the type of pulping process to be used commercially or the nature of the paper or paperboard products to be made is known. In this study it was assumed that the paper and pulp grades required would include those suitable for medium- to high-strength products such as unbleached wrappings, pulps for subsequent bleaching operations, or higher-yield pulps for paperboard. Pulps were therefore prepared in the laboratory from both hardwood and softwood species: first by the sulphate process, to determine the potential of these woods for the production of pulps suitable for a wide range of products; and second by the neutral sulphite semichemical (NSSC) process, to give high-yield pulps for lower-grade products. Refiner groundwood pulping of softwood chips was also carried out to prepare mechanical pulp for certain papers and paperboards.

Chemical pulps were made by treating wood chips with cooking liquor in laboratory digesters under pressure at 160°C for 3 hr. The resulting pulps were, in most cases, readily separated into free fibres by mild disintegration. Semichemical pulps were obtained from chips cooked at 170°C for 2 hr and subsequently treated in a laboratory defibrator to achieve fibre separation. The refiner groundwood pulp was also prepared using the defibrator but without any preliminary chemical treatment. Paper handsheets were then made from these pulps and tested for strength and other relevant properties.

Papers made from thinnings of marri, karri, and jarrah pulped by the sulphate process each had similar strength properties, although the jarrah pulp was produced in lower yield. Jarrah NSSC pulp, however, had somewhat poorer paper-making properties than karri and marri NSSC pulps from thinnings. It was found that mature marri required greater amounts of cooking chemicals than did thinnings for satisfactory pulp preparation and, while tearing resistance was superior, all other properties were inferior to those of pulps from thinnings. Tests also indicated that samples of marri of different ages gave sulphate pulps with varying paper-making properties. Pulps from karri and jarrah sawmill waste were inferior to pulps from thinnings of the same species. However, some improvement could be obtained by careful selection of the sawmill waste because wood from the outer portions of trees of both jarrah and karri gave pulps with better paper-making properties than wood from near the centres.

The preparation of the necessary pulps from the various wood samples and the determination of paper-making properties are not the end of an assessment such as this. There is still the question of what constitutes acceptable quality in any of the pulps and papers prepared. In the absence of specific knowledge of the requirements of a particular industry or market, some other basis for comparison is necessary. Throughout this work the assessment of potential was made by comparison with results on other wood species used for commercial pulp production. For hardwoods, a sample of mixed eucalypt species (ash-type) from Gippsland, Vic., was used for comparison, whereas the *P. pinaster* thinnings were compared against *Pinus radiata* grown in the eastern states of Australia.

Satisfactory chemical, semichemical, and refiner groundwood pulps were obtained from *P. pinaster* thinnings. As expected from the fibre properties, the bonding strengths (tensile, burst, and folding endurance) of paper from *P. pinaster* sulphate pulp were lower than those from *P. radiata* pulp, but tearing strength was higher. These results indicated that *P. pinaster* thinnings from Western Australia should be a suitable raw material for various pulping processes.

As stated above, the paper-making properties of karri, marri, and jarrah thinnings were superior to mature wood and sawmill waste of the same species. However, the sulphate and NSSC pulps from these thinnings gave papers with lower bonding strengths than did the sample of mixed eucalypt species (ash-type) processed under similar conditions. Papers made from a mixture of karri and *P. pinaster* pulps had much better tearing strength than those made from 100% karri pulp; other strength properties showed little change.

D.F.P. PUBLICATION ABSTRACTS

Air-drying Behaviour of Poles and Posts of *Eucalyptus viminalis* by J. E. Barnacle, F. J. Christensen, and L. E. Cuevas. Div. For. Prod. Technol. Pap. No. 48. *Availability.*—Industries concerned.

THE EFFECT of various treatments on the dried quality of poles was examined. These treatments were sap ringing before felling, drying at stump, stack covering, end coating, end restraint, and soaking in sodium chloride solution prior to drying.

The effect of height in stem and distance from pith on moisture content in the tree at the time of felling was determined.

The drying rate of sapwood and outermost heartwood was obtained for each treatment. The sapwood of poles dried to 25% moisture content in 1–2 months (summer) was not influenced by pole diameter or sapwood thickness.

The dried quality of control material was commercially acceptable and no special treatment was necessary for poles from north-east Victoria. Results for poles from south-west Victoria, however, indicated that if excessive cut-back wastage was to be avoided a greater excess length allowance would be required.

Results also indicated that the "typical" end splitting pattern, i.e. extension of growth splits, is modified if the tangential collapse shrinkage intensity tends to be high.

Fence posts cut from either the tops of pole-trees or saplings in north-east Victoria were dried satisfactorily without special treatment.

Optical and Electron Microscopy of Papers made from Chemical Pulps by G. W. Davies. *Appita*, 1966, **20**(1), 21–31. *D.F.P. Reprint 666.*

AN electron-microscopic examination has been made of paper hand sheets formed from pulps produced by the sulphate and the soda processes. As in a previous, similar study using cold soda and NSSC (neutral sulphite semi-chemical) pulps, bonding of a very intimate nature was found, and large spaces and the absence of fines were also noted. Evidence is given to show that the beating process has a marked effect on conformability, and therefore increases the number of possible bonding areas but does not alter the type of bond formed.

Radiata Pine and Pamphlet No. 112

THE USE of radiata pine as a house-framing timber was discussed in some detail in last month's Newsletter, particular reference being made to its use in accordance with Pamphlet No. 112 as part of the Victorian Building Regulations. To put the technical position beyond all doubt, the Division has arranged to have the following statement inserted in all copies of Pamphlet No. 112 held in stock. Those wishing to have this note in their own copies of Pamphlet No. 112, without having to deface this Newsletter, may obtain a copy on request to the Chief, Division of Forest Products, P.O. Box 310, South Melbourne, Victoria 3205.

PAMPHLET NO. 112
BUILDING-FRAMES: TIMBERS AND SIZES

Explanatory Note to Second Edition—1952

The reference on page 11 to radiata pine as being "below D" Strength Group applies, as with all of the other species listed, to its use in the green condition. However, when seasoned and selected in accordance with the grading rules of SAA Int. 377—Interim Grading Rules for Sawn Radiata Pine for Use as Light Framing Material, issued by the Standards Association of Australia, radiata pine is to be used in the sizes as tabulated in Pamphlet No. 112 appropriate to common grade,* Strength Group D timbers.

R. W. R. Muncey,
Chief, Division of Forest Products, CSIRO
August 1967

*** Although the grading in SAA Int. 377 is not the same as for "common grade" for hardwood species, this method of classifying dry radiata pine is, at present, the most convenient for determining appropriate member sizes from Pamphlet No. 112.**

The Victorian Building Regulations Committee has been officially advised of the Division's action in this matter.

Printed by CSIRO, Melbourne

CSIRO

Forest Products Newsletter

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

REGISTERED IN AUSTRALIA FOR TRANSMISSION BY POST AS A PERIODICAL

NUMBER 346 NOVEMBER 1967

1967##346

Paper is Safe in 1700°F Fire

By W. M. Harlow* and A. H. Bishop†

Editor's Note.—The following article appeared in the September 1966 issue of "Woodworking Digest", published by Hitchcock Publishing Company, Wheaton, Ill., U.S.A. As the protection of valuable documents against fire is a common problem, it was felt that the article would be of general interest. It is reprinted with the kind permission of the Editor of "Woodworking Digest".

WOOD burns, as everyone knows, and steel, used in filing cabinets and storage boxes, does not. However, the effect of fire on the containers should be considered secondary to how well they protect their contents. Make an experiment: hold a lighter under the opened cover of an ordinary one-thickness steel cash box. Place your hand on the top surface of the cover. It will be only three minutes or less before the cover is too hot to touch.

What about Steel?

Paper stored in metal files and boxes will be cremated in three to ten minutes, depending upon how fast the temperature rises as a fire sweeps through an office or home. Even asbestos-lined steel boxes will not protect their contents for much more than ten minutes. Specially insulated steel boxes are available which will protect their contents one hour from a fire reaching a maximum temperature of 1700°F. Such boxes, with a capacity of 1 cu ft and certified by the Underwriters' Laboratories, cost between $40 and $80 and weigh about 90 lb. Four-inch-thick redwood fire walls have withstood intense fire and remained standing after all other combustible material was consumed, while the surrounding structure of unprotected steel beams had collapsed in complete ruin. Five- to six-inch-thick redwood vaults now are used to protect valuable records from fire.

Wood, with its intricate structure of billions of air-filled cells, is a poor conductor in contrast with steel. Light a wooden match or even a paper match (which is made from wood), and notice that as the flame burns towards your fingers, the match stick remains cool. You finally drop the match because the flame is too hot and not because the unburned part is too hot to hold.

Why Wood?

The rate at which wood burns varies somewhat with the species. West Coast redwood seems somewhat more fire-resistant than the wood from some other species.

Experiments at the U.S. Forest Products Laboratory indicate that wood exposed to fire burns from the outside in at about $1\frac{1}{2}$ in. per hour. Initial flaming lasts only until a layer of charcoal is formed on the surface. The charcoal then reduces the

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<< Content

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Temperature under both boxes ranged from 1600 to 1700°F for 30 min. After 30 min, plywood box (Douglas fir) $1\frac{1}{2}$ in. thick contained undamaged papers. Papers were cremated after 3 min in steel cash box.

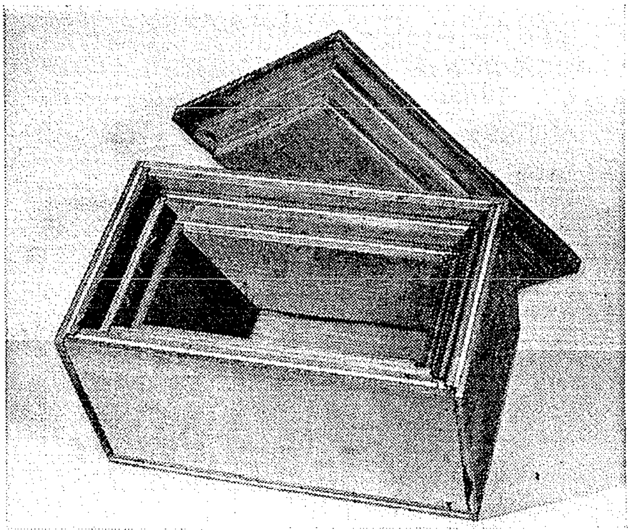
temperature and consequently the rate of further combustion. It is interesting to note that the carbon-graphite fibres used in the high-temperature-resisting re-entry cones of space vehicles and missiles are derived from rayon, a wood product, and the principle of progressive charring is similar to that in fire-resistant storage boxes.

Test Indications

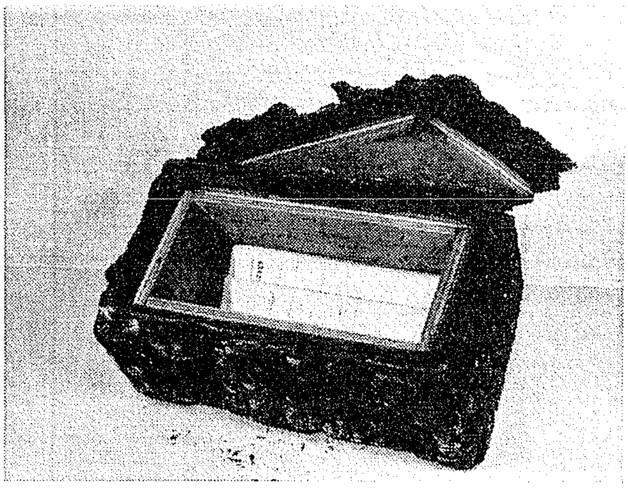
In our experiments, we found that the destruction of the sides, top, and bottom of wooden test boxes subjected to fire under controlled conditions is somewhat more rapid than the $1\frac{1}{2}$ in. per hour usually assumed. However, a wooden chest properly made with a thickness all around of 3 in. should compare favourably with the specially insulated steel chests. The box we made was constructed of $2\frac{1}{4}$-in.-thick material instead of the recommended 3-in. thickness, and not treated in any way. This box protected its documents against fire on all six sides for a full hour. A thermocouple under the box (air circulation was provided) indicated temperatures of 1600°F to 1740°F throughout the test. At the end of one hour, the box was cooled with a water sprinkler, and opened. Although the documents were safe, a crosswise fissure had developed up through the bottom of the box and there was some charring at one point, but still no break-through inside. This is why 3-in.-thick sides, top, and bottom should be provided rather than the $2\frac{1}{4}$-in. thicknesses that we used. Regardless of thickness, the plywood must be free of interior spaces. Ship-grade or marine-grade plywood should be specified.

Jointing and Adhesives

Take special note of how the box is con-



Redwood box measures $4\frac{1}{2} \times 4\frac{1}{2} \times 10$ in. inside. It is three thicknesses of $\frac{3}{4}$-in. plywood, with recessed construction and resorcinol adhesive.



Redwood box exposed to fire for 1 hour. Temperatures underneath ranged from 1600 to 1740°F.

structed at the corners with carefully machined tight-fitting, overlapping joints. Both bottom and top also are constructed the same way. The type of glue or adhesive used is extremely important. We recommend a resorcinol adhesive because the glue bond must withstand a temperature of at least 1700°F.

The weight of a 3-in.-walled redwood chest with a volume of 1 cu ft inside, will be about 55 lb. If this seems heavy, remember that the specially insulated steel box weighs some 90 lb.

How do you fasten the cover of such a wooden chest? This poses a problem since metal fastenings reduce the insulating efficiency of the wood. Three vertical dowels glued inside each side of the cover, with corresponding dowel holes in the box, will keep the cover in place. The chest should rest on the floor.

The Atomic Energy Commission at Oak Ridge already has tested successfully a fire- and drop-resistant, wooden, steel strap-bound shipping case for containing radioactive materials. They state that "surprisingly enough, treated wood has shown special resistance to both these hazards". Certainly, an industry possessing such a remarkable material as wood might explore the possibilities of profitably producing fire-resistant containers and a multitude of other products for various purposes.

Failure of a Diving Board

By W. Keating, Engineering Section

LAST swimming season, a laminated timber diving board at a Melbourne suburban pool failed after only one season's use. As far as could be ascertained, the recommendations set out in the Division's Technical Note No. 2, "Manufacture, Maintenance and Repair of Diving Boards", had been followed, and the reason for the failure was not immediately obvious.

Fracture occurred at the fulcrum position, which, of course, is where the board is subjected to its maximum stress. In this area of the board on its lower side were a number of severe compression failures, which suggested the possibility of overloading. While measurements showed most of the board to be at 17% moisture content, which is appropriate for the service conditions, the portion that had been located immediately above the rubber fulcrum roller was in the 30–40% range. This would be consistent with the board having been overloaded, as the rupturing of the paint film that would accompany the formation of compression failures would permit the timber to absorb moisture at this point.

However, a simple experiment showed that the sequence of events may have been rather different from that envisaged. By vibrating a board on a rubber mounting with water dripping onto the top face and some running down the sides, as is common in normal use, it was found that water was actually drawn in between the rubber and the board. Under these circumstances, it would appear that a film of water on top of the fulcrum could be in constant contact with the lower side of the board. Now, if water vapour were able to pass through the paint, or if minute failures of the paint layer allowed moisture pick-up in the timber, the strength of the board at this point would be significantly lowered, as emphasized in Technical Note No. 2. This situation could permit failure to occur without the board being subjected to abnormal loading conditions. Until further investigations are carried out, it is felt that this explanation is just as likely as the first.

Simple immersion-type tests duplicating service conditions are currently being conducted on several paint and other systems to determine the best way to prevent moisture absorption in diving boards. Meanwhile, attention is drawn to the need for careful maintenance and the provision of an extra, or "resting", board.

Another Course for Sawmill Executives

In November 1966 and in February 1967, courses entitled "Latest Developments in Sawmilling Equipment and Techniques" were run by the Division. The two courses, which were attended by some 60 executives of sawmilling companies throughout Australia, comprised three days of lectures and a 2000-mile tour of inspection of mills in eastern Victoria and southern New South Wales, the total time involved being 16 days. Details of the coverage of the course and an indication of the scope of the lectures were published in the *Australian Timber Journal* for January 1967 (p. 14).

The Division hopes to run another similar course in March 1968, but, before making any definite plans, would like to have an estimate of the likely interest.

Sawmill managers and executives of companies engaged in milling who would be interested in attending this course are therefore requested to advise the Division as soon as possible.

ARSENICAL CREOSOTE

By R. Johanson, Preservation Section

FOR SOME TIME, fortification of Australian creosotes with suitable termiticides has been investigated, and it is now considered desirable. In particular, concern has been caused by a number of recent instances of termite attack in creosoted eucalypt poles. For health and economic reasons it appears that arsenic offers advantages over other termiticides. Investigation by the Division has shown that Australian vertical retort creosotes have a small but adequate affinity for arsenic. When introduced into hot creosote arsenic trioxide dissolves, and then reacts chemically with the creosote constituents, forming numerous arsenical combinations.

Experimental evidence shows that this arsenical creosote, once formed, is quite stable. It does not deposit arsenic on cooling, nor is there any separation of arsenic on the surface of the treated wood. It was found that arsenical creosote is a heterogeneous mixture of various arsenical compounds. Some of these fix strongly in wood, and are extremely resistant to leaching with water and to extraction with organic solvents.

Experiments against *Coptotermes acinaciformis* and *Nasutitermes exitiosus*, which are economically important and widely distributed termites in Australia, have shown that arsenical creosote is a highly effective termiticide. The concentration of arsenic proposed for the commercial treatment of poles is at least four times as high as that required for control of termites under experimental conditions. It is expected that a concentration of 0·4 to 0·5% arsenic trioxide equivalent in the creosote will provide a powerful barrier to termites in protection of the treated sapwood in *Eucalyptus* spp. The cost of the arsenic at these concentrations should be less than 0·4 cent per gallon of arsenical creosote.

Corrosion studies with various metals showed that arsenical creosote behaves similarly to standard creosote, and no corrosion problems are expected either in the treating plants or in use of treated wood.

In a commercial pressure treating plant in Victoria, about 8500 gal of arsenical creosote, containing 0·46% As_2O_3 equivalent, was prepared by introducing arsenic trioxide (As_2O_3) through a device consisting of a 44-gal drum, a stirrer, and a pump. The creosote was allowed to flow continuously, under gravity, from the cylinder into the drum, and the arsenic was added in 5- to 10-lb lots and maintained in suspension by stirring. The arsenic-laden creosote was continuously pumped back from the drum into the treating cylinder and circulated through the heating system, to maintain the temperature at 180°F to 200°F. With this simple method, it appears that in 30 minutes, 500 lb of arsenic could be introduced into the plant system, enough to prepare 10,000 gal of arsenical creosote.

The behaviour of arsenical creosote in the commercial pressure treating plant proved very satisfactory. No evidence of sludge or other adverse effects was observed, and the surface of treated poles of *Eucalyptus cypellocarpa* and *E. obliqua* was at least as clean as that of the poles treated with standard creosote. It was also found that penetration of arsenical creosote into the treated poles was similar to that obtained with standard creosote. The treatment of poles with fortified creosote is being continued at this commercial plant. The arsenical creosote and the treated poles are safe to handle and the Department of Health, Victoria, considers that there is no hazard to be expected from the treated poles in the plant or in the field.

The initial commercial application of fortified creosote has been successful, and the Division of Forest Products is now recommending that the use of arsenical creosote for treatment of poles be extended. Further information may be obtained by writing to the Chief of the Division.

Printed by CSIRO, Melbourne

CSIRO

Forest Products Newsletter

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

REGISTERED IN AUSTRALIA FOR TRANSMISSION BY POST AS A PERIODICAL

NUMBER 347 DECEMBER 1967

1967##347

The Pulp and Paper Industry

Part I — History

By H. G. Higgins, Paper Science Section

Editor's Note.—There is a widening interest in the application of forest resources to the production of pulp, and the Division receives numerous enquiries for information on the pulp and paper industry. It was therefore decided to publish the following article, which was prepared originally for presentation to a Symposium on the Process Industries, held in Melbourne early in 1967. It will be continued in succeeding issues.

PAPER was first made in China at some time near the beginning of the Christian era. Its invention is sometimes attributed to Tsai Lun, an engineer at the Imperial Court. Hemp, rags, ropes, and other materials were pounded in a mortar with water and the beaten pulp was spread out on a loosely woven cloth through which the water drained, leaving a web of wet fibres which when semi-dry could be peeled off and dried in the air. Later, thin strips of bamboo tied together with silk thread were used as a mould or mesh.

It was not until about 700 years after its invention that the art of paper-making spread to the west through Samarkand, where Chinese paper-makers had been made prisoners by the Arabs. From there it spread to Baghdad, Egypt, and Morocco. In the twelfth century the Moors carried the craft into Spain and the Italians brought it from Palestine. Gradually, the techniques of paper-making became known in most European countries, and a paper mill was established in England towards the end of the fifteenth century.

At the end of the eighteenth century a machine was invented for making paper continuously instead of in batches. The fourdrinier machine, as it is now called, has continued to develop since that time in width, speed, and size. Earlier in the eighteenth century a machine for beating the fibres was invented by a Dutchman, and became known as the Hollander beater. Another notable advance later on was the invention of the refiner (a machine that clears the pulp of clumps or knots and can be used as a continuous beater).

The raw materials for paper-making through the ages had been flax and hemp and, much later, cotton, but in the nineteenth century wood pulp and grasses were introduced for this purpose. Groundwood, made by feeding a billet of wood against a grindstone, was introduced by Keller in Germany in 1840. The sulphite pulping process was developed by Tilghmann in 1866, and the sulphate process by Dahl in 1884. All these methods of producing wood pulp are still of major importance and a number of important modifications have been introduced.

The Industry in Australia and New Zealand

Some handmade paper was produced in New South Wales as early as 1818, but it was not until half a century later that the industry was properly established in Australia with the starting up of two mills equipped with paper machines, one at Liverpool, N.S.W., the other in Melbourne. A long period was to elapse, however, before indigenous woods were to be used to provide pulp. Following investigations and trials in southern Europe and Australia, it became apparent that some eucalypts could be used successfully for paper-making, provided a proportion of long-fibred pulp was incorporated in the furnish. Hardwoods, of which the eucalypts form an important group, are characterized by relatively short fibres (in the vicinity of 1 mm), whereas the softwoods, which were used first for wood pulping in the northern hemisphere, have considerably longer fibres (usually about 3 mm). Without a certain proportion of the longer fibres it is impossible to obtain suitable tearing strength, but in most other respects the paper made from eucalypts is of good quality if the fibres have been suitably processed.

In 1937, eucalypt sulphate pulp was produced on a pilot-plant scale at Maryvale, Vic., and these operations were expanded rapidly to produce wrapping papers and other grades. In 1938, soda pulping was commenced on a commercial scale at Burnie, Tas., for the production of writing and printing papers, and in 1941, the commercial manufacture of newsprint was commenced at Boyer, Tas., from a furnish containing a large proportion of eucalypt groundwood. With these developments, the pulp and paper industry (as distinct from paper-making) had really arrived in this part of the world, and in the last quarter century a rapid growth has taken place that has lifted these operations to the status of a major industry.

After the war, kraft pulping of radiata pine commenced at Kinleith, N.Z., to be followed by the production of newsprint from pine groundwood and sulphate pulp at Kawerau and board production at Whakatane. The large pine plantations in the North Island have provided the basis for this vigorous New Zealand industry, and in Australia the use of exotic pines, which have flourished in this environment, also has expanded rapidly and has gone some way towards meeting the demand for long-fibred pulps. At Millicent, S.A., groundwood has long been made from radiata pine and combined with waste paper to make boards; while in an adjacent mill radiata pine is now pulped by a bisulphite process and made into tissues.

One of the most significant developments in recent years is the application of high-yield pulping to the eucalypts. The more traditional methods of chemical pulping lead to the utilization of only 40–50% of the wood substance, but by combining chemical and mechanical treatments in order to effect fibre separation, it is possible to recover 70–80% of the wood as utilizable fibres. A successful mill has been established at Port Huon, Tas., in which eucalypt chips are converted to pulp in high yield by the neutral sulphite semi-chemical (NSSC) process. The pulp is pelleted and transported to Botany, N.S.W., for use. A chemi-mechanical process is used at Petrie, Qld., for converting pines to a pulp suitable for board manufacture, and at Boyer, a cold soda process is used for producing a pulp which can be combined with groundwood to provide a furnish that will permit the newsprint machines to run faster. The cold soda process is also used at Burnie, alongside the counter-current digester which operates as a hot soda process.

These activities by no means exhaust the ramifications of the industry in Australia and New Zealand. Considerable expansion and rationalization of the installations at several of the sites mentioned have taken place in recent years, and, in addition, paper or board manufacture has flourished at Shoalhaven, N.S.W.; Broadford, Vic.; Fairfield, Vic.; Spearwood, W.A.; in the South Island of New Zealand; and at various mills in Sydney, Melbourne, and Brisbane. The fairly closely related activity of building board manufacture is now to be found at Burnie, Sydney, Bacchus Marsh (Vic.), Ipswich (Qld.), and Auckland. The rather more distant process, technically speaking, of particle board manufacture is sometimes associated organizationally with pulp and paper or hardboard manufacture, and some large companies also maintain highly mechanized sawmills.

Parallel with this vast industrial complex, there is an extensive programme of forestry operations directed primarily towards a few indigenous *Eucalyptus* species and exotic *Pinus* species, of which the most important is *P. radiata*. Attention is divided between the very old eucalypts, which have certain disadvantages connected mainly with their high extractives content, and the younger regrowth trees. Pulping operations do not provide sufficient fibre for paper and board manufacture in Australia, and large quantities of pulp are imported. In New Zealand, this situation is reversed, considerable quantities of pulp being exported to Australia and other countries. Another source of fibre, as far as the immediate cycle of manufacture is concerned, is waste paper, and large collecting organizations exist in the major centres.

Tracer Activation in Forestry Research

By D. E. Bland, Physiology and Microstructure Section

RADIOTRACER methods have now been used extensively for some aspects of forestry research for many years. Tracer methods have also been applied very widely in investigation of biosynthetic pathways. These methods involve handling radioactive materials and feeding them to plants. In the laboratory the difficulties associated with the use of radioactive material usually can be coped with quite effectively. In field experiments the difficulties become much more apparent, particularly when large quantities of radiotracer have to be used and the possibility exists of radioactive material being scattered over a wide area.

Reports have now reached the Division of the results of experiments conducted at the Technical University of Hanover, under the direction of Professor H. Glubrecht, of the Institute of Radiobiology. Working in this Institute, Fendrik has developed a method for the investigation of pollen distribution from forest trees. Disregarding all safety problems, this could have been done simply by feeding a radiotracer to the tree and then detecting the radioactive pollen grains in the neighbourhood by some suitable means. These grains obviously would be derived from the labelled tree, but safety considerations would greatly complicate the use of this method and a radioactive tree would be left in the forest.

These workers solved the problem by the use of a tracer activation method. The experimental tree was injected with a suitable inactive tracer. The two principal requirements of an inactive tracer are that it is not toxic to the tree and that it can be readily activated, that is, made radioactive by irradiation. The substance chosen for these experiments was manganese, which was injected into the tree as manganese sulphate in dilute aqueous solution.

After a suitable period pollen specimens were collected at various distances from the experimental tree. These specimens were irradiated in an atomic reactor, and the pollen grains that became radioactive were detected simply by placing the irradiated pollen on photographic plates. This is the method of autoradiography. The natural manganese content of pollen was very low in comparison with the manganese content of the pollen from the experimental tree, which, therefore, was very much more radioactive than the pollen grains from other trees and could easily be distinguished from them. In this way it was possible to trace the pollen flight from the experimental tree without the use of any radioactive material in the field. It seems that this method of tracer activation might be applied to other problems in forestry and forest products research.

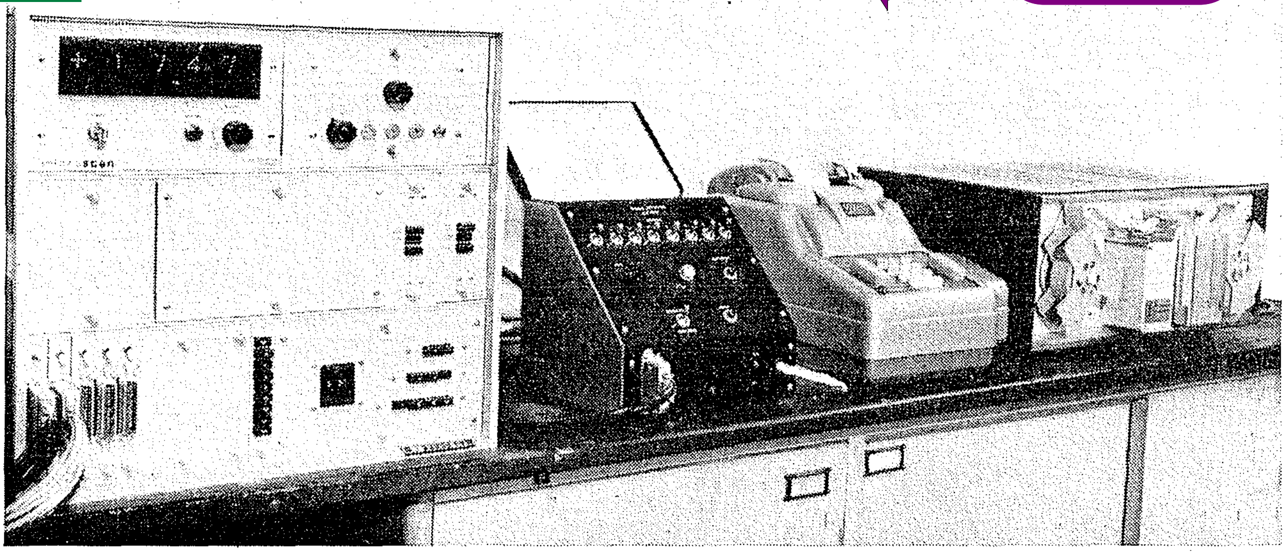
DONATIONS

The following recent donations are gratefully acknowledged by the Division:

A. A. Swallow Pty. Ltd., Melbourne ..	$200
Wilkinson's Timber Industries, Brisbane	$15
J. & T. Gunn, Launceston	$100
Mr. P. Vogel, Kallista, Vic.	$10
Timber Engineering Co., Sydney ..	$200
Automated Building Components (Aust.) Pty. Ltd., Melbourne ..	$100

Materials

Kauri Plywoods Pty. Ltd., Melbourne
1 sheet of waterproof pine plywood for experimental purposes approx. $10



Data logging equipment. From left, data logger with digital display, punch actuator, strip printer, and tape punch.

New Equipment in Timber Research

FOR MANY YEARS the rate of progress of most forms of research has been restricted by the number of man-hours required to observe and record results.

Recently the Division acquired a data logging system that will partially overcome this problem. If the quantities to be measured can be converted to electrical voltages, then they can be connected directly to the input of the data logger. The results can be in the form of a digital display, typed by means of a strip printer or punched on paper tape. If required, the three methods of obtaining results can be used simultaneously. The punched tape can be used directly with the CSIRO computer situated at Clayton, Vic. This means that if an appropriate computer programme is used, results obtained on punched tape from the data logging system can be fed directly into the computer and experimental results analysed much more quickly than by former methods.

The data logging system includes a digital voltmeter which is capable of reading d.c. voltages from a maximum of 1000 volts to a minimum of 10 microvolts. The unit is capable of scanning up to 50 channels at rates of 1, 2, 4, or 10 channels per second. However, the strip printer is limited to one channel per second and the paper punch to two channels per second. It is possible to obtain continuous scanning or a single scan of the selected channels. With the unit set for a single scan, it is possible to obtain delay times of 1, 2, 4, 8, 15, 30, 60, or 120 minutes between scans. It is also possible to read continuously any one selected channel.

As a simple example of how the system may be used, a small wooden beam, simply supported at both ends and loaded at the centre, was set up with strain gauges mounted at various points along the beam. The load was measured by means of strain gauges on a load cell. The electrical outputs of the circuits associated with the strain gauges on the beam and load cell were scanned by the data logger at several different values of the load. The readings were obtained in the form of punched paper tape. An appropriate computer programme was worked out and the results fed into the computer, which gave the strain at the various points along the beam under each load condition.

There are many more ways in which the system can be put to efficient use. In a case where 50 channels must be read at almost the same time, the data logger can scan and record these 50 channels in 25 seconds. An example of this would be measuring the air flow at 50 points in a drying kiln. Also, if one channel needs to be read 1000 or more times, the data logger simplifies a very tedious and time-consuming task.

In many cases the data logging system should make it possible to conduct experiments that were previously considered to be impractical.

Printed by CSIRO, Melbourne