PROCEEDINGS

FIFTH ANNUAL

FOREST PRODUCTS RESEARCH CONFERENCE

HELD AT

THE DIVISION OF FOREST PRODUCTS,

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION,

MELBOURNE

OCTOBER 9-13, 1950

VOLUME 1

DIVISION OF FOREST PRODUCTS
COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION
MELBOURNE

TECHNICAL MATTER FOR DISCUSSION
AT FIFTH ANNUAL
FOREST PRODUCTS RESEARCH CONFERENCE

To be held at
Division of Forest Products
Commonwealth Scientific and Industrial
Research Organization
Melbourne.

October 9 - 13, 1950.

VOLUME I

TECHNICAL MATTER FOR DISCUSSION AT THE CONFERENCE

NOTE: This material was assembled and the volume circulated some weeks prior to the conference. The subject matter contained herein was used as a basis of discussion. Additional material presented at the conference is included, together with discussion, in Volume II of these proceedings.

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* Technical matter has been assembled in the order of "Agenda Item Numbers". Page numbers of each subdivision are appended to the agenda numbers.

THE FIFTH ANNUAL FOREST PRODUCTS RESEARCH CONFERENCE

The Conference was held at the Division of Forest Products, Commonwealth Scientific and Industrial Research Organization, Melbourne, October 9th - 13th inclusive, 1950.

REPRESENTATION

Commonwealth Forestry and Timber Bureau	Mr. H.R. Gray Mr. J.P. Hauser
Commonwealth Department of External Territories, New Guinea Administration, Department of Forestry	Mr. J.B. McAdam
Forestry Commission of N.S.W., Division of Wood Technology	Mr. E.B. Huddleston Mr. L.K. Bryant Mr. E.R. Fogl
Queensland Forestry Department	Mr. C.J.J. Watson Mr. K.V. Cokley Mr. G. Littler
Victorian Forestry Commission	Mr. C.J. Irvine
Tasmanian Forestry Commission	Mr. H. Payne Mr. T.G. Walduck
Woods and Forests Department of South Australia	Mr. J. Thomas
Forests Department of Western Australia	Mr. G.E. Brockway
Defence Research Laboratories, Department of Supply	Mr. J.M. West Mr. K.L. Bussell
Division of Forest Products, C.S.I.R.O.	Mr. S.A. Clarke and Officers
Division of Entomology, C.S.I.R.O.	Mr. F.J. Gay
Building Research Liaison Service of Department of Works and Housing	Mr. R.E. Banks Mr. W.P. Brown
Forestry School, University of Melbourne	Mr. J.H. Chinner
Division of Industrial Chemistry, C.S.I.R.O.	Mr. L.K. Dalton Dr. J.S. Fitzgerald
Division of Building Materials, C.S.I.R.O.	Mr. B. M. Holmes
Dairy Research Section, C.S.I.R.O.	Mr. A.J. Lawrence
Associated Timber Industries of Western Australia	Mr. F. Gregson

(Chairman: Mr. S. A. Clarke, Division of Forest Products, C.S.I.R.O.)

BUILDING BOARDS FROM FOREST WASTE *

The work of Dalton on the preparation of waterproof tannin-formaldehyde adhesives from tannins extracted from local barks led the Division of Wood Technology, in 1949, to investigate the possibility of reacting catechol tannins, in situ, with formaldehyde.

Preliminary experiments with Euc. crebra bark using primitive equipment and pressures of 50 lb./sq.in. and temperatures of 100°C. showed some promise. It was found that, considering the pressures and temperatures used, quite a strong bond was formed due to the presence of the tannin-formaldehyde resin. At this stage we obtained the services of a chemical engineer who was able to proceed with the more developed experiments which followed.

Using an experimental veneer press the work was extended to white cypress pine. The press was modified by placing a 2" thick steel block on the bottom platen and surrounding this with a wooden frame which acted as a mould. Many boards were made using various proportions of white cypress pine bark and sawdust and the best conditions for making a standard board were found to be 130°C. and 300 lb./sq.in. for six minutes. It was found that a whole range of boards could be made from this species depending on the proportion of bark used. In addition to tannin, this bark contains about 10%, by weight, of a natural resin which flows under pressure and heat, helping the formation of a satisfactory board. Almost all the work done to date has been on a 50/50 mixture by weight, of bark and sawdust using 1% solid paraformaldehyde. Mechanical and physical tests on these boards have shown a modulus rupture of 2,000 to 2,500 lb./sq.in. with a density of about 62 - 63 lbs./cu.ft.

Water absorption has shown a high correlation with density, ranging from 5% to 30% water absorbed in 24 hours

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* Prepared by the Division of Wood Technology, N.S.W.

and a total absorption from 27% to 66%. Hardness, as measured by the ball drop test, and density had a high correlation on a series of tests done on 43 sections of one typical board.

Two boards, 4' x 2', have been made using a 50/50 mixture, by weight, of white cypress pine bark and sawdust on a commercial plywood press. The press limited the size of the board because of its pressure limitations. One board was made allowing the pressure to be released over a period of 1½ minutes and another using a quick unloading device. The first was, by far, the most satisfactory, blowing being experienced in the second. Blow holes were easily repaired, however, by re-pressing for two minutes. The board was made by spreading the mixture fairly evenly on a sheet of aluminium in a wooden surround. The wooden surround was removed and the aluminium sheet placed on the bottom platen of the press. The aluminium buckled when it started to heat on the platen thus disturbing the even distribution of the mixture. Further, there were no sides surrounding the mixture and some flow of powder took place resulting in the board having rather an exaggerated edge effect. Apart from these difficulties, which are partly associated with the technique and can be easily overcome with the correct plant, no difficulty was experienced in the manufacture.

During the period of the Royal Easter Show the only bark and sawdust readily available for the Commission's exhibit was radiata bark and sawdust. This was tested and found to be reasonably suitable but as the boards made at the exhibit were really to show the technique of manufacture to the public all that was required of them was that they should stay in one piece. Subsequently, however, we have found that 50% bark, 50% sawdust mixture of <u>Pinus radiata</u>

gives a board which is equal to, if not better than the Callitris glauca board. It does not appear possible to make the same range of bark-sawdust mixtures as with Callitris glauca, as the all bark radiata board is far too brittle to be nailed and high sawdust contents make the board extremely weak. An average modulus of rupture figure for 142 samples taken from 16 boards all manufactured from the same mixture under the same conditions showed a modulus of rupture of 2180. Six of these boards were also tested for tensile strength and gave a result of 1300 lb./sq.in. (range 1090 - 1620).

Boards made from Callitris glauca under the same conditions gave tensile strength of 990 lb./sq.in. (range 900 - 1105). The water absorption and density tests of these have not yet been done.

Using the same conditions of temperature and pressure as with the above species we have explored, in a very preliminary fashion, the barks of Euc. rostrata, Euc. dalrympleana, Euc. siderophloia and Euc. radiata and have obtained consistently good, although quite varying results. The Euc. radiata sample was by far the most interesting, producing a board very much more stable in a three-hour boiling test than masonite. It seems to have possibilities for external sheeting. We have also tested turpentine, north coast spotted gum, south coast spotted gum, flooded gum, brush box, bloodwood, red gum sawdust, and blackbutt, but found that our results were extremely erratic. Bark and/or sawdust alone were used in most cases. Euc. dalrympleana and spotted gum (ex north coast) sawdust alone gave interesting boards. The barks of all these timbers did not appear to be promising. We have since found, however, that the properties of a board may be directly related to the freshness of the material and/or its moisture content. A series of tests are being carried out to indicate whether or not this is correct but so far we have had difficulty in getting uniform material. Of course, if the board can be pressed from green bark and sawdust and its properties are improved at the same time it will further reduce the cost of production as drying plant will not be required.

A few boards have been made from hardwood sawdust at high temperatures and pressures, one at 800 lb./sq.in. and 180°C. More work is required on this, however, to see whether consistent results can be obtained. The boards made so far are rather uneven in strength from the centre outwards.

With the Euc. radiata bark we are fairly satisfied that the fibres do not play a major role in board formation. There is some evidence that the kino present in the bark plays a part in board formation and this is at present being investigated.

RAIL SLEEPERS

High Pressure Preservation Treatment*

Since the last Conference, work in this project has been mainly concerned with the design and preliminary testing of auxiliary equipment associated with the new high pressure cylinder. Installation of the high pressure plant and modification of the existing low pressure plant are now in progress.

In co-operation with the Victorian Railways and the Victorian Forests Commission, preliminary details have been decided as to timber species, preservatives, test localities, and number of sleepers. Briefly, these details are as follows:-

Four eucalypt species - E. obliqua, E. australiana, E. regnans, and E. eugenioides will be impregnated in sleeper sizes at high pressures with creosote and fuel oil mixtures, a creosote and coal tar mixture, 3 per cent. pentachlorphenol in fuel oil, and 5 per cent. copper naphthenate in fuel oil.

Untreated controls of these species will also be installed, and for comparison a small number of Pinus radiata sleepers will be treated at low pressure (200 lb./sq.in.), probably with a creosote and fuel oil mixture.

These species were selected because it was considered that they are likely to become available in considerable quantities for use as sleepers in a few years. Special attention has been paid to the possibility of using forest thinnings (especially of E. regnans) for this test, and sleepers of each species will be cut in at least two, and up to five localities in order to cover variations in species.

A minimum preservative loading of 5-6 lb./cu.ft.

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* Prepared by the Preservation Section, Division of Forest Products, C.S.I.R.O.

has been set and preliminary tests will be made to determine the highest moisture content at which each species can be treated. The minimum air seasoning period is desirable in view of the shortage of sleepers.

The test localities will include:-

(a) A metropolitan line with metal ballast, moderate to heavy traffic, and moderate rainfall.

(b) A dry climate with gravel ballast, and moderate traffic.

(c) A wet climate with moderate traffic and gravel ballast.

A fourth locality for comparing metal and gravel ballast in a restricted test will be set up. It is also intended to investigate the effect of seasoning on the development of end splits and checks in sleepers, and a number of end coats will be applied to sleepers as soon as they are cut, to gain information on their effectiveness.

About 700 sleepers of each species will be treated and in each locality there will be no less than 32 replications for each species-treatment combination. Sleepers will probably be laid to a face in lots of 192, each lot being a complete test unit which will be replicated 4 times in the one locality. The effect of pre-boring and, if necessary adzing, will also be included in the test, as will the effect of plating. The specification which is appended has been accepted by the Victorian Railways and the Victorian Forests Commission for the purposes of this particular test, and cutting of sleepers is now proceeding. One hundred and fifty Western Australian sleepers (50 each of karri, marri and jarrah) are now awaiting treatment for the W. A. Government Railways and these will be probably the earliest batch of timber to be treated in the new cylinder. Arrangements have also been completed with the Commonwealth Railways for the supply of 50 sleepers for high pressure treatment to be installed in the Port Augusta - Leigh Creek line, where their degree of resistance to mechanical breakdown should be of great interest.

In addition to sleepers, it is proposed to impregnate at high pressure a number of crossarm timbers including E. obliqua, E. pilularis, and E. diversicolor. These will also be pre-bored and framed before treatment and will be treated at the highest moisture content possible. The preliminary tests on crossarms will probably be followed by the treatment of some 2,000 crossarms for installation in service tests.

So far as the other States' requirements are concerned, it is considered that Tasmania is covered by the proposed test of Victorian sleeper species, and Queensland have now forwarded some 10 species for pilot tests. With the current programme of work, it appears unlikely that major treatments of large numbers of sleepers can be undertaken within the next 6 months. As seasoning of timber for high pressure treatment is likely to take 2-3 months, however, it is desirable for the States to notify us of their requirements in ample time to allow for the seasoning period.

SPECIFICATION FOR SLEEPERS TO BE USED IN HIGH PRESSURE PRESERVATIVE TREATMENTS

Size: At the time of cutting, sleepers shall measure from nominal up to ¾ in. over in width and from nominal to ½ in. over in thickness. For the purpose of this investigation, sleepers are required to be cut 6 in. longer than normal, i.e. 9 ft. 6 in., with a tolerance of plus or minus 1 in. The additional length is required since end coating will be used, this being subsequently removed before treatment. The cross section is to be 10 in. x 5 in.

Grade Description:

(a) Sleepers shall be sound wood, cut square and straight and shall not be quarter cut.

(b) Provided that the strength, durability and spike holding capacity at the rail seat of the sleepers are not unduly impaired, the following defects will be permitted:-

- (i) Gum veins
- (ii) Gum pockets up to 6 in. x ½ in. at the rail seat and 10 in. x ½ in. away from the rail seat
- (iii) Shakes or checks not greater than 4 in. from the end of the sleeper
- (iv) Pinholes
- (v) Camber or twist not exceeding ½ in.
- (vi) Sound tight knots, if clear of the rail seat, not exceeding 3 in. diameter
- (vii) Knotholes, if clear of the rail seat, not exceeding 2 in. diameter
- (viii) Sloping grain not exceeding 1 in 4
- (ix) Sapwood
- (x) Wane or want not exceeding at the rail seat 1¼ in. measured on the bevel of each of two edges or 2 in. if occurring on one edge only
- (xi) Heart, in sleepers cut from "twoor" blocks providing that ring shakes are not present and the heart is not decayed
- (xii) Grub holes, free of the rail seat
- (xiii) Decay - minor pockets only of primary rot.

PRESERVATION OF FENCE POSTS*

The work of the Division of Forest Products on the preservation of fence posts is fairly well known to most members of the Conference, and therefore, a brief summary should suffice to remind members of the present status of these tests.

The first fence post test was set up in Western Australia in 1930, in co-operation with the Forests Department of that State. It consisted of posts cut from saplings of eight relatively non-durable species available from local sources. The posts were of two classes, "natural rounds" from saplings of 4 to 6 in. in diameter, and "split" from saplings of up to 8 in. in diameter. Several preservative treatments were used. Similar tests were established in Victoria in 1934, and in New South Wales in 1936, using local timbers and the two most promising treatments from the W.A. tests, or modifications of them.

One of the expressed aims of the Western Australian test was "to provide information for a bulletin on the preservative treatment of these timbers (saplings of non-durable species) for the use of farmers in W.A." This objective has been fulfilled, in part at least, by the publication of the article "The Preservative Treatment of Fence Posts" by N. Tamblyn in our News Letter No. 139. From the News Letter the following quotation is taken:-

> "The principal tests were installed in 1930-31 to demonstrate that round fence posts of relatively non-durable timbers could be treated simply, effectively and cheaply without special equipment. The results over 16 years have shown conclusively

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*Prepared by the Preservation Section, Division of Forest Products, C.S.I.R.O.

that many timbers regarded as unsuitable for posts on account of low natural durability will give long and satisfactory service, if treated by the method described below".

The treatment referred to is the open tank butt treatment with creosote, or creosote plus oil, or with zinc chloride plus arsenic. The creosote mixtures are the more effective. From these tests it is evident that although the treatments are effective on the buried portion, posts of this type may fail in the above-ground portion. Some form of top treatment is therefore necessary and the most simple is full length open tank treatment.

There is little question about the demand for fence posts at all times, and the obvious advantages to Forest Departments of being able to sell thinnings etc. as posts. Once prejudice has been overcome and a market for treated fence posts created, it is probable that it would pay the Forest Departments to sell their thinnings in the treated state, thus gaining the advantage of large scale operations, uniformity and reliability of treatment, and additional revenue.

However, the availability of an effective treatment, and the willingness of the Forest Departments to supply suitable thinnings for treatment, or alternatively treated posts, is not sufficient. The people who would erect or require fences must be made aware of this source of material and it must be competitive in price and service with split posts of the traditional type.

In order that the rural and pastoral communities should be educated to the use of treated timber for fence posts, the Division considers that there should be uniformity of recommendation between all States and ourselves (e.g. full length open tank treatment of seasoned timber with creosote plus oil), that publicity should be arranged, that the interest of Soil Conservationists and Agriculture Departments should be enlisted and that Demonstration fences should be erected. These fences could well be placed around State Forests and Agricultural Research Stations and Schools and along main roads, and carry prominent notice boards saying that the fences are treated to increase their service life.

As a beginning, this Division, in co-operation with the Victorian Department of Agriculture, has arranged to establish a treated fence line at the Potato Research Station, Toolangi, near Healesville. It is proposed to treat a number of the posts on one of the Station's field days, when there should be a large number of people present.

Publicity, direct approach and visual demonstration, particularly the latter, are essential if pastoralists and farmers are to enjoy the benefit of research work on the preservation of fence posts and if the Forests Departments are to sell the material that should normally be removed as thinnings. It is in this regard that the opinions and assistance of members of the Conference are sought.

<u>TIMBER PRESERVATIVES - PHYSIOLOGICAL EFFECTS</u>

In conformity with a resolution of the Fourth Forest Products Research Conference that the Defence Research Laboratories prepare a statement on the health hazards associated with the use of sodium fluoride, the following paper has been submitted.

This paper has been prepared by the Information Section of Defence Research Laboratory and covers a summary of information available on the physiological effects of boric acid, pentachlorphenol and sodium fluoride.

TIMBER PRESERVATIVES - PHYSIOLOGICAL EFFECTS

The available information on the physiological effects of pentachlorphenol, sodium fluoride and boric acid is listed. No references have been found to injuries specifically incurred from the use of these compounds as timber preservatives but careful handling particularly of pentachlorphenol and sodium fluoride is desirable. The three compounds are included in an economic poisons for which warnings on labels are required. Details are quoted.

PENTACHLORPHENOL

Irritation of the skin and dermatitis may be caused by contact with this substance, an oil solution or emulsion of it, or an aqueous solution of sodium pentachlorphenate (1).

Harmful results may occur if fumes are inhaled and a concentration of 0.5 mg./cu. metre has been suggested as a "threshold limit" (3).

SODIUM FLUORIDE

This compound is toxic and may cause skin injury. Inhalation of finely divided particles can cause irritation of the nose and throat also the fluoride may be absorbed into the system with harmful results. "Fluoride dusts and smokes" are listed in the schedule to the "Amending Harmful Gases, Vapours, Fumes, Mists, Smokes and Dusts Regulations 1949" Victoria Department of Health and it is recommended that the concentration in the atmosphere should not exceed 1 mg. per cubic metre of air, unless special protective measures are taken (7).

BORIC ACID AND SODIUM BORATE

No harmful results have been reported other than by accidental ingestion of a quantity (11).

(Note: Ingestion of pentachlorphenol or sodium fluoride will cause injury).

REFERENCES

PENTACHLORPHENOL

1. CARSWELL, T.S. and HATFIELD, I.
Pentachlorphenol for wood preservation.
Ind. & Eng. Chem. 31, 1431 (Nov. 1939).

Toxicological studies indicate that pentachlorphenol is not a cumulative poison, but that excessive doses can cause death.

An oil solution of pentachlorphenol or water solution of its sodium salt causes irritation and dermatitis if allowed to remain on the skin a sufficient length of time. This dermatitis clears rapidly after exposure to the chemical is discontinued and the lesions heal without scars or other residual effects.

Toxicological data (animal experiments) have been collected by H. Bechhold and P. Ehrlich, Z. physiol. chem. 47, 173 (1906) and by R.A. Kehoe, W. Deichmann-Gruebler and K.V. Kitzmiller, J. Ind. Hyg. & Tox. 21, 160 (1939). The use of protective garments is recommended.

2. INTERNATIONAL LABOUR OFFICE
Phenols.
Occupation and Health Brochure No. 305.

Information on toxic properties of phenols is given. The chlorinated ... compounds of phenol have a caustic effect analogous to that of phenol and perhaps even more pronounced. It is stated that occupational poisoning by phenols is not very common.

3. TOPP, N.E.
Methods for detecting dangerous gases in Industrial Plants. B.C.S.O. Report No. 626.

A table of "threshold limits" for toxic fumes includes pentachlorphenol - 0.5 mg. per cu. metre (values recommended by Committee on Threshold Limits at 9th Annual Meeting of the American Conference of Governmental Industrial Hygienists).

4. UNITED STATES DEPARTMENT OF AGRICULTURE

Interpretation with respect to warnings, caution and antidote statements required to appear on labels of economic poisons.

Regulations for the enforcement of the Federal Insecticide and Fungicide and Rodenticide Act, 14.11.49.

i. Pentachlorphenol (except oil solutions or emulsions) - 5% and above. Warning - harmful if inhaled or swallowed. Do not breath dust. Avoid contact with eyes, skin or clothing. Wash thoroughly.

ii. Oil solutions or emulsions 3% and above. Warning - harmful if swallowed or absorbed through skin. Causes skin irritation. Do not breathe vapor, fumes or spray mist. Do not get in eyes, on skin or on clothing. Wash thoroughly.

SODIUM FLUORIDE

5. U.S. PUBLIC HEALTH SERVICE
Health of workers exposed to Sodium Fluoride at Open Hearth Furnaces.
Bulletin No. 299.

(From Labour and National Service Library 613. 63P. UNI. (Pub. 1948).

Fluorides are regarded as general protoplasmic poisons, but their effect is altered according to the chemical compounds and amounts involved in the specific exposure. Gaseous fluorides, such as hydrogen fluoride and silicon tetrafluoride, are very toxic because of their solubility and reactivity. The undissociated hydrogen fluoride molecule is capable of penetration of the intact skin and may exert a systemic effect, as well as its corrosive local action.

Cryolite (Na_3AlF_6) on the other end of the solubility scale has a low toxicity, as have the other almost insoluble fluorides. Since these compounds are not very irritating they are inhaled in large amounts without causing much cough and slowly absorbed to produce chronic poisoning or fluorosis. Outstanding symptoms of fluorosis are anorexia, vomiting, constipation, dyspnea on exertion, and rheumatic pains.

Relatively easily soluble fluorides and fluosilicates are classified as having high toxicity. Sodium fluoride falls in this latter group which is intermediate in the toxicity scale. Local corrosion is more pronounced from the extremely toxic group but may also occur from sodium fluoride. Skin changes range from erythema to coriaceous changes which may progress to ulcers. Blisters and pustules are fairly common and loosened finger nails are said to occur. Irritation of the mucous membranes also occurs and results in sneezing, coughing, and chemical bronchitis. Hydrogen fluoride has been shown to be a harmful agent as a pulmonary irritant and volatile poison. Outstanding in the experimental phase is the work done by McClure et al., who showed that up to 4 to 5 milligrams of sodium fluoride can be excreted daily without storage or harmful effects.

Other work indicates that inhaled fluorides are effectively absorbed. When absorption is great, a certain amount of storage occurs. Within limits, urinary excretion may be used as a measure of fluoride storage since the magnitude of urinary fluoride excretion varies directly with the amount absorbed.

Acute poisoning from sodium fluoride is not of industrial importance and occurs almost entirely from accidental or intentional ingestion. A lethal dose varies from 5 to 15 grams when taken by mouth. It produces a hemorrhagic enteritis which progresses to death from shock. Small amounts of sodium fluoride may be swallowed by industrial workers and may cause anorexia, nausea, and vomiting.

6. MEDICAL RESEARCH COUNCIL
Industrial Fluorosis (1949)
Memorandum No. 22.

This includes a comprehensive review of literature on toxicity of fluorine compounds.

Regarding toxic dosage to animals -

Peirce (1939) suggested that the amount of fluoride necessary to bring about toxic symptoms depended on the nature of the compound, the duration and method of intake, the amount of other dietary substances, and the species and age of the animal .... The toxicity of fluorine compounds appears to be greater when they are ingested in solution than in solid form.

7. HEALTH ACTS. DEPARTMENT OF HEALTH, VICTORIA
"Amending Harmful Gases, Vapours, Fumes, Mists, Smokes and Dusts Regulations 1949".

Concentration of "Fluoride dusts, smokes" listed in schedule is 1 milligram per cubic metre of air. If concentration is in excess of this either suction exhaust apparatus should be installed or suitable respirators provided.

8. MILLER, H.C.
Safety with Fluorine Chemicals - Plant operating and first aid methods.
C.T.J. Feb. 17, 1950. p.382.

Neoprene is recommended for manufacture of protective gloves and apron, and other protective devices for use when handling hydrofluoric acid are listed. Cotton or canvas gloves should not be used for soluble fluorine chemicals.

9. COOK, W.A.
Maximum allowable concentrations of Industrial Atmospheric Contaminants.
Ind. Med. 14, 936 (Nov. 1945).

Referring to hydrogen fluoride - 3 ppm. has been generally accepted as a maximum allowable concentration.

10. UNITED STATES DEPARTMENT OF AGRICULTURE
Regulations for enforcement of the Federal Insecticide and Fungicide and Rodenticide Act. Warnings, caution and antidote statements required to appear on labels of economic poisons.

Fluorides (1) Inorganic, water soluble fluorides 10% and above

Warning: May be fatal if swallowed: Do not breathe dust. Do not contaminate feed and foodstuffs. Keep out of reach of children and domestic animals.

Inorganic water soluble fluorides below 10%

Caution: Harmful if swallowed: Avoid prolonged breathing of dust. Avoid contamination of feed and foodstuffs. Keep away from children and domestic animals.

BORIC ACID AND SODIUM BORATE

11. MARTINDALE
Extra Pharmacopoeia, I, 34 and II, 8

The properties and uses (mildly antiseptic) are described. The only cases of poisoning reported have been from accidental ingestion of a quantity (1 teaspoon).

12. UNITED STATES DEPARTMENT OF AGRICULTURE
Regulations for enforcement of the Federal Insecticide and Fungicide and Rodenticide Act. Warnings, caution and antidote statements required to appear on labels of economic poisons.

Borax and Boric Acid 20% and above

Caution: Avoid contamination of feed and foodstuffs. Keep away from children and domestic animals.

THE LABORATORY EVALUATION OF TIMBER PRESERVATIVES*

1. INTRODUCTION.

The rapid development in recent years of new preservative treatments for timber has drawn attention to the need for more convenient quantitative methods of measuring the effectiveness of a new preservative. In most cases, our knowledge is not yet sufficient to predict this with any certainty from the chemical composition of the preservative, so that each preservative must be tested by exposure to whatever agent of deterioration it is intended to counteract. Deterioration of timber in normal service is usually a comparatively slow process, so an accelerated form of test is required. Because standardization of experimental conditions is essential to obtain reproducible results, there are great advantages in conducting exposure tests under laboratory conditions. There have been considerable advances recently in the development of laboratory methods of testing timber preservatives. Elsewhere in this Conference, reference will be made to laboratory tests of preservatives for use against termites and against the Lyctus borer; the following discussion is concerned only with preservatives used to protect timber against decay, i.e. against attack by wood destroying fungi, and the word "preservative" is used for convenience in this restricted sense.

2. DEVELOPMENT OF LABORATORY TECHNIQUES FOR THE EVALUATION OF PRESERVATIVES.

The first laboratory method of evaluating preservatives to be standardized and widely used was the

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*Prepared by the Preservation Section, Division of Forest Products, C.S.I.R.O.

agar plate toxicity test. In this the preservative is incorporated in various concentrations into nutrient agar jelly and the growth of the test fungus on this is then compared with its growth on untreated agar. Preservatives are usually compared on the basis of the total inhibition point (T.I.P.) which is the minimum concentration which must be present in the nutrient agar to inhibit completely the growth of the test fungus. Conditions of the test can be closely standardized and highly reproducible values of the total inhibition point determined in 2 - 3 weeks. This test has been used extensively, especially in U.S.A., during the past 35 years, and because any successful wood preservative must be at least moderately toxic to wood-destroying fungi, it does enable a preliminary screening-out of the less promising preservatives, but it is not a satisfactory technique for evaluating preservatives. The agar medium in which tests are made is very unlike the wood medium in which preservatives are used and no account is taken of the permanence of the protective effect. The agar plate toxicity test is, however, invaluable for more fundamental studies of the effect of chemical composition on toxicity, where a large number of compounds are to be compared and where highly reproducible results are required.

A considerable advance was made with the development of the wood block toxicity test. Small test blocks of a species which decays readily and which may be readily impregnated are treated with various loadings of the preservative and then exposed to attack by selected wood destroying fungi in pure culture. The amount of attack after some months incubation is measured in terms of the loss in weight of the blocks attributable to decay.

Preservatives are compared on the basis of the minimum loading required to give complete protection from attack. When the wood block toxicity test was originally developed in England and Europe about twenty years ago, the test fungus was established on nutrient agar and the test blocks placed in contact with the fungus. This method is still widely used, but most recent work in U.S.A. and Canada has been done with the test blocks buried in, or resting on the surface of, moist sterile soil.

The wood block toxicity test has the great advantage that it actually measures the effect of the preservative in protecting wood from decay and that the conditions often approach the conditions under which decay occurs in service. At the same time, by using carefully selected test fungi under standardized conditions, it is possible to obtain closely reproducible results in 3 - 4 months. It is still not possible to measure how long the protective effect of the preservative will last, and since the permanence of the preservative is a major feature, the wood block toxicity test is not in itself a good means of evaluating preservatives. However, it has recently been combined very effectively with <u>accelerated weathering tests</u> to give the first really satisfactory laboratory method of evaluating preservatives.

With the new procedure, test blocks are impregnated with various loadings of the preservatives under test and are exposed to various intensive weathering treatments before being exposed to decay in wood block toxicity tests. The weathering treatments may either be of a natural type, (e.g. exposure to sun, wind and rain for 12 months), or purely laboratory treatments such as intsensive leaching in distilled water, sometimes followed by mild oven drying to remove volatile constituents. Obviously, none of these accelerated weathering treatments can claim to reproduce the very complex changes which occur in the natural weathering of treated timber, particularly that in contact with the soil. It is assumed, however, that the ability of a preservative to withstand these laboratory treatments without losing its protective effect would be closely correlated with its ability to withstand natural weathering. Just how high is this correlation can be determined only by exhaustive comparison of laboratory results with field tests and service data on the same preservatives, but it is expected that the results of the laboratory tests give a reliable indication of the relative performances of preservatives, especially those of the same general nature.

Much of the development of these laboratory test methods is now being done in U.S.A. under the auspices of the American Wood Preservers' Association, with the object of setting out a standard laboratory procedure for measuring the effectiveness of wood preservatives. The intensive development of the wood preserving industry in U.S.A. has raised many problems which can only be settled in reasonable time by such a rapid laboratory method. For example, weathered block tests have recently been used to investigate the relative effectiveness of types of fuel oil as a carrier for pentachlorphenol and creosote and also to investigate the performance of complex mixtures of creosote, pentachlorphenol, copper naphthenate and crude oil in various proportions. The latter investigations indicate that some such mixtures may have greater effectiveness at lower chemical costs than any straight preservative.

3. WORK IN THE DIVISION OF FOREST PRODUCTS.

At the Division of Forest Products arrangements have been made to use this "weathered block" technique in the investigation of a number of problems connected with timber preservatives.

One problem to be studied is the relative effectiveness of a number of water soluble preservatives with special reference to their possible use on mining timbers, building materials and other uses where cleanliness, paintability and lack of odour are important. Some twenty water soluble preservatives will be used to impregnate mountain ash sapwood blocks for testing. In this work, the accelerated weathering technique will consist primarily of an intensive leaching by continuous shaking in frequently changed distilled water for some weeks. The blocks will then be tested for resistance to decay and further tests made with the more promising preservatives.

Another preservative being investigated by the Division is copper naphthenate, which has been used increasingly in recent years. Considerable chemical differences exist among the naphthenic acids produced in different refineries and hence in the copper naphthenates manufactured from them. Investigations were therefore commenced some time ago to determine whether these differences were sufficiently important to explain some of the inconsistent results obtained with copper naphthenate, or to justify a restricted specification for copper naphthenate to be used for timber preservation. The first stage of this investigation, consisting of a study of the chemical variation in crude and in purified naphthenic acids and the copper naphthenates manufactured from them, and of the effect of these chemical variations on the toxicity of the material as determined by a modified agar plate toxicity test, is now well advanced and the interim results are fairly clear.

The crude naphthenic acids from different sources vary considerably in toxicity, and it has been found that their relative toxicity is closely correlated with the acid number of the naphthenic acid itself. Removal of the unsaponifiable matter which is present as an impurity may increase the acid number but does not appreciably affect the toxicity. Copper naphthenates are always considerably more toxic than the naphthenic acids from which they are prepared, but their relative toxicity is correlated with that of the specific naphthenic acid used in their preparation. This correlation cannot be completely explained by the variation in copper content caused by preparation from naphthenic acids of different acid number, since the correlation still exists when toxicities are compared at equivalent copper concentrations. Work has also been carried out on the fractional distillation of naphthenic acids to provide material of more defined chemical composition for these tests.

These tests will enable selection of types of copper naphthenate which can be compared in wood block toxicity tests and in accelerated weathering tests. In this work, the accelerated weathering procedure will probably take the form of exposure to sun, wind and rain for some months, accompanied perhaps by leaching tests and by burial in non-sterile soil.

Apart from these intensive investigations, the general reliability of the laboratory evaluation will be assessed by conducting correlative laboratory tests on preservatives which are included in future small specimen and pole tests, so obtaining a comparison between the laboratory, field and service results. Only by such comparisons, and the systematic investigation of the causes of any discrepancies, can a completely reliable laboratory method for the evaluation of timber preservatives be evolved.

THE PRESENT POSITION OF PRESERVATIVE TREATMENT OF LYCTUS SUSCEPTIBLE TIMBER IN QUEENSLAND*

1. OBJECT.

It is proposed in this paper to review the history and development of anti-lyctus treatment in Queensland for the purpose of acquainting delegates to this Conference with the present position.

2. SCOPE.

The subject will be discussed under the following headings:

(a) Early history
(b) Treatment of veneer
(c) Treatment of sawn timber
(d) Legislation
(e) Associated problems
(f) Avenues of research

A number of subsidiary problems still exist and it is felt that the suggestions of the Conference will be of assistance for their solution.

At the conclusion of this paper it is hoped to demonstrate by slides the average type of plant installed in Queensland.

3. EARLY HISTORY

Queensland holds, with the exception of New Guinea, a unique position in Australia ranging as it does from sub-tropical to tropical climates resulting in a very large percentage of secondary species. The major portion are susceptible species with economically significant depths of starch-containing timber. Up to the mid-thirties these were rejected in favour of the pines and first class hardwoods such as the ironbarks, and the stringybarks. However,

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* Paper prepared by the Forest Products Research Branch, Queensland Forest Service.

as the supply of these diminished, the secondary species, which included the high grade fancy and cabinet woods, came into prominence. Accordingly research on their utilization, principally by the Division of Forest Products, increased and the first applications were made in our State where at Austral plywoods trials were conducted on silicofluorides which were soon replaced by boric acid. These trials were followed by the installation at Brisbane Sawmills of the first "Boiling Vat" for veneer treatment. Other mills soon followed the lead and the process became established in the plywood industry.

In the field of sawn timber two avenues were examined, the first being the "Hot Immersion" process proposed by Gregory of the Division of Forest Products, and the second "Starch Depletion" methods by A. R. Brimblecombe of the Queensland Department of Agriculture and Stock. Extension of the first method was carried out by A. R. Brimblecombe and G. L. Cook and a range of 14 species was thoroughly examined. Special credit must be given for the efforts of these two research workers whose studies played a major part in establishing the commercial possibilities of treatment in the State. The second method, viz. "High Ringing" was satisfactory especially to species such as spotted gum (Eucalyptus maculata) but has not received much attention since the war owing to the high cost of labour.

Commercial application may be said to have "stagnated" during the war and until 1946 treatment for all practical purposes was confined to veneers. Since that date both fields have expanded and now treatment is a major phase of timber exploitation.

4. TREATMENT OF VENEERS

From the initiation of treatment, the majority of plymills had installed "Hot Immersion" vats in which the veneer, loaded in crates and separated by fingers, was immersed in a hot solution (about 190°F.) for average periods of 20 minutes. Degrade was high, chemical costs were excessive and treated output comparatively low. However, by its use many millions of square feet of plywood were put to first class utilization rather than consumed as case plywood or boiler fuel.

A step of the greatest magnitude was made in 1947 by the initiation of tests on the Momentary Dip process by Mr. Tamblyn of the Division of Forest Products. Queensland firms did not in a number of instances await final results, but on their own initiative installed this type of treatment. The first was Cairns Plywood which at the end of 1947 installed a shallow wooden trough containing a strong solution of boric acid. Veneer was hand dipped and block stacked. This initial system did not increase the output but did result in a decreased degrade and rather lower chemical cost. In this regard I feel that this Momentary Dip Process has been the most important development in the entire field of preservation and has caused a complete reversal of the position from a "drudgery" to an economic process with unlimited output.

Cairns Plywood then improved the system by reducing the volume and installing power driven rollers both to feed the veneers through the solution and to wipe off excess solution. Small heated pre-mixing tanks ensured constant supply of made-up solution. This design with minor alterations is that followed by most mills now treating, which, with one exception, includes all plymills. Power driven rollers enable a feed rate of 80 ft. per minute on the average. Plant cost is so low that the units may be duplicated and in fact at one mill in North Queensland five dips are operating. Treated output now is not governed by the capacity of the treatment plant but is dependent solely upon the production of starch-containing veneers.

The following table will show the present position of veneer treatment in Queensland for the year.

TABLE 1

Veneer Treatment Plants in Queensland for Year

Year	Total Mills Veneer & Ply.	Total Treating	Total s. ft. (all sp. less pine)	Estimated sq. ft. treated Ø	Calculated Treatment Capacity all Mill *
1949	15	11	18.5×10^6	55.5×10^6	
1950	17	16			233,472,000
New (Under construction)	2				

Ø The estimated square footage for treatment has been calculated upon the following:

Starch-containing timber in log = 20 per cent.
Maximum recovery ratio on 3/16 in. basis = 5 : 1

The figure of 20 per cent. has been derived from commercial data and departmental studies on starch penetration and for tropical species can be regarded as conservative.

* Calculations have been based upon the following:

Annual working time	= 48 weeks
Working week	= 5 days
Working day	= 8 hours
Operating time/hour	= 40 minutes
Feed rate	= 80 lineal ft./minute
Sheet size	= nominal 6 ft. x 3 ft. of 1/16 in.
No. of 1/16 in. per feed	= 2

It will be seen from this figure that the possible treatment capacity is greatly in excess of what the industry would ever be called upon to utilize. It is again pointed out that this happy position must be attributed solely to the successful development of the Momentary Dip Process. Chemical consumption is moderate and from figures extracted by the Department and collated both from chemical analyses and plant consumptions over long periods is as follows:

Boric acid - 0.17 lb./100 sq.ft.
Borax - 0.20 lb./100 sq.ft.

5. TREATMENT OF SAWN TIMBER

Treatment in this field dates from June, 1946 when the first commercial plant in Australia commenced operation. This, consisting of twin r.c. open top vats equipped with bulk head doors and using the yard transfer system, was installed by T. W. Brandon of Brisbane. An earlier vat had been erected by Rosenfeld & Sons in North Queensland, but unfortunately could not commence operations until later in that year. Charges of 4,500 s.ft. and 2,000 s.ft. respectively were treated by these two firms giving an annual capacity of 864,000 and 480,000 s.ft. of treated timber. In 1947 the first steam/cold quench plant was installed and operated by the Hull Timber Syndicate with a charge capacity of 2,000 s.ft. comprising principally white cheesewood.

Over this period the industry was under the able direction of Mr. Young who may be regarded as being responsible for the process being on such a sound footing. Associated problems such as the formation of "clinker" caused by the burning of impregnated shavings were overcome, initial conditions reduced and a valuable lead given to the sawmill trade.

A problem that was of major importance to successful operation in the North in relation to fungal attack was overcome by the addition of alkaline solution to the boric acid resulting in effective protection from the use of chlorinated phenols. The success of this problem was due in no small part to Dr. H. E. Young, late of the Queensland Department of Agriculture & Stock. This result led in turn to the development of borax in place of boric acid and caused a marked lessening in the cost of constructional materials.

The number of treatment plants rapidly increased, special types were designed for country mills without heating facilities and the first "Thermo-syphon" plant in the State was erected by Mirani Sawmills outside Mackay. Steel plants were put into operation and have culminated in the erection by Lawson & Sons, Mareeba, of a steel cylinder with a unit charge of 6,000 s.ft. operating upon the Steam/Cold Quench System. Specialized plants for small users were developed, in particular electrically operated units for dowel timber treatment with a capacity of 300 s.ft. per charge.

In the applied timber industry such as joinery works where treatment output is a minor factor, "Cold Soak" plants came into play. On a broad average such plants have a capacity of 1,000-2,000 s.ft. and treat upon the basis of 1 in. thickness in 7 days.

The position in Queensland is such that medium charge units of 3 - 4,000 s.ft. are favoured by most mills. Scope does exist however, for the erection of large scale co-operative units especially where a number of small mills are operating in close range or alternatively in the applied industry. Unfortunately there is the practical problem of inducing millers to appreciate this fact and in most cases they prefer to either install their own plant or to sell to a firm so equipped. It is in this field that the sawmill associations could play a major part.

The present industrial development in the industry can be seen from the data given in Table 2.

TABLE 2

Treatment Capacity of Sawn Timber in Queensland

Unit Capacity	No. of Plants Operating	No. of Plants Installed (not operating)	Total Annual Capacity of Operating Plants
0 - 2,000	9		)
2 - 5,000	8	1	)
5,000 +	3	2	) 10.98×10^6 s.ft.

The types of plants using the different processes are as shown in Table 3.

TABLE 3

Treatment Processes for Timber in Queensland

Process	Operating Wood	Operating Steel	Operating R/c	Installed Wood	Installed Steel	Installed R/c	Total
(a) Hot and Cold							
(i) Steam	3		2			2	
(ii) Thermo-syphon		2	2*				
(iii) Electric		1					
(b) S/Cold Quench	1	2	1			1	
(c) Cold Soak			6				
TOTAL:	4	5	11			3	23

* One of these plants is 14 in. brick covered by 1 in. concrete.

From enquiries in this field new installations which it is reasonably anticipated will be in operation by 1.12.51 number 14. Hence the position at that date should be as follows:

Plants now operating	20
Plants installed anticipating operation by 1.10.50	3
Anticipated new installations for year 1951	14
Total	37

It will be noted that an output of approximately 11 million super feet is possible under optimum conditions. The major development is the number of plants to be installed predominantly in North Queensland sawmills and in other areas by applied industry. So firmly established however, is the treatment that the writer is of the opinion that research along existing lines is unnecessary and that the present processes can be regarded as optimum. Refinements only are necessary of such features as schedules and plant equipment. In the engineering field some investigations were made upon heat losses which were found to be principally losses to atmosphere.

6. LEGISLATION.

As intimated at the last Conference, legislation covering preservatives has been introduced in Queensland. The 'Timber Users' Protection Act of 1949', as the Act is called, was gazetted on 3rd January, 1950, and is now law. It is not proposed here to discuss the Act in detail as the various clauses follow closely the original Bill and members have doubtless perused copies. However, we feel that conference is interested in the present position. As was anticipated some sections were objected to by the trade. Principally these referred to certain species such as spotted gum where restriction in the regulations eliminates previous trade practice of a small "sapwood" percentage on building members.

Inspections: No additional staff has been appointed for inspectoral duties under the Act. Senior officers both in Brisbane and in the field have been authorized. No prosecutions have as yet been launched.

Chemical Control: Chemical control of solution is carried out by the firms' operators and until recently all wood analyses were done by this office. Whilst satisfactory when fewer plants were operating, the demand was so great that the laboratory was fully occupied upon this work. Accordingly routine analyses are being rejected except for special purposes such as new installations and for sale purposes by the buyer.

For other material the mills are being encouraged to obtain the services of a local analytical chemist. For example in North Queensland, sugar mill chemists are located in most major centres.

7. ASSOCIATED PROBLEMS.

Existing problems associated with the industry are confined principally to what may be termed "maintenance". These may be listed as follows :

(a) Shortage of materials
(b) Shortage of chemicals
(c) Technical

(a) Shortage of Materials. The national shortage of steel is of importance to the industry in that firms desirous of enlarging or building plants are unable to do so. This is not confined to the industry and is beyond the power of this Conference to remedy.

(b) Shortage of Chemicals. On several past occasions, there has developed in Queensland a shortage in the supply of boric acid and borax. Complaints have been received from both suppliers and mills that curtailment is being made.

Quotas applied for in licences are being reduced to 50 per cent. of their value and are based upon a three month period. To indicate the actual position we have recently extracted data for all firms in Queensland. Our initial estimate for the present year was 300 tons (revised estimates give 332 tons) based upon calculated absorptions.

This figure includes approximately 55 tons for veneers, giving an overall percentage absorption of 0.67 per cent. This is lower than results obtained in practice which range about 1.0 per cent. for 1/16 in. thickness. The remainder of 280 tons gives an estimated <u>average</u> absorption of .69 per cent.

The present practice of a 3 monthly period is felt to be insufficient for Queensland requirements due to shipping and transport difficulties, and a quota upon a 6 month basis should be substituted.

(c) Technical Problems. The major technical problem still outstanding is the treatment of veneers glued with phenol-formaldehyde resins. One item of importance lies in the treatment of heavy density timbers such as brown tulip oak in thick sizes such as 2-1/2 in. Some tests carried out indicated that the schedule used had the effect of severely checking the material thus rendering it useless for the intended utilization as turnery.

This feature introduces the problem as to whether in speciality uses such as this the Department should not rather permit the treatment of the finished articles in oil solutions specifying a penetration of say 25 per cent. of the thickness. Thus in 4 in. thick timber a minimum penetration of 1 in. would be required. The article could then be sold under these conditions. Difficulties such as recutting after treatment would not apply as treatment would be to the finished article. Ample scope for approvals of this value exist under our legislation.

8. AVENUES OF RESEARCH.

The trend of research that we feel should be followed at least as far as Queensland conditions are concerned is as follows:

(a) Alternative Chemicals for Treatment. The use of 'all-round' preservatives such as pentachlorphenol in oil solution, water soluble salts such as Wohlman Salts and Ascu should be investigated. Particular application of these is felt strongly warranted for tropical conditions where Lyctus is only one of the problems.

(b) Alternative processes. No further research is felt necessary upon the existing processes. However, necessary refinements will evolve and we suggest that the application of pressure methods for large scale treatment be examined. I understand that some preliminary work has been done by D.W.T. in this respect.

(c) Susceptibilities. The degree of susceptibility of a considerable number of species is still doubtful. Data are based at present upon observations, starch intensities, botanical groupings and reports from reputable sources.

(d) Resin Bonding. The effect of boron salts upon phenol-formaldehyde resins has been previously raised. Alternative lines may be in the use of chlorinated phenols. This work should, we feel, parallel studies upon toxicity.

(e) Minimum Concentrations. The minimum of 0.20per cent. (on OD weight) has been fixed for both borax and boric acid. We know that seasoning lifts core concentration by approximately 50 per cent., should this requirement therefore be met by inclusion of one months seasoning or alternatively be required immediately after treatment. There are arguments in favour of each method and personally I feel that both should be accepted by an over riding phrase such as "at time of sale" or departure from yard.

The second, which has been raised at previous Conferences, refers to permissable tolerances. We have seen the variations in the two analytical methods and feel that an allowance of ± .02 per cent. should be officially recognized in the specification. This is bound up with which specifications are accepted for these treatments.

9. CONCLUSIONS.

(a) Preservation of timber against Lyctus is commercially well established in Queensland. Some minor problems exist in its application but in general the industry is now on a sound footing.

(b) Future research should be confined to alternative chemicals and determining the true relation of the susceptibilities of a number of tropical species.

PROTECTION OF TIMBER AGAINST MARINE BORER ATTACK IN QUEENSLAND *

1. OBJECTIVES. The purpose of this paper is firstly, to summarise the most useful discoveries with regard to the activities of marine borers in Queensland waters, and secondly, to urge that these be used more fully to save the purse of the public.

It is now fourteen years since the publication of Queensland Forest Service Bulletin No. 12 "Destruction of Timber by Marine Organisms in the Port of Brisbane", and many additional facts are now available, including details from other Queensland ports and tidal streams.

The information given in Bulletin No. 12 in no respect has become outmoded, but has proved the foundation upon which further research has been made. Unfortunately, the data provided have not been used to the fullest extent, and while hundreds of wooden structures suffer irreparable damage from marine borers, some 400 copies of this low priced booklet still remain on our shelves.

Perhaps we have failed to properly inform those interested of the information available. Whatever the cause, it is evident that needless expense is being incurred on the waterfront, and action should be taken to improve the position. The Division of Forest Products through its excellent Trade Circulars is probably best able to achieve the desired results.

For the past twenty years the Division's officers have shown considerable interest in marine timber borers and have personally given me much valuable help and encouragement,

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* Prepared by Department of Forestry, Queensland.

but no official trade circular has ever been issued on this interesting subject. Much data are now available from the recent Australian port survey, and Mr. Gottstein has considerable personal experience of marine borer problems, to which can be added the published papers from the Queensland Forest Service and Maritime Services Board of New South Wales. Of the latter, it may be said with confidence, that Mr. R.A. Johnson, M.Inst. C.E., of the Research L boratory, Fort Macquarrie, is the best informed person in Australia on the problems associated with the attacks by marine borers on timber.

I close this section on "objectives" by quoting one paragraph from page 75 of Q.F.S. Bulletin No. 12 written over fourteen years ago -

"It is considered that the problem is of sufficient importance to justify marine borer research work being undertaken by a National Committee working in close co-operation with the Council for Scientific and Industrial Research, port authorities, forest services, and the scientific institutions already interested in the problem in the various States."

2. GENERAL REVIEW OF METHODS. So far as Queensland is concerned, marine borer research began in 1926 with an attempt by the officer in charge of timber utilisation to obtain reliable information regarding the native species of timber which are most resistant to attack. Evidence from experienced river men was most conflicting and the Brisbane harbour engineer then believed that Limnoria was the most destructive agent. To him the position was hopeless, because all timbers were attacked.

This officer then decided to secure first hand information on timbers attacked in the river but soon found that a knowledge of the identity of the attacking borer was essential to compare results, and the first borer identifications were made by the Queensland Museum. It was also decided to place samples of various timbers at low tide level in the Brisbane River at Chelmer and examine these at intervals for marine borer attack.

At this stage Messrs. F.A. McNeil and T. Iredale of the Australian Museum, and R.A. Johnson of the Sydney Harbour Trust visited Brisbane with a view to extending to Queensland the survey of marine borer activity already commenced in Port Jackson. Unhappy with the attitude of the Brisbane port authority, they retreated to the Queensland Museum from where Dr. Longman directed them to the Forest Service which had interested itself in this problem.

The Queensland Forest Service was more than pleased to join forces with these authorities, and a complete survey of the Port of Brisbane was planned along similar lines to that in operation in Port Jackson. Sawn timber test samples were standardised at 3" x 3" x 5' long, hung vertically from cables or chains with the lower end 2' below low tide datum. Douglas fir was chosen as the best for control purposes and for collecting living specimens of the attacking borer.

Examinations of the test samples were made monthly by scraping the surface and counting the number of entrance holes per square inch, and later cutting transverse sections from the lower ends and estimating the cross sectional area destroyed, squaring the diameter of the burrows. At the same time a pint sample was taken of the surface water for estimation of the salinity (expressed in grams per kilo), hydrogen ions, and Oxygen content (ccs per litre). The temperature at one foot below the surface was also taken. Borer infested samples were transferred to other sites to determine the effect of salinity.

These data were supplemented by observations of standing piles, beacons, legs, boats and other submerged timber to determine the identities of the borers and other marine growths, species of timber, local conditions of varying salinity, and ages of the structures. Identifications of borers were made by Australian Museum officers.

In later tests on creosoted timber, for which the Division of Forest Products provided some of the samples, sections 9" to 12" in diameter (including sapwood) and 2 ft. long were used. These were capped on top and bottom with copper plate, and suspended with the lower end one foot below low water level. Inspections of these were made at intervals of three months.

During recent years the Maritime Services Board research staff have developed special methods for collecting the larvae of teredine or "shipworm" borers by means of fine gauze nets. The collection and identification of the larvae is a very useful means of determining the identity and numerical concentration of the borers in different waters during seasonal variations.

3. <u>OUTLINE OF RESULTS</u>

A. <u>MARINE TIMBER BORERS IN QUEENSLAND WATERS</u>. In colloquial terms all underwater damage to timber is due to the "crabs" and the "oysters", or more scientifically, the Crustacea, and Bivalve Mollusca.

Of the Crustacea, in descending order of size, (1) Sphaeroma terebrans, (2) Sphaeroma quoyana, and (3) Limnoria lignorum are represented in Queensland waters. <u>S. terebrans</u>, called the Beetle Borer or Pillbug from its habit of rolling into a ball, is very active and is the most destructive crustacean on the Queensland coast. <u>S. quoyana</u> is rarely seen, although it is more active in Port Jackson.

Limnoria lignum, known as Sea Lice, are very small and usually do much less damage than Sphaeroma. It is possible that the specific name of this Queensland species may have to be changed.

Chelura cambrica, which is well known in New South Wales and Victorian waters, is unknown in Queensland.

The Bivalve Mollusca are represented in Queensland waters by (4) Nausitora queenslandica, (5) Teredo poculifer, (6) Teredo tristi, (7) Dicyathifer caroli, (8) Bactronophorus subaustralis, (9) Bankia gronningi and others of the Teredo (Or "Cobra") family, in addition to (10) Martesia striata and (11) Modiolus sp. which have their bodies totally enclosed within their shelly valves. There is also a small teredine species, (12) Glumebra elegans, which appears to confine its attacks to floating coconuts in the tropics.

Finally, there are the Date Mussels (Lithophaga spp.), elongated totally enclosed bivalves, which readily bore hard coral and limestone, and are believed to be capable of boring concrete. Apparently they never attack timber.

(a) How do they bore? The tunnels of both Crustacea and Bivalve Mollusca in timber are mostly the result of mechanical abrasion. The difference in action can probably best be described as "chewing" for the Crustaceans and semi-rotary for the serrated valves of the Teredine borers.

In both cases it is believed that there is a primary urge to shelter, but the tunnels of the Crustaceans, remain uniform in cross section, while those of the "Shipworms" or "Cobra" tribe begin with a pin-head sized aperture and rapidly expand internally to a diameter, in some specimens, up to two inches. For this reason, the attacks of Crustaceans are easily seen on the external face of the timber, while those of the "teredo tribe" require scraping of the surface and very close examination for detection.

Another major difference is that the body of the Crustacean fills only a small portion of the burrow, while the "Shipworms" normally fill the whole of their burrows from the small entrance, which leads out to the water, to the end of the tunnel which is constantly being extended. The Crustaceans can leave their burrows at will, but the "Shipworms" are prisoners "for life" by reason of the narrowed entrance. The "Teredos" can, and often do, line their burrows with Calcareous shell for additional protection from their enemies, while the Crustaceans live in unlined tunnels. Finally, the burrows of the Crustaceans may be measured in fractions of an inch or at most, a few inches in length, while those of the "Teredos" may range from a few inches to four or more feet. Burrows of Limnoria, however may be developed into extensive galleries.

The method of boring used by the two totally enclosed bivalves, Martesia and Modiolus is uncertain. With the former, which seldom penetrates more than twice its length into wood, a rocking action of its serrated shell is suspected, Modiolus, however, has a smooth mussel type outer shell and it is possible that the animal extrudes a "tongue" which slowly removes the wood surface away. It is certainly capable of boring hardwood, making a slightly oval hole into which the shell is snugly fitted.

In size the circular tunnels of Limnoria are the smallest being often less than 1/32" in diameter. Sphaeroma holes usually range from $\frac{1}{8}$" to $\frac{1}{4}$" in diameter. The maximum size of "Cobra" burrows ranges from about $\frac{1}{4}$" for the two small Teredos, to $\frac{1}{2}$" for Bankia, $\frac{3}{4}$" for Dicyathifer, 1" for Nausitoria and 2" for the tropical giant Bactronophorus.

(b) When do they bore? From the viewpoint of age, the Crustaceans, Sphaeroma and Limnoria, appear to bore wood for protection as soon as they are old enough to leave their parent to fend for themselves. This may be at any time of the year, but the evidence suggests that the most severe damage occurs during the warmer months.

It is also known that the development of the "shipworms" is greater over the summer months, but it is probable that this has less significance in warmer tropical waters. Boring into the wood commences a short period after the semi-floating larvae find lodgement on the wood surface.

(c) Where do they bore? This question has considerable importance from the viewpoint of control. The Crustaceans, particularly Sphaeroma, confine their activities to the vertical zone a few feet in height between low tide level and about three quarter tide mark, while the "shipworms" can attack wherever the water is in contact with the wood for a sufficiently long time to gain an entry.

With most Teredine species this means that entry is made from the sea bed to a little above half tide mark. An exception can be made for the two more tropical forms, Bactronophorus and Dicyathifer, which appear to be capable of flourishing in timber in places so high that they can only snatch a drink of water during the higher tides once a fortnight! As the Teredine larvae are semi-buoyant and drift along near the surface of the water, the greatest intensity of attack is usually found a little below low tide level. Martesia and Modiolus enter piling over the same range as the "shipworms" but are much less dangerous.

Marine borers are very sensitive to salinity changes in the water. Sphaeroma normally prefer almost sea salinity, but occasionally may be seen many miles from the sea in drinkable water. On the other hand Limnoria will not tolerate any decided lowering of sea salinity and are rarely found in rivers, except occasionally in wide estuaries.

The "shipworms" are divided broadly by salinity conditions into three classes - (1) those which inhabit brackish waters (salinities up to about 10 grams per kilo) - Nausitora spp; (2) those in estuarine waters (salinities from 10 to 25 grams per kilo) - Teredo poculifer; and probably Dicyathifer, Bactronophorus, and (3) those in high salinity waters (over 25 grams per kilo) - Teredo tristi and Bankia spp. There is a very real danger of Teredine attack wherever there is a tidal inflow, even at very infrequent intervals and for short periods.

So far, it seems that Victorian Dock, Melbourne has escaped. The water would be ideal for Nausitora but is apparently too cold. They even died during the winter in the fresh water above tide level at the head of Middle Harbour, Sydney. On the other hand, a considerable number of Nausitora in a Douglas fir test sample grew eighteen inches in length in two years when transferred to a freshwater lagoon above the tidal limit in the Brisbane River. Those which died apparently did so from lack of wood to burrow. Whether they can increase in numbers, and infest other timber under such circumstances, is unknown.

In addition to many coastal localities and tidal streams of which we have records, the main Queensland ports can be classified by the borers operating as follows: -

(a) "Nausitora" ports - Brisbane (above Victoria Bridge), Bundaberg, and Rockhampton.

(b) High Salinity Ports - Brisbane (New Farm reach and downstream), Gladstone Harbour, Mackay Harbour, Bowen Harbour, and Cairns. In these ports the life of Turpentine piles is normally about 30 years, because of the absence of Nausitora, but protection against Sphaeroma is usually necessary. In addition to Bankia and Teredo spp., Bactronophorus has been noted at Mackay and Bowen and is probably also present at Townsville and Cairns. Dicyathifer, which at times attacks Turpentine, has been recorded for the mouth of the Brisbane River, Gladstone, Townsville and Cairns.

In regard to the actual medium in which the tunnels are made, Limnoria, the Teredine borers and Martesia apparently confine their attentions to submerged timber, but Sphaeroma terebrans is equally at home in soft sandstone or chalk. The Date Mussels (Lithophaga spp.) apparently ignore wood entirely to bore into hard corals and limestones. We have some concrete blocks exposed to the attack of these odd creatures in Moreton Bay.

With regard to timber, the Crustacean borers appear capable of attaching any species, but softer woods are generally preferred. The "Shipworms" show a marked objection to timber with a high silica content such as Turpentine and Swamp Mahogany, and to Cypress and Forest Red Gum. Cypress contains a phenol but no complaints of silica in Forest Red Gum have been noted. The exception to this rule is with Nausitora, which can destroy a good Turpentine pile in five years and a Grey Ironbark pile, which is much harder, in one year.

Crustacean borers take advantage of timber defects such as cracks, limb scars and softer material to take quick refuge and enlarge into tunnels, but Teredine borers normally avoid defects in lengthening their tunnels giving marked preference, like skilled miners to "driving" through "sound country". They rarely, if ever, cross a crack, even between two closely fastened boat planks. "Shipworms" normally enter wood from the longitudinal section at a slightly oblique angle to the fibres, but will more readily attack the cross section if this is exposed.

(d) Why do they bore? All borings are believed to be for the purpose of protection, and with some species this appears to be the only reason. One cannot imagine that Sphaeroma finds much nourishment in sandstone.

On the other hand the elaborate tunnellings of the "Shipworms" and of Limnoria point strongly to the conclusion that these borers obtain some essential food from finely divided wood. It has been noted that Teredine borers continue to bore throughout their lives and die "en masse" when there is little or no wood left to be tunnelled. Where they reach the edge of a piece of wood, they shorten their bodies, seal off the end of the tunnel with a concave calcareous diaphram, and proceed to "drive" in a new direction where more wood is available to be "mined". This is sometimes done several times.

It can be seen that the wood flour, "filed" from the "face" of the tunnel by the rasping action of the semi-circular shelly valves, is swallowed by the "Shipworms" and passes through the alimentary tract. In fact the exhalent siphon is specially enlarged to discharge the "chips".

Teredine borers progress much more slowly in, or are entirely repelled by some siliceous timbers or those containing toxic chemicals, and this suggests strongly that these creatures "march upon their stomachs", and can best be controlled through this medium. It has also been noted that Teredine borers first attack creosoted wood close to seasoning checks or upon the cross section where the maximum rate of leaching could be expected.

B. RESISTANCE OF UNTREATED TIMBER TO MARINE BORER ATTACKS

It has been shown that any species of timber is liable to crustacean borer attacks but some preference is shown to defective material and softer wood. No variation in intensity of attack by *Martesia* or *Modiolus* in different timbers has been noted, but a notable change in the rate of attack of Teredine borers has resulted from a change in the species of wood submerged.

This variation in "Shipworm" resistance in most cases appears to be related to the presence of silica in the wood, in others to phenolic substances, but the cause is not always obvious. Following are the results of observations extending over many years both at test stations and in submerged woodwork generally.

1. Swamp Box (*Tristania suaveolens*) - highly resistant.
2. Turpentine (*Syncarpia laurifolia*) - do, not equal to (1).
3. Guiana Greenheart (*Nectandra rodioei*) - highly resistant.
4. N.Guinea Kasi Kasi (*Meterosidros* sp?) - highly resistant.
5. Coastal Cypress Pine (*Callitris columellaris*) - do.
6. Forest Red Gum (*Eucalyptus tereticornis*) - highly resistant.
7. Satinay (*Syncarpia hillii*) - moderately resistant.
8. Brush Box (*Tristania conferta*) - moderately resistant.
9. Yellow Penda (*Xanthostemon pachyspermus*) - do.
   (now believed to be a Tristania)
10. Broad Leaved Teatree (*Melaleuca leucadendron*) - do.
11. Red Penda (*Xanthostemon pubescens*) - reported highly resistant at Cairns.
12. Brown Pine (*Podocarpus elata*) - moderately resistant.
13. Grey Ironbark (*Eucalyptus paniculata*) - non resistant.
14. Spotted Gum (*Eucalyptus maculata*) - non resistant.
15. Red Bloodwood (*Eucalyptus gummifera*) - non resistant.

16. White Mahogany (Eucalyptus acmenioides) - non resistant.
17. Blackbutt (Eucalyptus pilularis) - non resistant.
18. Rose Gum (Eucalyptus grandis) - non resistant.
19. Jarrah (Eucalyptus marginata) - non resistant.
20. Grey Satinash (Eugenia gustavioides) - non resistant.
21. Karri (Eucalyptus diversicolor) - non resistant.
22. Tallowwood (Eucalyptus microcorys) - non resistant.
23. Red Tulip Oak (Argyrodendron peralatum) - non resistant.
24. Grey Mangrove (Avicennia marina var officenalis) - do.
25. Red Mangrove (Rhizophora mucronata) - non resistant.
26. Small Black Mangrove (Aegiceras majus) - non resistant.
27. Swamp Sheoak (Casuarina glauca) - non resistant.
28. River Sheoak (Casuarina cunninghamiana) - non resistant.
29. Bollywood (Litsea reticulata) - non resistant.
30. Sassafras (Doryphora sassafras) - non resistant.
31. Red Cedar (Cedrela toona var australis) - do.
32. Hoop Pine (Araucaria cunninghamii) - non resistant.
33. Queensland Kauri (Agathis palmerstoni) - non resistant.
34. Douglas Fir (Pseudotsuga taxifolia) - Best collecting piece.

C. METHODS FOR PREVENTING ATTACK IN TIMBER. Attack in timber by marine borers may be prevented or much retarded by five main methods: -

(1) Keep the timber out of the water.
(2) Keep the borers away from the timber.
(3) Use naturally resistant timber.
(4) Use timber impregnated with toxic substances.
(5) Exterminate the borers periodically.

(1) The first method is not as impractical as it appears. Timber is often submerged in tidal water which could be kept clear of danger. For example, what use is a diagonal hardwood brace on piling where the lower bolted end is eaten off by borers? If the lower end of the brace is

kept above half tide level the risk of attack may be entirely avoided. It is admitted that high bracing is less efficient and the best method of securing stability is the raking pile. This not only replaces the braces but also facilitates floating collar treatment described under method (5).

Above tide mark the larvae of most teredine borers have insufficient time to attach themselves, and this discovery can be used with advantage for docking (at high tide) small launches on sills which keep the keels always above half tide level. Light craft such as racing skiffs, and plywood military boats, can be kept free from trouble if removed from the water and kept wet when not in use. Water pumped from a tidal stream can be dangerous as a businessman found when his wooden cooling tower, some distance from the river, collapsed owing to "worms".

Wooden vessels plying regularly between high and low salinity river waters may escape attack for the reason that Teredine borers which favour either of these conditions cannot establish themselves under constant change. At the same time a pause for two or three months at either upstream or downstream wharves could collect borers of either type which could continue to bore when travel was recommenced by closing the entrances to their tunnels when the salinity was unfavourable.

(2) Teredine borers should be denied access to any timber submerged in tidal water which is not otherwise protected. The oldest method is probably sheathing with Muntz metal or pure copper. This is both expensive and liable to corrosion of the sheeting if any metalic impurities are present. The use of nails of different composition can give serious trouble. Galvanised iron may provide protection up to about 12 months for temporary structures.

Alternate dressings of hot tar and sand gives very fair protection to wooden punts and barges. Sheathing with closely fitted boards of resistant timber such as Turpentine will give considerable protection to underwater planking of boats.

New standing piles of non-resistant timbers are often protected by encirclement with concrete collars filled between the collar and pile with sand. This method is effective provided that the lowest collar is pressed into the mud, the joints are tight and the inner space is kept continually fitted with sand. Old standing piles may be protected by concrete collars lowered in two half sections and cemented together around the pile before sand filling. This method is used by Mr. J.R.W. Hyde of Brisbane who, it is understood, holds patent rights. Old piles can also be both strengthened and protected by the provision of solid concrete jackets from the mud line to near high water level. Mr. R.A. Johnson has developed a protective plastic jacket using tar and cement.

Temporary protection is afforded by regular brushings of copper paint, creosote, tar, red lead and proprietary lines such as Carbolignum, Hardiproof, Cuprinal and Coponol. These brushings should be repeated at intervals of not longer than 3 or 4 months to maintain protection under Brisbane conditions, and less in tropical waters. Charring and creosoting gives a short life.

(3) Before selecting naturally resistant timbers for use, the borers present at the site should first be identified. A choice can then be made from the list under (B) above. While moderately resistant timbers may give long life where Nausitora are absent, no unprotected wood should be used where this destructive borer is known to be active.

(4) Brisbane tests with creosote impregnated timber showed that a heavy concentration of creosote to the full depth of the sapwood in hardwoods and pine gave protection against the high salinity Teredine borers for at least five years. Nausitora were able to attack in less than this period. Hoop Pine, which had the deepest sapwood, gave the best results.

It would appear that the main points for success are: -

I. The wood should carry as much creosote as possible and with penetration as deep as is practicable.

II. The creosote should be both highly toxic and resistant to leaching as long as possible. (Attack first took place close to seasoning checks and on "end grain". Coarse pored woods failed earlier than fine pored woods.)

III. No truewood should be exposed.

Cuprinol in Kauri Pine gave considerable protection against Nausitora but was not good against Teredo and Bankia.

A.S.C.U. gave very little protection. Fluarised Karri produced larger Nausitora than the untreated wood after a short delay.

(5) While heavy brushings or sprayings with creosote on standing piles may be regarded as extermination treatments, the best method of application is that patented by Mr. R.A. Johnson where a floating metal collar is used to retain a short head of creosote which moves up and down the pile with the tide. This treatment, being limited to the zone between tide levels, is effective only for Crustanean borers, for teredine borers a canvas collar would need to be provided to reach to the mud line and be completely filled with creosote. After a sufficient period,

the creosote can be pumped back into a container on the wharf or punt.

Creosote sprays or heavy brushings may also be used on boat bottoms but the planking should first be allowed to skin dry, and several treatments may be necessary to kill Teredine borers extending some depth under the surface.

A simple and very effective method for keeping Sphaeroma population to a minimum has been applied at Newstead Wharves in the lower Brisbane River. A galvanised iron wire of heavy gauge is placed round each pile some six inches from its perimeter and supported in the water on short creosote-impregnated pine blocks which are curved to match the pile face on the inside of the circle. This ring of blocks floats up and down with the tide and is constantly joggled about by wave action bumping against the outside of the pile. This is not fair to the "Pillbugs" which are unable to stand still and bore in without serious risk of being taken in the rear by the blocks.

4. CONCLUSIONS.

(a) It is most important to ascertain the identities of marine borers present in tidal waters where timber is to be submerged.

(b) Certain timber species are highly resistant to some species of marine borers, the majority have little resistance.

(c) No known timber is reasonably resistant against Nausitora spp.

(d) The habits of Crustaceans are quite different from those of Teredine borers and may necessitate different control methods.

(e) Spray and Brush Surface Treatments are not permanent in effect.

(f) Impregnation of wood with toxic preservatives can be highly efficient in some cases if deep penetration, and permanence can be attained.

(g) The greatest factors controlling the distribution of marine borers are water salinity and temperature.

(h) Given complete information regarding borers present and timbers available, piling and other submerged timber, can, in most cases, be suitably protected, to give 30 or more years service.

5. PROPOSED FUTURE DEVELOPMENT IN MARINE BORER WORK. A drive could well be made to inform all interested parties of the data now available and where. Complete information on the species, distribution and life history of marine borers at each centre of importance should be known. Work on the relative values preservatives (both inherent and for impregnation) should be continued with present researches on the relationship of silica to the development of Teredinidae.

TERMITE INVESTIGATIONS*

Termite investigations are among the oldest research projects of the Division of Entomology. The work was begun by Mr. G. F. Hill more than 20 years ago and has been carried on, with the exception of a break during the war years, up to the present time.

A fundamental point on which all the work hinges is the correct identification of the species concerned, and this very difficult task has been lightened by the taxonomic studies of Mr. Hill, who in 1942 published a monograph of the termites of the Australian region in which almost 200 species are described. Since this time, the taxonomic work has consisted of the identification of collections sent in from various parts of Australia and the preparation of distribution maps of some of the more important economic species.

Aspects of termite biology which have been investigated are the conditions necessary for colony foundation and the rate of development of these incipient colonies. In addition, some studies have been made on the production of neoteinics, or supplementary sexual forms. This latter point is of interest in relation to the introduction of harmful species into other countries. The longevity of termite colonies in nature is being determined by measurements of mound growth rates.

A number of ecological investigations have produced information of value to other phases of termite work, chiefly to laboratory and field testing. A study of the temperature and humidity conditions within mounds of

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* Prepared by the Division of Entomology, C.S.I.R.O.

Nasutitermes exitiosus materially assisted the work of standardizing termite laboratory colonies, whilst studies of the subterranean gallery systems of N.exitiosus and Coptotermes lacteus led to a considerable improvement in field-testing technique.

A wide variety of materials for the direct control of termites have been suggested from time to time by various workers. All materials which appeared to show some promise were tested but the outstanding group was the arsenicals, and of these, white arsenic has consistently proved to be the most reliable and most toxic.

The greater part of the investigations at present is devoted to testing timbers, timber treatments and miscellaneous materials for their resistance to termite attack either under laboratory conditions or in the field.

The initial steps in developing a laboratory testing method were made by Messrs. G.F.Hill and T.Greaves about 1930. Subsequently Dr. F.G.Holdaway carried out a considerable amount of experimental work which resulted in the development of a standard laboratory colony, which is virtually a standard eating unit and provides a reliable bio-assay for the determination of termite resistance. The standard colony method was developed with N.exitiosus, but has since been adapted for use with Coptotermes lacteus.

During the past three years, a considerable amount of testing has been carried out using this method. The more important tests have been:-

(i) various building boards, including "Masonite", "Synthawood", and "Woodtex",

(ii) improved woods, densified with phenolformaldehyde or urea-formaldehyde resins,

(iii) cotton furnishing felts treated with lauryl pentachlorphenol,

(iv) various exotic plywoods with BHC and pentachlorphenol added to the glue line,

(v) assorted overseas timbers of reputed termite resistance - including teak, gurjun, agba, iroko,

(vi) plastic piping - cellulose acetate butyrate, polyvinyl chloride, and "Polythene",

(vii) pentachlorphenol at various loadings in a susceptible timber (Sloanea woollsii),

(viii) zinc chloride, boric acid and Tanalith at various loadings in Pinus radiata and Podocarpus spicata. (A co-operative test with D.S.I.R., New Zealand),

(ix) Australian commercial timbers. The first series (concluded) comprised samples from 50 trees of each of the following species: E. pilularis, E. maculata, E. microcorys, E. acmenioides and Tristania conferta. The second series (in progress) embraces E. crebra, E. grandis, E. micrantha, E. paniculata, E. tereticornis and Syncarpia laurifolia. In addition E. marginata E. resinifera and E. siderophloia have been tested.

The laboratory testing method has also been used to determine whether any correlation exists between the specific gravity of timber and its resistance to termite attack.

Field testing of timbers and timber treatments was originally carried out merely by placing the test samples in the soil around termite mounds or in the mounds themselves, and the results were often very variable. Considerable improvements have been made and the present "connecting strip" technique has resulted in a more reliable and uniform attack on test material. Field tests at present in service are:-

(i) International Termite Exposure Test - now in its 21st year,

(ii) billets and 2" x 2" specimens impregnated with Ascu, Cuprinol, zinc chloride and arsenic, or creosote - a co-operative project with Division of Forest Products,

(iii) Bolidens impregnations,

(iv) a comparison of the natural resistance of *Callitris glauca* and *C. calcarata*.

This field testing method has been adapted successfully to the testing of soil poisoning treatments and tests are being carried out of the following materials: pentachlorphenol, creosote, sodium pentachlorphenate, sodium arsenite, D.D.T., white arsenic and lead arsenate. So far these tests have been made around mounds of *N. exitiosus* only, but this season tests will be installed around mounds of *C. lacteus*.

STATISTICAL SURVEY OF PEST DAMAGE IN HOUSING*

One of the aspects of preservation which receives a good deal of attention at the Division of Wood Technology is pest damage in housing. So many enquiries are received from the general public relating to insect pests and wood decay fungi that it is clearly necessary for the Division, as an advisory organization, to have a clear perspective of the damage that is being caused by these pests.

A chance contact early in 1948 with a quantity surveyor of the Department of Works and Housing, suggested that this Department might have the machinery for collecting data of the type that would give us the perspective view of pest damage that the Division requires.

The suggestion was put to the Sydney office of the Department of Works and Housing that their field valuating staff might be able, during the normal course of their duties, to fill in a questionnaire-type form containing the information we require and to forward the completed form to the Division for collation.

This suggestion was agreed to in principle and a form was devised in collaboration with the Entomologist of the Division and officers from the valuating staff of the Department. The form was a compromise in that it provided us with the main items of information but did not delve as deeply as we might have wished. However, it was clearly seen that any attempt to pin down valuators too closely would interfere with their main work and perhaps only cause confusion to the detriment of the project as a whole.

A working plan for this project was written in August, 1948, and it became Pt12 - "A Statistical

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*Prepared by the Division of Wood Technology, N.S.W. Forestry Commission.

Survey of Pest Damage in Housing".

The term 'statistical' was indicative of ambition rather than fact since it was apparent early in the work that we did not have the facilities for collation on a sufficiently large scale for the work to be regarded as truly statistical. We did aim, however, at obtaining sufficient number of samples from the Sydney - Metropolitan area for us to hazard a shrewd guess at the incidence of pest damage and the accompanying sheet shows the type of information that we have been able to collect over a period extending from August, 1948, to January, 1950.

In order to obtain an impression of grouping (if such a grouping exists) we have plotted these results onto a map of the County of Cumberland with coloured flags to represent the different scales of damage sustained. Other results have also been recorded graphically.

The system of collation employed is to sort the completed returns into suburbs and then separate the 'positives' from the 'negatives'.

A card index system is then used (with reference number of each return) and a set of questions is applied to each return.

Broadly the type of information sought is indicated from the accompanying table, but it is hoped that in addition to stereotyped queries there may emerge from a survey of this kind an indication of desirable trends in Australian housing or factory design. Improvements in methods of handling specific environments under Australian conditions may also become apparent, and,of course, the value of providing for preservation practice should become much more obvious.

It was proposed in the original Working Plan covering this project to set up a Committee representing the Department of Works and Housing and this Division and to report the findings of the survey in reputable trade magazines.

The size of the Committee was to be extended according to the results obtained and the possible interest of other organizations, e.g. Local Government, Bank valuators, Government Insurance and so forth. Interest was not to be confined to housing but would be extended also to factories, wharfing and miscellaneous wooden structures.

If, as seems desirable, this project is to be extended to a Commonwealth scale, the Committee plan might make collation of results easier and could certainly help to keep interest alive in the somewhat tedious work involved.

Providing co-operation is extended by all concerned, it should be possible to reach some finality with this survey within five years and a final report then, prolifically illustrated, should be of considerable assistance to those interested in building construction, both Government and private.

From Aug. 1948 to Jan 25th, 1950.

Total number of houses inspected	874
Number infested	168
Percentage infestation	19.2%

Cause of Infestation

Borers	60.1%
Termites	38.6%
Fungi	26.8%

Type of House

Number of brick houses	59.2%
Number of timber framed houses	40.8%

Age Group.

	Brick	T.F.	Borers	Termites	Fungi
1850-1910	26	26	71.2%	38.5%	30.7%
1910-1920	36	23	67.8%	37.3%	22.0%
1920-1928	24	11	45.7%	31.4%	42.8%
1928-1948	11	11	22.7%	31.8%	13.6%

Damage

Minor damage	65%
Extensive damage	35%
Total cost of damage	£6,488
Cost per house	£38.12.0

Ashfield	3/12	Holroyd	2/16
Auburn	3/16	Hornsby	8/21
Bankstown	7/50	Hunter's Hill	0/3
Bellevue Hill	0/4	Hurstville	5/34
Bexley	0/8	Kogarah	6/25
Blacktown	0/10	Kuring-ai	4/27
Botany	4/7	Lane Cove	8/26
Burwood	4/8	Lidcombe	0/3
Canterbury	17/80	Leichhardt	1/4
Concord	3/19	Liverpool	1/1
Cabramatta	0/1	Manly	4/9
Campbelltown	1/9	Marrickville	11/18
Dundas	2/2	Mosman	5/9
Drummoyne	2/13	Newtown	0/1
Eastwood	1/4	North Sydney	2/12
Enfield	1/4	Parramatta	5/16
Five Dock	0/1	Randwick	5/15
Fairfield	1/16	Rydalmere	1/1
Granville	2/3	Richmond	0/2

Rockdale	10/34
Ryde	4/22
Strathfield	2/8
Sutherland	3/33
Warringah	10/49
Waverley	5/12
Willoughby	16/24
Woollahra	2/3
Waterloo	0/1

Major Faults Observed

No ant caps or defective ant caps
Bad ventilation
Defective damp courses
Faulty gutters and down pipes

Condition of Houses

Good	13.3%
Fair	58.3%
Poor	28.4%

Cause of Infestation

Neglect by householder 48.7%

SURVEY OF PEST DAMAGE IN BUILDINGS

Form D.F.P.

Return: Negative [ ]

Positive [ ]

ADDRESS: (Give Municipality also)...

DATE OF INSPECTION: ....

GENERAL DATA: (To be filled in whether return is negative or positive)

1. Type of Construction: (underline) - Brick, brick veneer, timber frame, other (description)....................
2. Use : (underline) - Residential, factory, public building, other (description)..................
3. Age (approximately) : ....yr.

PEST -	BORERS	WHITE ANTS	DECAY
1. Attack is : (Mark with x)	Recent [ ] Old [ ]	Recent [ ] Old [ ]	Recent [ ] Old [ ]
2. Members attacked (give timber species if possible) - e.g. Flooring (baltic pine) :	....	....	....
3. If roof timbers are attacked, roof covering is :	....	....	....
4. Has house been sprayed or treated? :	....	....	....
5. Ground clearance (from underside of floor boards) :	....	....	....
6. Underfloor ventilation is :	Good [ ] Fair [ ] Poor [ ]	Good [ ] Fair [ ] Poor [ ]	Good [ ] Fair [ ] Poor [ ]
7. Drainage under house is :	Good [ ] Fair [ ] Poor [ ]	Good [ ] Fair [ ] Poor [ ]	Good [ ] Fair [ ] Poor [ ]
8. Are ant caps or shields fitted - if so, are they effective? :	....	....	....
9. Have any other control measures been taken - if so, what are they? :	....	....	....
10. Damage is :	Extensive [ ] Minor [ ]	Extensive [ ] Minor [ ]	Extensive [ ] Minor [ ]
11. Any other remarks :	....	....	....

Date: 7 /19 . Organization: ....

....

Inspector: ....

BORER ATTACK IN TIMBER BUILDINGS*

A. Objectives.

The main object of this discussion is to clarify the position with regard to damage by borers in timber buildings in Queensland, and the methods used to reduce both damage and building costs.

B. Review of Methods.

Control of timber borers is being achieved by -

(a) Research into chemical immunisation methods for use by sawmillers, plymillers, and joinery manufacturers.

(b) Advice upon plant and treatment methods.

(c) Development of improved timber grades.

(d) Legislation regarding the sale and use of borer susceptible timbers.

Research work in regard to the use of boric acid and borax in treatment plants has been covered by previous papers by K. V. Cokley, B.Sc., A.A.C.I. and will not be further mentioned in this paper, which will focus upon the problems which arise daily in regard to buildings. It is the aim of the Department to prevent borer attack if possible, rather than allow conditions to develop where the householder is put to considerable worry and expense from infestations, which, with proper care, never should have occurred.

Numerous borer complaints are received by the Forest Products Research Branch, mostly in the warmer months from October to April. These take the form of telephone enquiries, personal interviews, and letters of

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*Prepared by the Department of Forestry, Queensland.

enquiry, the latter mostly from out-of-town locations. The great majority of people desire an immediate on the spot inspection by a member of the staff to advise upon ways and means to exterminate the "pests", and a considerable number are under the impression that all the woodwork in the building, including the furniture, is in serious danger of early disintegration into dust. Where the stumps (or "stilts") of the house are attacked the collapse of the building is sometimes feared.

Many enquirers have already consulted their friends, neighbours and professional "borer exterminators" who frequently confuse the issue and add to the panic, while those who consult builders are mostly assured that there is very little to worry about. Often in the latter case it would appear that the most important thing is to cause no loss of time or money to a builder who recently has received his final payment on a new contract.

Owing to staff limitations, immediate inspections of buildings are normally refused unless there is some special reason for urgency, including legal proceedings. Persons seeking help are requested to assist by bringing small samples of attacked timber and insects to the Forest Products Research Branch for examination and report. In all entomological matters Mr. A. R. Brimblecombe, M.Sc., is regarded as the final authority.

Requests for assistance usually fall into four broad groups:-

(1) From homes erected over 20 years.
(2) From homes two to three years old.

(3) From homes completed within the past year.

(4) From homes under construction.

Enquiries regarding old homes (1) usually follow a familiar pattern - "I've got borers in my house."

"What parts are being attacked?"

"They are in the floor."

"Is it a pine floor?"

"Yes."

"The house is over twenty years old?"

"Yes. What do you recommend to kill these pests, the floor is becoming dangerous. One of the chair legs has gone through it."

This is typical of first reports of attack by the Hoop Pine Beetle (Calymmaderus incisus) in old Hoop Pine floors. Home owners are usually unaware that damage has been increasing over many years until the floor yields slightly under the linoleum or some concentrated load punctures a hole. The frequency of the latter event gave rise to the local name of "Calamity Beetle". The fras is easily recognised from that of Lyctus borers being hard, granular and egg shaped when seen under a hand lens.

Attack usually commences first in the darker corners under the house, rarely earlier than ten years after erection, and may extend internally to pine skirtings and partitions which are unpainted. A detailed description of the insect, its habits and control is contained in Advisory Leaflet No.27 of the Queensland Department of Agriculture and Stock entitled "The Queensland Hoop Pine Beetle and its Control" by A. R. Brimblecombe.

This paper is usually supplied to enquirers who are advised to commence treatment in August and repeat this later as required until activity ceases. Retreatment annually for three years is suggested.

For floors, surface saturation on the under side with equal parts of K55 Standard Creosote and kerosene is usually recommended for effectiveness, low cost and availability. For walls, wood preserving oil (containing 5 per cent. of pentachlorphenol), and a solution of paradichlorbenzene in kerosene (1 lb. to 1 gallon) is recommended, to be followed by painting when the borers are exterminated. Other solutions containing 20 per cent. of zinc naphthenate are also recommended if available. Injection back through the flight holes by means of a pump with a small nozzle gives th most effective penetration.

Householders are assured that these borers will not attack timber other than pine in the house. Anobium punctatum, of the same family as Calymmaderus, is rarely seen in Queensland.

(2) Occasional complaints are received from owners of homes some two, three or even more years old. Borer holes some 3/16 in. to 1/4 in. in diameter are reported to have suddenly appeared in painted pine walls or in plywood panelling or plaster sheeting. Sometimes the "Borer" itself is caught in the act of emerging and is produced for identification from an empty "Aspro" bottle. Because of the unusually large size of the flight hole the householder is considerably worried and desires prompt action to stop further damage.

Further enquiry usually reveals that the "infested" plaster or plywood panelling is fastened to Hoop Pine battens. This gives all the evidence required. The home owner is then informed that there is no necessity to call back the "borer exterminators" at once to remove the weatherboards or panelling in order to "pressure spray" the source of "infestation", but simply to fill the holes with some plastic material of a colour to match the wall and forget them. The borer is the Jewel Beetle (Prospheres aurantiopictus) which lays its eggs in unseasoned pine. The adult beetles often do not emerge until several years later when the size of the few holes causes a minor panic in the house. Jewel Beetles do not attack seasoned timber and have a marked preference for green Hoop Pine. Last month a quarter inch diameter hole appeared in a painted Hoop Pine lining board in the writer's home built thirteen years ago.

(3) Borer complaints from homes completed within the previous twelve months are the most frequent of all, and commonly follow the finding of little piles of soft floury dust during the summer months on the floors, or sprinkled on the hood of the motor car parked under the house. Sometimes the children call their parent's attention to "wogs" appearing in considerable numbers through the linoleum, wallpaper or masonite sheeting.

This trouble is most frequently traced to starch bearing sapwood in the flooring or in the 2 in. x 1 in. rough sawn battens backing sheet plaster and masonite. In flooring, some of the best known hardwoods give the most trouble, including Spotted Gum, Tallowwood and Crow's Ash. Use of these woods and various brushwoods with wide starch filled sapwoods are the most frequent reason for infestation in battens.

Sometimes, the householder finds that the upper side of his ceiling is liberally sprinkled with powder as the result of the use of Lyctus susceptible timber in tile and plaster battens. One home examined by the writer had the entire tile roof supported upon 2 in. x 1 in. battens of Brown Tulip Oak, most of which was so riddled as to be breakable in the hands. The owner, through his solicitors, sought £150 damages or a new roof from his contractors the tile company. He obtained a new roof.

In houses where a considerable volume of Lyctus susceptible timber is being attacked in studs, nogging and battening between double walls, cyaniding is sometimes used by professional "borer experts" as an alternative to rebuilding the walls.

Other starch feeding borers which give rise to occasional complaints are the Small Augur Beetle (Xylion cylindricus) which has a special liking for "Sappy" Spotted Gum and Crow's Ash flooring, and the much rarer Augur Beetle (Bostrychopsis jesuita) which makes sharp crunching sounds as its powerful mandibles tear pieces from the sapwood of Yellow Boxwood and other favourite brush woods. The flight holes of Xylion are usually about 1/16 in. or more in diameter while those of the Augur Beetle are about 1/4 in. wide, causing considerable alarm to the owner of the timber. To prevent further damage by the starch feeding borers similar measures to those employed for the Hoop Pine Beetle are recommended. Queensland Department of Agriculture and Stock Pamphlet

No.116 by A. R. Brimblecombe, M.Sc., and C.S.I.R.O. Trade Circular No.6 on Lyctus borers are supplied when necessary. It is emphasized that surface treatments are of little use unless deep penetration to the feeding insects can be achieved.

(4) A considerable number of requests for information come from people interested in homes under construction. The most practical are those who want to know how to prevent borer attack. These are advised to avoid the use of Lyctus susceptible sapwood in any permanent work and refer samples of any doubtful timber to the Forest Products Research Branch for identification and report on susceptibility. Special warning is given regarding the prevalence of susceptible sapwoods in brushwoods, and contractors are reminded of their responsibilities under "The Timber Users' Protection Act" proclaimed on 3rd January, 1950. They are also warned against borer proofing "treatments" which are not approved by the Department, and are invited to forward samples of timber sold as "treated" for chemical checking.

Sometimes Lyctus attack is already in evidence in timber on the job. In the case of flooring, battening and mouldings, exclusion from the work is recommended rather than surface treatment in the building. Small edgings of susceptible sapwood on hardwood scantlings which are not adjacent to wall sheeting, and have ample strength in truewood, are not regarded seriously, and no treatment is advised except where the dust is a nuisance, for example, over the "wet day" clothes drying lines under the home. Here the tannins in the borer dust stain the wet clothes.

The publicity regarding the passing of "The Timber Users' Protection Act" has done a great deal of good in making people more borer conscious, and many home makers are determined to be sure now rather than sorry later. Pine and hardwood scantlings and boards containing numerous pinholes, and sometimes larger grub holes, are often cause for alarm, and the people concerned are much relieved when informed that the Pinhole Borer Group (families Platypodidae, Scolytidae, and Lymexylonidae) attack only unseasoned timber and perish miserably when this dries out. Sawmillers, who see the larvae of these borers crawling out of sawn flitches, often have serious doubts regarding their inability to complete the job in the seasoning stacks. If sawmillers and others would give more study to C.S.I.R.O. Trade Circular No. 25 on "Pin-Hole Borers" they would be less likely to confuse these with Lyctus.

After long periods of wet weather, complaints are received from builders regarding pine which is heavily attacked by large "borers". The holes are very irregular in shape and size, varying from 1/32 in. to 3/8 in. in diameter and frequently filled with pale mud like material composed of fine dust of the timber.

This damage is caused by the Hoop Pine Stump Weevil (Mitrastethes australasiae) which attacks pine logs lying for considerable periods in the rain or in damp places. Like the pinhole borers, damage ceases when the timber is seasoned, and builders are assured that dry timber showing this form of attack is quite safe to use for the backing of fibro and plaster sheeting and for other covered situations. It is not at all related to the Hoop Pine Beetle with which its attack is frequently confused. The remedy lies in the early removal of Pine logs from the scrub, or if this is delayed, in spraying the logs all over with K.55 creosote or with a hot creosote emulsion - 1 part K.55 creosote with 1 or 2 parts of 5 per cent. hot soft **soap solution** A and S **Pamphlet No.116,** p.11 - soft soap emulsion as a borer deterrant. Similar treatment will protect other brushwood logs from pinhole borer attack.

C - D. Results and Conclusions.

While it cannot be claimed that the borer problem in houses has been removed, it is safe to say that adequate means are now available to prevent infestation, and when "The Timber Users' Protection Act" becomes better known to sawmillers and building contractors, it is believed that complaints will fall to a minimum.

Trouble from the Hoop Pine Beetle will progressively decrease as the old Hoop Pine floors are either treated or replaced, and future houses will contain this valuable timber only in joinery and mouldings which are painted or varnished.

Occasional complaints as a result of attacks by Jewel Beetles and the Hoop Pine Stump Weevil will continue while green logs are left for considerable periods under damp conditions without some toxic surface protection.

With the increasing number of sawmills installing boric treatment vats, and with adequate limitations of susceptible timber in official timber grades, damage from starch feeding Lyctus and Xylion borers should soon be greatly reduced, except in small edgings of scantlings in roof members and underframing when the lowest grade has been used.

E. Future Work will continue along the lines of assistance in plant installation and development of improved toxic impregnation methods, education with regard to different types and food requirements of borers with methods of preventing attack, grading demonstrations in regard to limitations of Lyctus susceptible timber, and publicity regarding "The Timber Users' Protection Act".

LYCTUS SUSCEPTIBILITY LIST

This list has been prepared by the Preservation Section of Division of Forest Products as an appendix for inclusions in the revised Lyctus Trade Circular, (No. 6).

The timbers listed have been graded for susceptibility, after examination of the Division of Forest Product's wood collections, and in correlation with the State Forest Services.

The list is being circulated in the form of a technical paper before the Forest Products Conference, so that delegates may have an opportunity of critically reviewing it, and of suggesting amendments, particularly in those States where legislation exists regulating the sale of certain classes of timber.

APPENDIX II

Lyctus susceptibility of timbers used in Australia

This list refers to the average degree of susceptibility to Lyctus attack which is usually exhibited by the untreated sapwood of the species named. It will be reviewed as additional information is collected, but this will apply principally to the lesser known species not yet widely used by the timber industry.

"*" Species thus marked are regarded as having a higher susceptibility to Lyctus in one State than in another. It is not yet known whether such differences are due to geographical factors or due to different gradings. Wherever possible, these differences will be reconciled as more information is collected.

True softwoods - non-pored timbers - are immune from Lyctus attack and have been omitted from this list.

The symbols used have the following meanings:-

I - Immune from Lyctus attack for all practical purposes. In a few instances attack has been recorded but its intensity has been so light that the infestation may be regarded as exceptional in the species.

RS - Rarely susceptible. Attack is not usual and is seldom severe, but attack has been recorded in up to 20 per cent. of specimens containing sapwood.

MS - Moderately susceptible. Attack in these species is fairly frequent and often severe, and may be expected in 60 per cent. of specimens containing sapwood.

HS - Highly susceptible. Severe attack may occur in over 60 per cent. of the specimens containing sapwood.

S - Susceptible. These timbers may be attacked but the degree of attack cannot be determined from the limited amount of material available.

The names given in heavy type are the Australian standard trade common names (See "Nomenclature of Australian Timbers". Standards Association of Australia No. 0.2) published in Trade Circular 47.

In view of the indefinite common names of some species about which information on Lyctus susceptibility is available, it has been necessary to include some species in a separate list after the main one, classifying them by botanical name only.

APPENDIX 2

LYCTUS SUSCEPTIBILITY OF SOME TIMBERS USED IN AUSTRALIA

Common Name	Botanical Name	Suscept-ibility Rating
Acacia cedar	Albizzia toona	HS
Alder, Blush	Sloanea australis	HS
Alder, Brown	Ackama muelleri	*RS-MS
Alder, Rose	Ackama quadrivalvis	I
Almond, Red	Alphitonia excelsa	I
Almond, Rose	Owenia venosa	I
Alpine Ash	Eucalyptus gigantea	RS
Antarctic Beech	Nothofagus moorei	RS
Apple, Black	Sideroxylon australe	MS
Apple, Narrow-Leaved	Angophora bakeri	HS
Apple, Broad-Leaved	Angophora subvelutina	HS
Apple, Red	Eugenia brachyandra	S
Apple, Rough-Barked	Angophora intermedia	HS
Apple, Smooth-Barked	Angophora lanceolata	HS
Apple	Angophora cordifolia	HS
Apple-top Gum	Eucalyptus angophoroides	HS
Ash, Alpine	Eucalyptus gigantea	RS
Ash, Bennett's	Flindersia bennettiana	MS
Ash, Blue Mountains	Eucalyptus oreades	I
Ash, Crow's	Flindersia australis	HS
Ash, Gully	Eucalyptus badjensis	HS
Ash, Hickory	Flindersia ifflaiana	MS
Ash, Leopard	Flindersia collina	MS
Ash, Mountain	Eucalyptus regnans	I
Ash, New England	Eucalyptus andrewsi	S
Ash, Northern Silver	Flindersia pubescens	MS
Ash, Queensland Silver	Flindersia bourjotiana	MS
Ash, Scrub	Elaeocarpus longifolius	MS

Common Name	Botanical Name	Suscept-ibility Rating
Ash, Silky	Ehretia acuminata	HS
Ash, Silver, Northern	Flindersia pubescens	MS
Ash, Silver, Southern	Flindersia schottiana	MS
Ash, Silvertop	Eucalyptus sieberiana	I
Ash, White	Eucalyptus fraxinoides	S
Australian Nut	Macadamia ternifolia	HS
Bailey, Stringybark	Eucalyptus baileyana	HS
Banksia, River	Banksia verticillata	I
Banksia, Red	Banksia serrata	I
Banksia, White	Banksia integrifolia	S
Banksia, Silver	Banksia marginata	S
Barrel, Brown	Eucalyptus fastigata	MS
Basswood, Silver	Panax elegans	HS
Basswood, White	Panax murrayi	MS
Bean, Black	Castanospermum australe	HS
Beech, Brown	Pennantia cunninghamii	S
Beech, Myrtle	Nothofagus cunninghamii	*RS-MS
Beech, Negrohead	Nothofagus moorei	RS
Beech, Silky	Villaresia moorei	RS
Beech, Silver	Nothofagus menziesii	I
Beech, White	Gmelina leichhardtii	RS
Birch, Ivory	Baloghia lucida	MS
Birch, White	Schizomeria ovata	HS
Black Bean	Castanospermum australe	HS
Black Box	Eucalyptus bicolor	HS
Black Kurrajong	Sterculia diversifolia	HS
Black Sallee	Eucalyptus stellulata	HS
Black Sheoak	Casuarina suberosa	I
Black Wattle	Acacia mollissima	I
Blackbutt	Eucalyptus pilularis	RS

Common Name	Botanical Name	Suscept-ibility Rating
Blackbutt, W.A.	Eucalyptus patens	HS
Blackwood	Acacia melanoxylon	MS
Bloodwood, Brown	Eucalyptus trachyphloia	HS
Bloodwood, Red	Eucalyptus corymbosa	MS
Bloodwood, Yellow	Eucalyptus eximia	HS
Blue Gum, Southern	Eucalyptus globulus	MS
Blue Gum, Sydney	Eucalyptus saligna	MS
Blue-Leaved Stringybark	Eucalyptus agglomerata	I
Blush Alder	Sloanea australis	HS
Blush Coondoo	Sideroxylon richardi	S
Blush Tulip Oak	Tarrietia actinophylla	HS
Blush Walnut	Beilschmiedia obtusifolia	MS
Bolly Silkwood	Cryptocarya oblata	MS
Bollywood	Litsea reticulata	HS
	Litsea lefeana (syn. ferruginea)	S
Booyong (Brown Tulip Oak)	Tarrietia argyrodendron	HS
Bottle-brush, Red	Callistemon viminalis	S
Box, Bimbil	Eucalyptus populifolia	MS
Box, Black	Eucalyptus bicolor	HS
Box, Brush	Tristania conferta	I
Box, Coast Grey	Eucalyptus bosistoana	RS
Box, Fuzzy	Eucalyptus baueriana	MS
Box, Green-Leaved	Eucalyptus microcarpa	MS
Box, Grey	Eucalyptus hemiphloia	RS
Box, Ironwood	Syncarpia subargentea	I
Box, Long-Leaved	Eucalyptus elaeophora	HS
Box, Red	Eucalyptus polyanthemos	MS
Box, Rudder's	Eucalyptus rudderi	MS
Box, Slaty	Eucalyptus dawsoni	RS

Common Name	Botanical Name	Suscept-ibility Rating
Box, Steel	Eucalyptus rummeryi	I
Box, Swamp	Tristania suaveolens	RS
Box, White	Eucalyptus albens	RS
Box, White-topped	Eucalyptus quadrangulata	I
Box, Yellow	Eucalyptus melliodora	RS
Boxwood, Grey	Hemicyclia australasica	RS
Boxwood, White	Excaecaria dallachyana	S
Boxwood, Yellow	Sideroxylon pohlmannianum	HS
Brigalow	Acacia harpophylla	MS
Broad-Leaved Red Ironbark	Eucalyptus siderophloia	RS
Broad-Leaved Peppermint	Eucalyptus dives	MS
Broad-Leaved Tea-Tree	Melaleuca leucadendron	RS
Brown Alder	Ackama muelleri	*RS-MS
Brown Barrel	Eucalyptus fastigata	MS
Brown Bloodwood	Eucalyptus trachyphloia	HS
Brown Cudgerie	Bursera australisica	HS
Brown Mallet	Eucalyptus astringens	I
Brown Penda	Xanthostemon chrysanthus	RS
Brown Stringybark	Eucalyptus capitellata	I
Brown Tulip Oak	Tarrietia argyrodendron	HS
Brown-top Stringybark (Tas.)	Eucalyptus obliqua	HS
Brush Box	Tristania conferta	I
Brush Mahogany	Geissois benthami	*RS-MS
Bull Oak	Casuarina luehmanni	I
But But	Eucalyptus bridgesiana	HS
Butternut, Rose	Blepharocarya involucrigera	HS
Buttonwood, Red	Glochidion ferdinandi	I
Cabbage Gum	Eucalyptus amplifolia	HS
Caledonian Oak	Carnarvonia araliaefolia	S

Common Name	Botanical Name	Suscept-ibility Rating
Calgaroo	Eucalyptus parramattensis	HS
Camden Woollybutt	Eucalyptus macarthuri	MS
Camphor Laurel	Cinnamomum camphora	S
Camphorwood	(Cinnamomum oliveri	HS
	(Cinnamomum virens	S
Candlebark	Eucalyptus rubida	MS
Candlenut	Aleurites moluccana	HS
Carabeen, White	Sloanea langii	HS
Carabeen, Yellow	Sloanea woollsii	HS
Carbeen	Eucalyptus tessellaris	HS
Cassia	Cassia brewsteri	MS
Cassia	Cassia candolliara	HS
Cattlebush	Heterodendron oleaefolium	HS
Cedar, Peach	(Trema amboinensis	S
	(Trema orientalis	S
Cedar, Red	Cedrela toona	HS
Cedar, White	Melia dubia	*RS-HS
Cedrela	(Cedrela mexicana	S
	(Cedrela odorata	S
Celtis, Silky	Celtis paniculata	HS
Cheesewood	Sarcocephalus cordatus	HS
Cheesewood, White	Alstonia scholaris	HS
Cherry, Native	Exocarpus cupressiformis	I
Cherry, Sour	Eugenia corynantha	HS
Cherry, Creek	Eugenia myrtifolia	S
Cider Gum	Eucalyptus gunnii	S
Coachwood	Ceratopetalum apetalum	I
Coast Grey Box	Eucalyptus bosistoana	RS
Cooktown Ironwood	Erythrophloeum laboucherii	S
Coolibah	Eucalyptus microtheca	RS
Coolibah, Western	Eucalyptus coolabah	RS

Common Name	Botanical Name	Suscept-ibility Rating
Coondoo, Blush	Sideroxylon richardi	S
Corduroy	Sarcopteryx stipitata	MS
Corduroy, Tamarind	Arytera lauteriana	MS
Corkwood, Grey	Erythrina vespertilio	HS
Cornbeef wood	Barringtonia calyptrata	S
Crow's Ash	Flindersia australis	HS
Cudgerie, Brown	Bursera australisica	HS
Cuttail	Eucalyptus fastigata	MS
Damson (Sovereign Wood)	Terminalia sericocarpa	S
Dwyer's Mallee	Eucalyptus duyeri	RS
Erima	Octomeles sumatrana	S
Evodia, Northern	Evodia vitiflora	S
Evodia, White	Evodia micrococca	I
Fig, Moreton Bay	Ficus macrophylla	HS
Fig, Rusty	Ficus rubiginosa	HS
Fig, Sandpaper	Ficus stephanocarpa	S
Fig, Wild, or Cluster	Ficus glomerata	S
Figwood	Ficus cunninghamii	MS
Forest Red Gum	Eucalyptus tereticornis	*RS-MS
Foambark	Jagera pseudorhus	MS
Frangipanni, Native	Hymenosporum flavum	S
Four O'Clock	Hibiscus heterophyllus	HS
Gidgee	Acacia cambagei	I
Gimlet	Eucalyptus salubris	I
Gimlet, Silvertopped	Eucalyptus campaspe	I
Greenheart, Queensland	Endiandra compressa	RS
Green Satinheart	Geijera salicifolia, etc.	HS
Grey Box	Eucalyptus hemiphloia	RS
Grey Corkwood	Erythrina vespertilio	HS
Grey Gum	Eucalyptus punctata	*RS-MS

Common Name	Botanical Name	Susceptibility Rating
Grey Handlewood	Aphananthe philippinensis	MS
Grey Ironbark	Eucalyptus paniculata	RS
Grey Persimmon	Diospyros pentamera	MS
Grey Satinash	Eugenia gustavioides	MS
Gully Gum	Eucalyptus smithii	MS
Gum, Apple-top	Eucalyptus angophoroides	HS
Gum, Black	Eucalyptus aggregata	HS
Gum, Blue, Southern	Eucalyptus globulus	MS
Gum, Blue, Sydney	Eucalyptus saligna	MS
Gum, Brittle, White	Eucalyptus maculosa	RS
Gum, Brown Grey	Eucalyptus canaliculata	S
Gum, Cabbage	Eucalyptus amplifolia	HS
Gum, Cider	Eucalyptus gunnii	S
Gum, Eungella, White	Eugenia hemilampra	MS
Gum, Flooded, W.A.	Eucalyptus rudis	I
Gum, Flooded	Eucalyptus benthami	I
Gum, Forest Red	Eucalyptus tereticornis	*RS-MS
Gum, Giant Snow	Eucalyptus de Beuzevillei	S
Gum, Grey	Eucalyptus punctata	*RS-MS
Gum, Grey, Mountain	Eucalyptus goniocalyx	HS
Gum, Grey, Nowra	Eucalyptus nowraensis	MS
Gum, Gully	Eucalyptus smithii	MS
Gum, Lemon-Scented	Eucalyptus citriodora	HS
Gum, Maiden's	Eucalyptus maideni	HS
Gum, Manna	Eucalyptus viminalis	MS
Gum, Mountain	Eucalyptus dalrympleana	HS
Gum, Mountain Grey	Eucalyptus goniocalyx	HS
Gum, Pink	Eucalyptus fasciculosa	S
Gum, Red, Forest	Eucalyptus tereticornis	*RS-MS
Gum, Red, River	Eucalyptus rostrata	MS

Common Name	Botanical Name	Susceptibility Rating
Gum, Rose	Eucalyptus grandis	RS
Gum, Rough-barked Ribbon	Eucalyptus huberiana	S
Gum, Round-Leaved	Eucalyptus deanei	HS
Gum, Round-Leaved Snow	Eucalyptus perriniana	S
Gum, Salmon	Eucalyptus salmonophloia	I
Gum, Scribbly	Eucalyptus haemastoma	RS
Gum, Shining	Eucalyptus nitens	HS
Gum, Silver	Eucalyptus dealbata	*RS-MS
Gum, Southern Blue	Eucalyptus globulus	MS
Gum, Spotted	Eucalyptus maculata	HS
Gum, Sugar	Eucalyptus cladocalyx	HS
Gum, Swamp	Eucalyptus ovata	HS
Gum, Sydney Blue	Eucalyptus saligna	MS
Gum, W.A. Flooded	Eucalyptus rudis	I
Gum, White (Ash gum)	Eucalyptus dunnii	HS
Gum, Yellow	Eucalyptus leucoxylon	HS
Gum, York	Eucalyptus loxophleba	I
Gympie Messmate	Eucalyptus cloeziana	RS
Hakea, Striped	Hakea vittata	HS
Handlewood, Grey	Aphananthe philippinensis	MS
Handlewood, White	Pseudomorus brunoniana	HS
Hard Quandong	Elaeocarpus obovatus	RS
Heart, Red	Dissiliaria baloghioides	
Hickory Ash	Flindersia ifflaiana	MS
Holly, White	Pittosporum rhombifolium	HS
Hollywood, White	Pittosporum undulatum	S
Hollywood, Yellow	Vitex lignum-vitae	I
Horizontal	Anodopetalum biglandulosum	I
Incense Wood	Amoora nitidula	MS
Ironbark, Broad-Leaved Red	Eucalyptus siderophloia	RS

Common Name	Botanical Name	Suscept-ibility Rating
Ironbark, Grey	Eucalyptus paniculata	RS
Ironbark, Narrow-Leaved Red	Eucalyptus crebra	RS
Ironbark, Red	Eucalyptus sideroxylon	HS
Ironbark, Silver-Leaved	Eucalyptus melanophloia	I
Ironwood	Backhousia myrtifolia	I
Ironwood, Box	Syncarpia subargenta	I
Ironwood, Cooktown	Erythrophloeum laboucherii	S
Ironwood, Wattle	Acacia excelsa	RS
Ivory Birch	Baloghia lucida	MS
Ivorywood	Siphonodon australe	HS
Jam, Rasp berry	Acacia acuminata	I
Jarrah	Eucalyptus marginata	RS
Kamala, Rose	Amoora nitidula	MS
Kamarere	Eucalyptus deglupta	S
Kanuka	Tristania laurina	I
Karri	Eucalyptus diversicolor	I
Kurrajong	Sterculia diversifolia	HS
Kurrajong, Flame	Sterculia acerifolia	HS
Kurrajong, White	Sterculia discolor	S
Leatherwood	Eucryphia billardieri	I
Lemon-Scented Gum	Eucalyptus citriodora	HS
Lightwood	Acacia implexa	RS
Lilly Pilly	Eugenia smithii	I
Lomatia, Tree	Lomatia frazeri	S
Luster (Turpentine)	Syncarpia laurifolia	I
Magnolia	Golbulimima baccato	S
Mahogany, Brush	Geissois benthami	*RS-MS
Mahogany, Miva	Dysoxylum muelleri	HS
Mahogany, Red	(Eucalyptus resinifera	MS
	(Eucalyptus pellita	S

Common Name	Botanical Name	Suscept-ibility Rating
Mahogany, Rose	Dysoxylum fraseranum	HS
Mahogany, Southern	Eucalyptus botryoides	RS
Mahogany, Spur	Dysoxylum pettigrewianum	MS
Mahogany, Swamp	Eucalyptus robusta	*RS-MS
Mahogany, White	Eucalyptus acmenioides	RS
Maiden's Gum	Eucalyptus maideni	HS
Mallet, Brown	Eucalyptus astringens	I
Malletwood, Brown	Rhodamnia trinervia	I
Malletwood, Silver	Rhodamnia argentea	I
Mangrove, Cedar	Carapa moluccensis	I
Mangrove, Grey	Avicennia officinalis	I
Manna Gum	Eucalyptus viminalis	MS
Maple, Queensland	Flindersia brayleyana	I
Maple, Rose	(Cryptocarya erythroxylon (Cryptocarya patentinervis	HS S
Maple, Scented	Flindersia laevicarpa	I
Mararie	Geissois lachnocarpa	HS
Marblewood, White	Acacia bakeri	HS
Marri	Eucalyptus calophylla	MS
Marri, Mountain	Eucalyptus haematoxylon	I
Mealy Stringybark	Eucalyptus cinerea	MS
Messmate, Gympie	Eucalyptus cloeziana	RS
Messmate, N.S.W.	Eucalyptus phellandra	*RS-MS
Messmate Stringybark	Eucalyptus obliqua	HS
Messmate, White-top	Eucalyptus vitrea	I
"Milky Pine" (White Cheesewood)	Alstonia scholaris	HS
Miva Mahogany	Dysoxylum muelleri	HS
Moonah	Melaleuca genistifolia	RS
Moreton Bay Fig	Ficus macrophylla	HS
Morrell, Red	Eucalyptus longicornis	I

Common Name	Botanical Name	Suscept-ibility Rating
Mountain Ash	Eucalyptus regnans	I
Mountain Grey Gum	Eucalyptus goniocalyx	HS
Mulga	Acacia aneura	I
Musk	Olearia argophylla	I
Muskheart, Black	Marlea vitiensis	RS
Myall	Acacia pendula	*RS-MS
Myrtle Beech	Nothofagus cunninghamii	*RS-MS
Narrow-Leaved Red Ironbark	Eucalyptus crebra	RS
Narrow-Leaved Tea-Tree	Melaleuca linariifolia	I
Native Cherry	Exocarpus cupressiformis	I
Needlewood	Hakea leucoptera	I
Negrohead Beech	Nothofagus moorei	RS
New England Ash	Eucalyptus andrewsi	S
Northern Silky Oak	Cardwellia sublimis	HS
Northern Silver Ash	Flindersia pubescens	MS
Nut, Australian	Macadamia ternifolia	HS
Nutmeg, Queensland	Myristica insipida	S
Oak, Blush Tulip	Tarrietia actinophylla	HS
Oak, Brown Tulip	Tarrietia argyrodendron	HS
Oak, Bull	Casuarina luehmanni	I
Oak, Caledonian	Carnarvonia araliaefolia	S
Oak, Northern Silky	Cardwellia sublimis	HS
Oak, Red Silky	Stenocarpus salignus	HS
Oak, Red Tulip	Tarrietia peralata	HS
Oak, Satin	Embothrium wickhami	HS
Oak, Silky, Southern	(Grevillea robusta (Orites excelsa	HS MS
Oak, White	Stenocarpus sinuatus	MS
Onion-wood	Eugenia cormiflora	HS
Pear, Native	Xylomelum pyreforme	HS

Common Name	Botanical Name	Suscept-ibility Rating
Pearwood, Brown	Lucuma amorphosperma	I
Penda, Brown	Xanthostemon chrysanthus	RS
Penda, Red	Xanthostemon pubescens	RS
Lenda, Southern	Xanthostemon oppositifolius	RS
Penda, Yellow	Xanthostemon pachyspermus	RS
Peppermint, Black	Eucalyptus amygdalina	MS
Peppermint, Broad-Leaved	Eucalyptus dives	MS
Peppermint, Narrow-Leaved	Eucalyptus australiana	MS
Peppermint, Queensland	Eucalyptus exserta	RS
Peppermint, River	Eucalyptus numerosa	RS
Peppermint, Sydney	Eucalyptus piperita	RS
Peppermint, White	Eucalyptus linearis	S
Pepperwood	Cinnamomum laubatii	HS
Persimmon, Grey	Diospyros pentamera	MS
Pine "Milky" (White cheesewood)	Alstonia scholaris	HS
Pine "Putts" (Silver silkwood)	Flindersia acuminata	MS
Pink Gum	Eucalyptus fasciculosa	S
Pink Poplar	Euroschinus falcatus	HS
Plum, Tulip	Pleiogynium solandri	HS
Powder-Bark Wandoo	Eucalyptus accedens	RS
"Putts Pine" (Silver Silkwood)	Flindersia acuminata	MS
Quandong, Hard	Elaeocarpus obovatus	RS
Quandong, Silver	Elaeocarpus grandis	RS
Queensland Greenheart	Endiandra compressa	RS
Queensland Maple	Flindersia brayleyana	I
Queensland Peppermint	Eucalyptus exserta	RS
Queensland Silver Ash	Flindersia bourjotiana	MS
Queensland Walnut	Endiandra palmerstoni	RS

Common Name	Botanical Name	Suscept-ibility Rating
Raspberry Jam	Acacia acuminata	I
Red, Almond	Alphitonia excelsa	I
Red Bloodwood	Eucalyptus corymbosa	MS
Red Box	Eucalyptus polyanthemos	MS
Red Cedar	Cedrela toona	HS
Red Mahogany	Eucalyptus resinifera	MS
Red Morrel	Eucalyptus longicornis	I
Red Penda	Xanthostemon pubescens	RS
Red Plum	Cadellia pentostylis	HS
Red Silkwood	Lucuma galactoxylon	HS
Red Siris	Albizzia toona	HS
Red Silky Oak	Stenocarpus salignus	HS
Red Stringybark	Eucalyptus macrorrhyncha	MS
Red Tingle	Eucalyptus jacksoni	RS
Red Touriga	Calophyllum costatum	RS
Red Tulip Oak	Tarrietia peralata	HS
Ribbon wood	Bosistoa evodiformis	MS
River Banksia	Banksia verticillata	I
River Peppermint	Eucalyptus numerosa	RS
River Red Gum	Eucalyptus rostrata	*RS-MS
River Sheoak	Casuarina cunninghamiana	RS
Rose Butternut	Blepharocarya involucrigera	HS
Rose Gum	Eucalyptus grandis	RS
Rose Mahogany	Dysoxylum fraseranum	HS
Rose Maple	Cryptocarya erythroxylon	HS
Rose Satinash	Eugenia francisii	RS
Rose Sheoak	Casuarina torulosa	I
Rough-Barked Apple	Angophora intermedia	HS
Round-Leaved Gum	Eucalyptus deanei	HS
Rudder's Box	Eucalyptus rudderi	MS

Common Name	Botanical Name	Suscept-ibility Rating
Saffron-Heart	Halfordia drupifera	I
Saffron-Heart, False	Xanthophyllum macintyrei	HS
Sallee, Black	Eucalyptus stellulata	HS
Sallee, White	Eucalyptus coriacea	RS
Salmon Gum	Eucalyptus salmonophloia	I
Salwood, Brown	Acacia aulacocarpa	MS
Sandalbox	Eremophila mitchelli	RS
Sassafras	(Doryphora sassafras (Daphnandra aromatica	I I
Sassafras, Southern	Atherosperma moschatum	I
Satinbox	Phebalium squameum	I
Satin Oak	Embothrium wickhami	HS
Satin Sycamore	Ceratopetalum succirubrum	RS
Satinash, Grey	Eugenia gustavioides	MS
Satinash, Rose	Eugenia francisii	RS
Satinay	Syncarpia hillii	I
Satinheart, Green	Geijera salicifolia, etc.	HS
Satinwood, Scented (Coachwood)	Ceratopetalum apetalum	I
Satinwood, Tulip	Rhodosphaera rhodanthema	HS
Scented Maple	Flindersia laevicarpa	I
Scribbly Gum	Eucalyptus haemastoma	RS
Scrub Ash	Elaeocarpus longifolius	MS
Sheoak, Beach	Casuarina equisetifolia	I
Sheoak, Black	Casuarina suberosa	I
Sheoak, River	Casuarina cunninghamiana	RS
Sheoak, Rose	Casuarina torulosa	I
Sheoak, Swamp	Casuarina glauca	I
Shining Gum	Eucalyptus nitens	HS
Silkwood, Bolly	Cryptocarya oblata	MS
Silkwood, Red	Lucuma galactoxylon	HS

Common Name	Botanical Name	Suscept-ibility Rating
Silky Ash	Ehretia acuminata	HS
Silky Beech	Villaresia moorei	RS
Silky Oaks (See Oak)		
Silver Basswood	Panax elegans	HS
Silver Quandong	Elaeocarpus grandis	RS
Silver Silkwood	Flindersia acuminata	MS
Silver Sycamore	Cryptocarya glaucescens	I
Silver-Leaved Ironbark	Eucalyptus melanophloia	I
Silvertop Ash	Eucalyptus sieberiana	I
Silvertopped Gimlet	Eucalyptus campaspe	I
Siris, Red	Albizzia toona	HS
Siris, White	Ailanthus imberbiflora	HS
Siris, Tulip	Pithecolobium pruinosum	HS
Siris, Yellow	Albizzia zanthoxylon	MS
Smooth-Barked Apple	Angophora lanceolata	HS
Southern Blue Gum	Eucalyptus globulus	MS
Southern Mahogany	Eucalyptus botryoides	RS
Southern Penda	Xanthostemon oppositifolius	RS
Southern Sassafras	Atherosperma moschatum	I
Southern Silky Oak	Grevillea robusta	HS
Southern Silver Ash	Flindersia schottiana	MS
Sovereign Wood	Terminalia sericocarpa	S
Spotted Gum	Eucalyptus maculata	HS
Spur Mahogany	Dysoxylum pettigrewianum	MS
Steel Box	Eucalyptus rummeryi	I
Stringybark, Bailey	Eucalyptus baileyana	HS
Stringybark, Blue-Leaved	Eucalyptus agglomerata	I
Stringybark, Brown	Eucalyptus capitellata	I
Stringybark, Mealy	Eucalyptus cinerea	MS
Stringybark, Messmate	Eucalyptus obliqua	HS

Common Name	Botanical Name	Suscept-ibility Rating
Stringybark, Planchon's	Eucalyptus planchoniana	I
Stringybark, Red	Eucalyptus macrorrhyncha	MS
Stringybark, White	Eucalyptus eugenioides	RS
Stringybark, Yellow	Eucalyptus muelleriana	I
Sugar Gum	Eucalyptus cladocalyx	HS
Swamp Box	Tristania suaveolens	RS
Swamp Mahogany	Eucalyptus robusta	*RS-MS
Swamp, Sheoak	Casuarina glauca	I
Sycamore, Red	Synoum glandulosum	HS
Sycamore, Satin	Ceratopetalum succirubrum	RS
Sycamore, Silver	Cryptocarya glaucescens	I
Sydney Blue Gum	Eucalyptus saligna	MS
Sydney Golden Wattle	Acacia longifolia	I
Sydney Green Wattle	Acacia decurrens	S
Sydney Peppermint	Eucalyptus piperita	*RS-MS
Tallowwood	Eucalyptus microcorys	MS
Tamarind	Diploglottis cunninghamii	HS
Tamarind, Corduroy	Arytera lauteriana	MS
Tamarind, Pink (Foambark)	Jagera pseudorhus	MS
Tea-Tree, Broad-Leaved	Melaleuca leucadendron	RS
Tea-Tree, Red	Melaleuca decora	RS
Tenandra Ironbark	Eucalyptus tenandrensia	RS
Tingle, Red	Eucalyptus jacksoni	RS
Tingle, Yellow	Eucalyptus guilfoylei	RS
Touin	Pometia pinnata	S
Touriga, Red	Calophyllum costatum	RS
Touriga, Brown	Calophyllum touriga	RS
Tuart	Eucalyptus gomphocephala	MS
Tulip Plum	Pleiogynium solandri	HS
Tulip Satinwood	Rhodosphaera rhodanthema	HS

Common Name	Botanical Name	Suscept-ibility Rating
Tulipwood	Harpullia pendula	RS
Tulipwood, Tortoiseshell	Pithecolobium grandiflorum	S
Turpentine	Syncarpia laurifolia	I
W.A. Blackbutt	Eucalyptus patens	HS
W.A. Flooded Gum	Eucalyptus rudis	I
Walnut, Blush	Beilschmiedia obtusifolia	MS
Walnut, Brown	Endiandra subtriplinervis	S
Walnut, N.S.W.	Endiandra virens	*RS-MS
Walnut, Pink	Endiandra sieberi	MS
Walnut, Queensland	Endiandra palmerstoni	RS
Walnut, Rose	Endiandra discolor	S
Walnut, White	Cryptocarya obovata	MS
Walnut, Yellow	Beilschmiedia bancroftii	HS
Wandoo	Eucalyptus redunca	I
Wandoo, Powder-Bark	Eucalyptus accedens	RS
Wattle, Black	Acacia mollissima	I
Wattle, Golden, Sydney	Acacia longifolia	I
Wattle, Green, Sydney	Acacia decurrens	S
Wattle, Hickory	Acacia penninervis	I
Wattle, Ironwood	Acacia excelsa	RS
Wattle, Maiden's	Acacia maideni	HS
Wattle, Red	Acacia flavescens	S
Wattle, Sally	Acacia cunninghamii	MS
Wattle, Silver	Acacia dealbata	RS
Wattle, Silver, Q'ld.	Acacia podalyriaefolia	I
Wattle, Willow	Acacia salicina	RS
Western Coolibah	Eucalyptus coolabah	RS
White Ash	Eucalyptus fraxinoides	S
White Banksia	Banksia integrifolia	S
White Basswood	Panax murrayi	MS

Common Name	Botanical Name	Suscept-ibility Rating
White Birch	Schizomeria ovata	HS
White Box	Eucalyptus albens	RS
White Brittle Gum	Eucalyptus maculosa	RS
White Cedar	Melia dubia	*RS-HS
White Cheesewood	Alstonia scholaris	HS
White Eungella Gum	Eugenia hemilampra	MS
White Handlewood	Pseudomorus brunoniana	HS
White Holly	Pittosporum rhombifolium	HS
White Mahogany	Eucalyptus acmenioides	RS
White Marble Wood	Acacia bakeri	S
White Oak	Stenocarpus sinuatus	MS
White Peppermint	Eucalyptus linearis	S
White Sallee	Eucalyptus coriacea	RS
White Siris	(Ailanthus imberbiflora (Ailanthus malabarica	HS
White Stringybark	Eucalyptus eugenioides	RS
White Walnut	Cryptocarya obovata	MS
White-Topped Box	Eucalyptus quadrangulata	I
Whitewood	Atalaya hemiglauca	HS
Wilga	Geijera salicifolia, etc.	HS
Willow Wattle	Acacia salicina	RS
Wirewood	Acradenia frankliniae	I
Woollybutt	Eucalyptus longifolia	MS
Woollybutt, Camden	Eucalyptus macarthuri	MS
Yarran	Acacia homalophylla	RS
Yate	Eucalyptus cornuta	RS
Yellow Boxwood	Sideroxylon pohlmannianum	HS
Yellow Carabeen	(Sloanea woollsii (Sloanea macbrydei	HS
Yellow Gum	Eucalyptus leucoxylon	HS
Yellow Penda	Xanthostemon pachyspermus	RS

Common Name	Botanical Name	Suscept-ibility Rating
Yellow Siris	Albizzia xanthoxylon	MS
Yellow Stringybark	Eucalyptus muelleriana	I
Yellow Tingle	Eucalyptus guilfoylei	RS
Yellow Walnut	Beilschmiedia bancroftii	HS
Yellowwood	Flindersia oxleyana	MS
Yertchuk	Eucalyptus consideniana	RS
York Gum	Eucalyptus loxophleba	I

SPECIES FOR WHICH WELL-ESTABLISHED COMMON NAMES ARE NOT YET AVAILABLE

Name	Susceptibility Rating
Acronychia baueri	S
Albizzia canescens	S
Arytera distylis	MS
Arytera divaricata	S
Arytera lauteriana (Corduroy Tamarind)	MS
Atalaya hemiglauca (Whitewood)	HS
Atalaya multiflora	HS
Cadellia monostylis	RS
Cadellia pentastylis (Ribbonwood)	HS
Capparis mitchelli	RS
Ceratopetalum virchowii	I
Chrysophyllum (Niemeyera) prunifera	I
Commersonia fraseri	RS
Cryptocarya murrayi	S
Cycas media	S
Duboisia myoporoides	I
Dysoxylum bechlerianum	S
Dysoxylum glabrescens	HS
Dysoxylum rufum	MS
Elaeocarpus bauerlinii	RS
Elaeocarpus holopetalus	RS
Elatostachys xylocarpa	S
Evodia accedens	RS
Evodia vitiflora	S
Excoecaria agallocha	HS
Geijera muelleri	S
Guioa semiglauca	HS
Harpullia hillii	RS
Helicia ferruginea	MS

Name	Susceptibility Rating
Hicksbeachia pinnatifolia	S
Jacksonia scoparia	HS
Litsea dealbata	HS
Mallotus discolor, philippinensis	S
Melaleuca coriacea	I
Melaleuca genistifolia (Moonah)	RS
Melaleuca maideni	RS
Melaleuca pauciflora	S
Melaleuca smithii	RS
Mischocarpus pyriformis	S
Myoporum serratum	I
Niemeyera prunifera	I
Orites excelsa (Southern Silky Oak)	MS
Pithecolobium grandiflorum (Tortoiseshell Tulipwood)	S
Pithecolobium hendersoni	HS
Pentaceras australis	HS
Sterculia quadrifida	HS
Syncarpia leptopetala	I
Sideroxylon chartaceum	S

NUTRITIONAL REQUIREMENTS OF *Lyctus* LARVAE*

The problem of the food requirements of *Lyctus* larvae may be approached in a number of different ways viz.

(i) Chemical analysis of food and excrement.

(ii) Testing for the presence of certain enzymes in the gut.

(iii) Removal of certain substances from the wood by extraction with solvents.

(iv) Addition of certain substance to wood by impregnation techniques.

(v) Feeding on artificial diets.

The first two methods have been discussed in some detail by Parkin (1936) and it did not appear profitable to pursue these any further at the present time. Of the remaining three methods both (iii) and (v) have also been investigated by Parkin, and he has shown that in oak sapwood, a substance, soluble in water at 60°C., is necessary for larval development, and that starch, sugars and protein are necessary constituents of the larval food.

Method (iii) has been re-investigated in conjunction with (iv) using *Alstonia scholaris* as the food material and it was shown (a) that the removal of starch by acid hydrolysis rendered the wood unsuitable for larval development, and (b) that impregnation either with soluble starch alone (up to the 4 per cent. level), or with soluble starch plus sucrose, peptone and salt mixture failed to make extracted or naturally starch-free wood suitable for larval development.

Further tests of this type have shown that extraction of *Alstonia* containing abundant starch with alcohol-benzene-alcohol and ether removes some substance which speeds up larval development, whilst the addition of

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*Prepared by the Division of Entomology C.S.I.R.O.

soluble starch to unextracted starch-free <u>Alstonia</u> has no effect on larval development below the 4 per cent. level. In a series of "addition" tests with <u>Eucalyptus regnans</u>, the addition of 2 per cent. soluble starch has been sufficient to support larval development for at least seven months.

The work on artificial diets is based on Parkin's technique, but differs in using day-old larvae as the test insects. A basic diet of soluble starch, casein, sucrose, yeast, cholesterol and salt mixture has proved adequate for nutritional purposes and has produced adult beetles in 70 days at 26°C., and 75 per cent. R.H. Variations of this basic diet are now being investigated with a view to determining more precisely the requirements of the larvae. Very little development takes place in the absence of yeast, clearly indicating the need for vitamin B complex. The removal of cholesterol from the diet slows down the development quite markedly and increases larval mortality; this is in keeping with general insect nutritional requirements, since all insect species so far studied have been shown to require a sterol in their diet.

The basic diet has a carbohydrate: protein ratio of approximately 4:1, but subsequently adults were reared on a diet with a carbohydrate: protein ratio of 9:1. This finding is of considerable interest in relation to the problem of how wood eating insects obtain their nitrogen, for since successful development took place at this ratio, no special explanation is required for their ability to develop in wood in which according to Parkin's figures the carbohydrate: protein ratio is 3.5:1.

It appears, therefore, that this artificial diet technique is a most useful tool for arriving at a more precise understanding of the basic dietary requirements of <u>Lyctus</u> larvae.

THE DEVELOPMENT OF A SIMPLE METHOD OF ESTIMATING BORIC ACID IN TREATED TIMBER*

SUMMARY

A previous report (1) indicated that the entire boric acid content of twelve commonly used timbers, (see Appendix A) could be extracted with ease by leaching with dilute HCl and that this solution could be subsequently accurately titrated. The present report indicates that the use of higher concentrations of boric acid in the above method gives less satisfactory results and recommends the leaching of a 2 gm. sample with 40 ml. of dilute HCl, the final volume to be 100 ml., and an aliquot of 10 ml. This should give satisfactory results for the 16 species now tested. Spotted gum, however, gave unsatisfactory end points probably due to the presence of tannins. All of the other species tested gave reasonably clear solutions, and no precipitate was noticed on neutralisation. The use of more effective wood macerating agents such as H_2SO_4, HNO_3 + $KClO_4$, is proposed.

The method of ashing without lime-eschka did not give good results and appreciable amounts of boric acid appeared to be lost in this treatment. It is considered that this may be overcome by the addition of small amounts of alkali such as $Ba(OH)_2$ to the ground sample.

INTRODUCTION

The methods in general use for the determination of boric acid in treated timber (2) are long, expensive and require staff skilled in analytical work. Hence this investigation was undertaken to develop a quick simple and accurate method of analysis, suitable for both plant control and routine laboratory work.

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*Prepared by the Division of Wood Technology, N.S.W.

The standard procedure of analysis is to ash the ground wood sample with lime-eschka, dissolve the ash in HCl, make up to the required volume, select an aliquot and titrate with N/25 NaOH using either the B.T.B. or the Double Indicator Method (2). It is most desirable to eliminate the ashing process if possible not only because of the time consumed in this operation, but also because it requires the use of equipment (e.g. an electric muffle furnace) which is not only expensive but for which facilities are not always available, particularly for treatment plants located in country districts. Furthermore, the use of lime-eschka introduces a number of possible sources of error into the estimation.

Consequently, investigations were begun with the objects of

(1) Developing a method of extracting the boric acid from the wood sample by leaching.

(2) Developing a method of ashing the wood sample without the use of lime-eschka.

Progress Report No. 1 indicated that, with all the species tested, excepting yellow carabeen, the entire boric acid content of a sample of treated timber can be extracted with ease by leaching with dilute HCl, giving a solution which may subsequently be accurately titrated. Further, time is again saved by the aliquot not requiring a reflux. The yellow carabeen samples could be satisfactorily analysed by taking a smaller aliquot. The first report concluded with the proposal to extend the experiment to cover other species not included in the report as they came to hand and to examine the results obtained when higher concentrations of boric acid were used. The present report gives the results obtained from the analysis of 90 samples by three methods:-

1. Ashing with lime-eschka.
2. Ashing without lime-eschka.
3. Leaching with dil. HCl.

In this series, certain species not dealt with in the first progress report were included, namely, coachwood, spotted gum, mararie and silver ash. The concentration of boric acid in the aliquots were higher in this series, the sample of ground wood taken 2.5 gm. as against the 2 gm. sample used by the previous worker.

PROCEDURE

Each of the samples submitted for analysis was treated in the following manner:-

1. 2.5 gm. of the ground wood were ashed with lime-eschka in the electric muffle furnace. The ash was dissolved in conc. HCl almost neutralised, (see note 2 in Appendix A) and the solution then made up to 100 ml. with distilled water. A 10 ml. aliquot was titrated by the B.T.B. method, after refluxing.
2. 2.5 gm. of the ground water were ashed in the electric muffle furnace. Then proceed as in (1).
3. 2.5 gm. of the ground wood were placed in a 250 ml. Erlenmeyer flask, 40 ml. of approximately N HCl were added and the contents refluxed for five minutes on a sand bath. After cooling the solution was filtered into a 100 ml. volumetric flask. The Erlenmeyer flask, filter paper and funnel were washed down by three small (10 ml.) successive portions of distilled water, so as to ensure that all the original solution was transferred to the volumetric flask. The solution was then almost neutralised and made up to 100 ml. with distilled water. A 10 ml. aliquot was then titrated by the B.T.B. method.

RESULTS

The results have been tabulated in Tables 1 to 111 as follows:-

(1) The recorded results for the three methods and the differences between them for each sample are shown in Table 1.

(2) A comparison of the results to show the degree of agreement between the three methods is given in Table 11. The methods were compared first, using all the results obtained, and secondly, using only those results of less than approximately 0.6% boric acid content. The number of positive and negative differences obtained in each comparison are also shown. Those differences of more than 0.09% are shown in a separate column together with their respective boric acid content.

(3) The results have also been compared in Table 111 using adjusted figures for the ashing with lime-eschka results. When the leaching and ashing without lime-eschka results agree, and this figure differs markedly from the ashing with lime-eschka result the former has been taken as correct and the latter adjusted accordingly. The adjusted ashing with lime-eschka results and the adjusted differences are shown in Table 1 in brackets.

DISCUSSION

A. Table 11

1. The agreement between the ashing without lime-eschka and ashing with lime-eschka methods is not good when taken over the whole range of concentration used as shown in Table 11. Of the 48 samples compared, only 21 (43.7%) agreed to within ± 0.02% and 35 (72.9%) agreed to within ± 0.05%.

It is interesting to note that 43 samples were in agreement to within ± 0.07% and that of the remaining 5 samples which markedly disagreed all but one had high boric acid content. The number of negative differences recorded was much higher than that of positive differences, namely 25 to 16, and this would seem to indicate that some boric acid is lost when ashing without lime-eschka.

The effect of concentration of boric acid is shown by considering the corresponding figures obtained by tabulating the results of samples containing up to 0.06% boric acid only. Of the 30 such samples compared, 15 (50%) agreed to within ± 0.02% while 24 (80%) agreed to within ± 0.05%. Only one sample showed disagreement of more than 0.07%, and the number of positive and negative differences were equal.

2. The comparison of the leaching against the ashing with lime-eschka results is more promising. Of 85 samples taken over the whole concentration range, 62 (73%) showed agreement to within ± 0.02% and 79 (93%) agreed to within ± 0.05%. Here again more negative than positive differences were recorded and this would seem to indicate that all the boric acid was not removed from the samples by leaching. Furthermore, those results showing marked disagreement were obtained from samples with a high boric acid content. This effect is again brought out by the figures obtained by comparing only those samples with a boric acid content of up to 0.6% approx. Of 68 such samples, 54 (79.6%) agreed to within 0.02% and 67 (98.6%) to within ± 0.05%. These results were the best obtained in these experiments. However, there were still more negative (30) than positive differences (23).

3. The comparison of the leaching results against those of ashing without L.E. revealed that 56% of the samples

agreed to within 0.05% as against 76.7% of the former. Thus there appears to be better agreement between the ashing without L.E. and the leaching results than between the former and the ashing with L.E. results.

B. <u>Table 111</u>

The above figures were obtained using the assumption that the ashing with L.E. results were correct. The remarks in the preceeding paragraph A3 and an examination of Table 1 which shows that in some cases (e.g. HN227-1) the ashing with L.E. figure differs markedly from the results given by the other two methods which latter show reasonable agreement in such cases, suggests that the ashing with L.E. results might be misleading. In such cases the ashing with L.E. results has been assumed to be incorrect and has been adjusted accordingly, and these adjusted results have been compared in Table 111. This step was taken in order to see what real agreement is reached between the three methods, if as suspected, some of the ashing with L.E. results were wrong, and this was taken into account. The results support the views expressed above that the leaching method appears to be the most promising, 84% of these samples containing up to 0.6% boric acid agree to within ± 0.02 as against 60% of the samples ashed without L.E. and 100% of the former agree to within ± 0.05 as against 95.4 of the latter.

C. <u>General</u>

Although the results indicate that the leaching method is more successful than ashing without L.E., there still seems to be a loss of boric acid in both methods, as shown by the greater number of negative differences recorded. With regard to ashing plant material it is considered by many workers (3), (4) that the boric acid should be retained if the ash remains alkaline and hence some of them ash with a little $Ba(OH)_2$ or KOH etc. To overcome any doubt that all the boric acid is removed by the leaching process it may be that a more effective wood macerating agent is required. Such an agent is Schulze's macerating solution (5) consisting of HNO_3 + $KClO_4$ which not only separates but disrupts the cells through dissolving the middle lamella. One disadvantage that might arise from the use of any solution containing HNO_3 is that calcium oxalate dissolves in it and this might give rise to a source of error in the titration. Both H_2SO_4 and chromic acid dissolve cellulose (6) and the latter also dissolve lignin. Thus a solution containing 5-10% each of chromic and nitric acids will macerate wood even in the cold, and it has been suggested that a suitable mixture is HNO_3 + $KClO_4$ + H_2SO_4 (7). The effect of conc. of boric acid appears to be very important, increase of concentration causing a corresponding decrease in accuracy. The results show marked divergencies when the concentrations approach 1%. This effect of course can be overcome by selection of an appropriate aliquot, and although taking a smaller aliquot increases the multiplying factor, the increase in the accuracy of the titration would give a more reliable final result. The solutions obtained by leaching were in all cases free of any sign of a precipitate and although several cases of distinct colouring (e.g. Pacific maple gave a ruby solution) were observed in the original 40 ml. of leaching, this usually became less noticeable on dilution to 100 ml. and in the selected aliquot no interference in the titration by the solution colour was detected. Most of the leachings have a light yellowish or pink colour only. The above remarks do not apply to the case of spotted gum. The addition of alkali to the leachings of this species produced a deep red brown colouration, and a very faint colloidal precipitate, probably due to the presence of Tannin (1.5 to 5%). The end points for this species were not good, and in some cases were very bad, in both leaching and ashing methods. The three titrations of yellow carabeen carried out did not support the previous worker's comments on this species. In two of these titrations, results agreeing to within ± 0.02% were obtained for all three methods, while the third titration was unreliable owing to the high conc. of boric acid present. The end points were quite good. Only one sample of bollywood was analysed for this species. The previous report also mentioned difficulty with this species but this was not supported by our analysis. The end point was quite good and the results agreed to within ± 0.03%. No sample of red silkwood, which had also been reported as causing some difficulty in titrating was available for these experiments. All the samples used for the analysis were submitted by commercial firms and plants and unfortunately the range of species offering was fairly limited. However, most of the commonly used timbers have now been included in these reports.

CONCLUSIONS

The results of these investigations show that the leaching method of analysis of boric acid is more satisfactory than the ashing without lime-eschka method. The former should be quite satisfactory provided the concentration of boric acid in the aliquot be kept low, and it is suggested that the practice of leaching a 2 gm. sample as used for the compilation of the first progress report, be resumed, the results obtained by the use of these concentrations being quite satisfactory. The use of a more effective wood maceration agent is considered desirable in order to ensure the removal of all the boric acid from all species and it is proposed to carry out a set of experiments to determine the efficiency of (a) H_2SO_4

(b) $HNO_3 + KClO_4$

(c) Chromic + HNO_3 (Cold)

Ashing without lime-eschka is still considered to be feasible if the ash is alkaline and it is proposed to carry out experiments using the addition of small amounts of alkalis to the sample before ashing. This should reduce the loss of boric acid indicated by the results.

REFERENCES

1. The Development of a Simple Method of Estimating Boric Acid in Treated Timber. Sub-Project P8-5 Progress Report No. 1. (W.J. Stephen).

2. D.J. McKenzie & J. Sterling C.S.I.R.O. Division of Forest Products, Experiment C-O-Y-28 Report 35, "Bromothymol Blue Method and Double Indicator Method".

3. K. Scharrer Z. Anal Chem. 128 - 435-42 (1948).

4. Austin & McHargue J.O.A.C. 31 - 284-5 (1948) Cf. remarks by Dickinson - Analyst 68 - 106-9 (1943)

5. Jones "The Structures of Timbers".

6. Jeffrey "The Anatomy of Woody Plants" P. 446.

7. Abramson & Kahane, Bull. Soc. Chim. France 1146-9 (1948).

APPENDIX A

The following species were reported as being suitable for analysis by the leaching method in Progress Report No. 1.

Tulip oak	Pacific maple
White birch	Tawa
White Cheesewood	Ramin
Ivorywood	Black bean
Rose butternut	White siris
Red silkwood	Bollywood.

To this list is now added the following species, recommended as suitable in the present report.

Yellow carabeen
Coachwood
Mararie
Silver ash.

<u>NOTE 1</u>: Spotted gum analyses by the leaching method are as reliable as those by the ashing method.

<u>NOTE 2</u>: By "<u>almost neutralised</u>" (line 15 Page 3) is meant the following procedure:

The Conc. HCl solution containing the dissolved ash is made slightly basic by the addition of 10% NaOH, using BTB as indicator. Then 10% HCl is added slowly till the ppt. is redissolved. This results in a slightly acid solution which is made up to 100 ml. with distilled water. Care should be taken not to add too much 10% HCl as the subsequent aliquot will need an excessive amount of N/25 NaOH to bring it to the first end point when titrated.

TABLE 1

Lab, No.	Species	% BORIC ACID Ashing with Lime-Eschka (1)	Ashing w/out Lime-Eschka (2)	Leaching (3)	Difference between (2) and (3)	Difference between (3) and (1)	Difference between (3) and (2)
HN221-1	White birch	0.25(0.18)	0.19	0.16	- 0.06(+0.01)	- 0.09(0.02)	- 0.03
2		0.19	0.18	-	- 0.01	-	-
3		0.11(0.09)	0.09	0.09	- 0.02(Nil)	- 0.02(Nil)	Nil
4		0.23	0.23	0.24	Nil	+ 0.01	+ 0.01
HN232-1		0.97	0.94	-	- 0.03	Nil	-
2		0.83	0.86	0.84	+ 0.03	+ 0.01	- 0.02
3		0.93(0.86)	0.86	0.85	- 0.07(Nil)	- 0.08(0.01)	- 0.01
4		0.99	0.97	-	- 0.02	-	-
HN243-1		0.55	0.41	0.50	- 0.14	- 0.05	+ 0.09
2		0.73(0.69)	0.69	0.69	- 0.04(Nil)	- 0.04(Nil)	Nil
3		0.34	0.40	0.34	+ 0.06	Nil	- 0.06
4		0.39	0.39	0.40	Nil	+ 0.01	+ 0.01
HN248-1		0.72	0.58	0.71	- 0.14	- 0.01	+ 0.13
2		0.48	-	0.48	-	Nil	-
3		0.29	0.29	0.28	Nil	- 0.01	- 0.01
4		0.46	0.39	0.47	- 0.07	+ 0.01	+ 0.08
042-1		0.59	0.61	0.55	+ 0.02	- 0.04	- 0.06
2		0.94	0.94	0.94	Nil	Nil	Nil
4		0.99	0.99	0.95	Nil	- 0.04	- 0.01
5		0.62	0.61	0.60	- 0.01	- 0.02	- 0.01
6		0.47	0.40	0.45	- 0.07	- 0.02	+ 0.05
043-4		1.25	1.04	1.13	- 0.21	- 0.12	+ 0.09
* 043-7							
DWT- 9	Ivorywood	0.34	0.30	0.34	- 0.04	Nil	+ 0.04
10		0.42	0.45	0.44	+ 0.03	+ 0.02	- 0.01
12-1		0.47	0.51	-	+ 0.04	-	-
12-2		0.24	0.26	0.23	+ 0.02	- 0.01	- 0.03
12-3		0.43(0.38)	0.36	0.39	- 0.07(-0.02)	- 0.04(+0.01)	+ 0.03
12-4		0.42	0.44	0.46	+ 0.02	+ 0.04	+ 0.02
NP - 19	Ramin	0.68	0.64	0.66	- 0.04	- 0.02	+ 0.02
NP - 21		0.27	0.24	0.26	- 0.03	- 0.01	+ 0.02
NP - 22		0.44	0.43	0.45	- 0.01	+ 0.01	+ 0.02
23		0.29	0.32	0.30	+ 0.03	+ 0.01	- 0.02
24		0.34(0.38)	0.39	0.38	+ 0.05(+0.01)	+ 0.04(Nil)	- 0.01

TABLE 1. (Cont'd.)

Lab. No.	Species	% BORIC ACID Ashing with Lime-Eschka (1)	Ashing w/out Lime-Eschka (2)	Leaching (3)	Difference between (2) and (1)	Difference between (3) and (1)	Difference between (3) and (2)
P10 - 2	Ivorywood	0.02		0.07		+ 0.05	
3		0.14		0.19		+ 0.05	
4		0.03		0.03		Nil	
5		0.03		0.04		+ 0.01	
DWT11-1		0.15		0.16		+ 0.01	
		0.20		0.21		+ 0.01	
		0.03		0.02		- 0.01	
		0.03		0.02		- 0.01	
		0.03		0.02		- 0.01	
		0.03		0.03		Nil	
		0.19		0.19		Nil	
		0.16		0.15		- 0.01	
DWT B	Bollywood	0.45		0.48		+ 0.03	
T1 42	Cheesewood	1.59		1.43		- 0.16	
S1A	Tulip oak	0.09		0.11		+ 0.02	
S1B	" "	0.06		0.10		+ 0.04	
S1C	Mararie	0.08		0.10		+ 0.02	
S1D	"	0.04		0.05		+ 0.01	
S1E	Silver ash	0.05		0.04		- 0.01	
S1F	" "	0.06		0.03		- 0.03	
S2A	Tulip oak	0.08		0.07		- 0.01	
S2B	" "	0.04		0.04		Nil	
S2C	Mararie	0.04		0.06		+ 0.02	
S2D	"	0.16		0.16		Nil	
S2E	Silver ash	0.05		0.05		Nil	
S2F	" "	0.06		0.02		- 0.04	
TOTAL		90	48	85	48	85	43

TABLE 1. (cont'd.)

Lab. No.	Species	% BORIC ACID Ashing with Lime-Eschka (1)	Ashing w/out Lime-Eschka (2)	Leaching (3)	Difference between (2) and (1)	Difference between (3) and (1)	Difference between (3) and (2)
NP 20	Pacific maple	0.52	0.51	0.52	- 0.01	Nil	+ 0.01
NP 18		0.38	-	0.37		- 0.01	-
TI 44		0.72	-	0.75		+ 0.03	-
041-2		0.95	0.89	-	- 0.06	-	-
041-6		0.25	0.26	0.27	+ 0.01	+ 0.02	+ 0.01
-7		0.42	0.43	0.44	+ 0.01	+ 0.02	+ 0.01
NP 25		0.86	0.93	0.86	+ 0.07	Nil	- 0.07
041-3		0.88	0.67	0.92	- 0.21	+ 0.04	+ 0.15
041-4		1.1	1.1	1.1	Nil	Nil	Nil
DWT-1C	Coachwood	0.53	0.56	0.52	+ 0.03	- 0.01	- 0.04
2C		0.57	0.53	0.55	- 0.04	- 0.02	+ 0.02
3C		0.62	0.65	0.62	+ 0.03	Nil	- 0.03
4C		0.55	0.55	0.54	Nil	- 0.01	- 0.01
043-3	Yellow carabeen	0.57	0.58	0.55	+ 0.01	- 0.02	- 0.03
* 7		0.98	0.96	0.98	- 0.02	Nil	+ 0.02
5		1.23	1.19	1.01	- 0.04	- 0.12	- 0.18
* 6		1.74	1.97	1.74	+ 0.23	Nil	- 0.23
* 8		1.45	1.43	1.34	- 0.02	- 0.11	- 0.09
NB-1		0.19		0.15		- 0.04	
2		0.19		0.15		- 0.04	
3		0.20		0.20		Nil	
4		0.17		0.15		- 0.02	
5		0.23		0.21		- 0.02	
WTD-1H	Spotted gum	0.04		0.03		- 0.01	
2H		0.11		0.11		Nil	
3H		0.05		0.07		+ 0.02	
4H		0.09		0.09		Nil	
5H		0.03		0.02		- 0.01	
6H		0.04		0.02		- 0.02	
7H		0.05		0.05		Nil	
8H		0.06		0.07		+ 0.01	

TABLE 11.

Comparison of the Results as Recorded

Method of Comparison	Range of Comparison	No. of Samp. Comp.	Degree of Agreement (up to 0.09%)										No. of +	No. of −	Remainder	
			Full	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09			Difference	Conc. of Boric Acid.
Ashing without L.E. Against Ashing with L.E.	Over all Conc. used.	48	7	14	21 43.7%	28	34	35 729%	38	43			16 33.2%	25 52%	− 0.14 − 0.14 − 0.21 − 0.21 − 0.23	0.55 0.72 1.25 0.88 1.74
	Up to Conc. of 0.6% only	30	4	11	15 50%	20	23	24 80%	26	29			13	13 43.4%	− 0.14	0.55
Leaching Against Ashing with L.E.	Over all Conc. used.	85	20	46	62 73%	65	76	79 93%	79	79	80	81	26 32.7%	39 45.9%	− 0.12 − 0.11 − 0.12 − 0.16	1.25 1.45 1.23 1.59
	Up to Conc. of .6% only.	68	15	39	54 79.6%	56	64	67 98.6%	67	67	67	68	23 33.9%	30 44.3%		
Leaching Against Ashing W/out L.E.	Over all Conc. used.	43	4	16	24 56%	29	31	33 76.7%	34	35	36	39	19	20	+ 0.13 + 0.15 − 0.18 − 0.23	0.72 0.88 1.23 1.74
	Up to Conc. of .6% only.	28	1	11	16 56.2%	21	23	24 85.9%	26	26	27	28	14	13		

TABLE 111.

Comparison of Results Using Adjusted Values of Ashing with L.E. (A.L.E.)

Method of Comparison	Range of Comparison	No. of Samp. Comp.	Degree of Agreement (up to 0.09%)										No. of +	No. of −	Remainder	
			Full	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09			Difference	Conc. of Boric Acid
Ash without L.E. against Ashing with L.E.	Over all Conc. used.	48	10	19	26 54.2%	33	38	38 79.2%	40	43			17 35.4%	21 43.8%	As in Table 11.	
	Up to .6% only	30	5	14	18 60%	23	26	26 95.4%	27	29			14 46.7%	11 36.7%	− 0.14	0.55
Leaching against Ashing with L.E.	Over all Conc. used	85	22	50	66 77.8%	69	78	81 95.4%					26 33%	37 43.6%	As in Table 11.	
	Up to .6% only	68	17	42	57 84%	59	65	68 100%					23 33.8%	28 41.2%	−	−

THE DETERMINATION OF BORON BY COLORIMETRIC METHODS*

1. OBJECT.

It is intended in this paper to -

(a) indicate to this Conference our experiences using the colorimetric techniques quoted in selected references,

(b) show some of the difficulties encountered and the accuracy obtained,

(c) obtain the advice and assistance of this Conference.

2. METHODS.

At the Fourth Conference, when the two existing methods were discussed fully, the subject of alternative methods was raised. The decision was reached that these methods warranted refinement. The results of such studies have been discussed fully elsewhere at this Conference and it is not intended to discuss them further herein. It was also decided that the Division of Forest Products would investigate a satisfactory colorimetric method.

In recent months an "Eel" photo-electric colorimeter was purchased by our Department for the Laboratory for general chemical analyses with particular emphasis on preservation and wood chemistry studies. It was realised early that colorimetric methods would possibly vary in relation to each type of instrument. As a large number of samples on hand in the laboratory had been thoroughly examined by the present standard methods, it was felt opportune to apply existing methods used for biological examination of boron with the aim that possibly such results would be of assistance to the Division in their investigation.

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*Prepared by the Forest Products Research Branch, Queensland Forest Service.

A search of available literature indicated that three main colour reagents were used as shown in Table 1.

Table 1.

Common Colour Reagents for Boron Determination.

Reagent	Colour*
Tumeric/Hydrochloric Acid	Red - Yellow
Quinalizarin/98% Sulphuric Acid	Blue - Red
Chromotrope 2B/98% Sulphuric Acid	Blue

*The variable colour is shown first.

The second of these was selected as published techniques existed for this reagent (1)(2).

3. EXPERIMENTAL PROCEDURE.

The experimental procedure (1) followed in our tests consisted in detail of the following.

PART A.

Preparation of Standards.

(a) Colour Reagent. A concentrated solution of quinalizarin in 98 per cent, sulphuric acid (A.R. grade concentrated) was prepared containing 125 mg./litre and retained in a glass stoppered flask.

This was diluted to a working solution containing 5 mg. of quinalizarin per litre.

(b) Basic Boron Solutions. Gravimetrically accurate solutions were prepared of the following concentrations.

0 g./ml.
1×10^{-6} g./ml.
2×10^{-6} g./ml.
3×10^{-6} g./ml.
4×10^{-6} g./ml.
5×10^{-6} g./ml
7×10^{-6} g./ml.
10×10^{-6} g./ml.
15×10^{-6} g./ml.
20×10^{-6} g./ml.

(c) Selection of Filter. A red filter (No.607 "Eel") was selected as giving the maximum range on the instrument. The matter of filters appears to be of reasonable importance and one which we would like to see thoroughly examined in the Division's investigations.

(d) Development of Colour. The literary references quoted are at variance in the time/colour relationship. On the one hand Piper considers 24 hours necessary but the method used simply requires the condition that the sample should reach room temperature, which we found under our conditions was attained after 30 minutes. Accordingly this period was fixed for test material. That this does not fully satisfy requirements is shown by the fact that samples left overnight in tubes (unstoppered) showed an irregularity (up to 5 per cent.) in colour over initial readings. This effect may be related on the other hand to absorption of moisture with consequent alteration of the colour. In practice however, the factor may be overcome by fixing a specific time ratio.

(e) Colour - Temperature Relationships. The reference indicated that there is a temperature effect upon the colour intensity. As we are at present not equipped with thermostatic water baths an approximate value only of this could be obtained during cooling. The order of the results obtained indicated an approximate rise of 0.3 units per degree centigrade.

The exact variation would require study and its effect upon the concentrations determined.

PART B.

Calibration of Instrument.

Calibration of Instrument. Using the pure boron standards prepared as in Part A(b) the instrument was calibrated by the following methods.

A 1.0 ml. sample was pipetted into a clean dry test tube and 10 ml. of the quinalizarin/sulphuric mixture added from a burette. This was shaken and allowed to cool for 30 minutes and readings taken. This was repeated three times and the mean taken.

It was found that the readings ranged from 14.37 for zero concentration to 28.67 for 20 x 10^{-6} g./ml. of boron. Unfortunately, the curve flattened out very rapidly and the most accurate portion was up to about 12 x 10^{-6} g./ml.

PART C.

Comparison with Standard Wood Samples.

(a) Standard Analysis. All samples tested were analysed using the Double Indicator (Methyl Red and Phenolphthalein) method. Ignition of the sample was carried out using lime-esckа mixture as the binding agent.

(b) Preparation of Sample. In preparing the sample for analysis a simpler and more rapid procedure was used. This consisted of the following:-

(i) Reflux extraction of the ground wood.

(ii) Charring and solution.

Of these (i) was eliminated due to slight colour and it was considered undesirable to introduce the further step of decoloration before testing. The char method had given promise and has been discussed more fully elsewhere at the Conference.

In this 2½ grams were charred to a black ash over a burner without ignition. The ash was washed into a beaker with 50 ml. of water and warmed for 2 minutes to ensure solution of the boric. This was then transferred to a 250 ml. volumetric flask and made to volume. By this means a colourless solution was easily obtained.

(c) Development of Colour. Each sample was then treated with the sulphuric acid/quinalizarin solution and allowed to develop as given in Part B.

(d) Amendments to Technique. The results although reasonable were considered to warrant improvement. In an attempt to improve accuracy, a further dilution was made to bring the range into the steep portion of the curve. Accordingly the volume was increased such that $2\frac{1}{2}$ gm. of the wood were dissolved in 500 ml. This alteration did in general increase the accuracy especially in the higher ranges above .6 per cent. boric acid.

In an endeavour to cause the "lifting" of the curve it was felt advisable to examine the factor of quinalizarin/boron concentration. This was based upon the possible theory that the colour was due to the formation of a complex between the two and that, for the ratio taken, above a certain concentration of boron, e.g. 12×10^{-6} g./ml., all the quinalizarin had been reacted and hence no further development of colour occurred.

Accordingly a range of quinalizarin solutions were made containing:

(i) 5 mg./litre
(ii) 10 mg./litre
(iii) 15 mg./litre
(iv) 20 mg./litre
(v) 25 mg./litre

and the colour developed with a gravimetric standard. Results obtained in this test were as follows:

Mg. Quinalizarin/litre	Meter Range (app.)	Diff.
5	14 - 28	14
10	32 - 55	23
15	47 - 80	33
20	62 - 100+	38
25	Off meter scale	-

However, the apparent increase may not be practical for the increased numerical range is compensated for by the decreased accuracy of the scale which is logarithmic - a fact indicated by measurement of the tangential distance which is approximately the same. This is a tentative conclusion only however and mathematical analysis would be necessary before final conclusion could be reached.

It seems desirable therefore that some means to amplify the deflection should be used, e.g. a relay. This would be difficult as the selenium cell incorporated has a full scale deflection of 7 micro-amps but it is raised here to indicate to Conference the lines along which it is felt desirable that work should be done for our particular type of instrument.

4. RESULTS OBTAINED.

The results obtained were more promising than expected as the experiments were initial trials for the purpose of familiarising our staff with colorimetric techniques and in the hope that from them Mr. Christensen and his staff may be able to develop a method.

All results are listed in Appendix 1. Plotting them against the concentration determined by the standard titration methods showed that they are reasonably well distributed about the theoretical line.

Examining the results, some divergence is seen in the lower ranges, examples of which are shown in Table 2.

Table 2.

Relation between PE and Titration Readings.

PE.	Titration
.12	.13
.10	.03
.07	.03
.07	.08
.05	.06
.05	.00
.22	.18
.22	.24
.21	.22
.14	.05
.03	.02

This may be due to the very small titration in these limits around .05 per cent. just as much as to the colorimeter.

5. MATHEMATICAL EXAMINATION.

The results have not been exhaustively examined mathematically as at present no biometrician is available at our Department. However, it is intended to forward all results and data to Mr. Christensen for critical analysis. One point of interest lies in the fact that when scale readings are plotted against log concentration (on log paper) a linear relationship is found.

6. COMPARISON WITH OTHER METHODS.

The results even in the present elementary state of technique development would compare reasonably with the comparison between the two existing methods viz. the Bromthymol blue and Double Indicator titration. This can be seen from other discussions upon these latter methods and is shown in selected results in Table 3.

Table 3.

Comparison between Existing Methods.

D.I.	B.T.B.*	D.I.*	P.E.
.27	.10	.56	.57
.23	.25	.52	.51
.10	.08	.00	.09
.29	.17	.02	.04
.03	.09	.15	.24
.42	.13	.72	.74
.44	.40	.84	.80
.46	.87	.83	.80

*Not same samples.

Accordingly the view of Conference is requested upon whether this Department should continue using the method for routine commercial checks as distinct from experimental projects.

In elaboration of this point I would mention that for one quarter only of 1950, 484 commercial analyses were carried out resulting in a very big lag in the experimental work that this laboratory should be doing and a more rapid and less costly procedure is felt very desirable.

7. CONCLUSION.

(a) Colorimetric methods appear satisfactory for boron analysis within the range of timber preservative treatments.

(b) Existing techniques as published in references appear at variance in various factors which require determination before a completely satisfactory method is found. Inter alia it is suggested that priority be given to examine:-

(i) Quinalizarin/boron ratio.

(ii) Time/Colour Development relationships.

(iii) Temperature/Colour Development relationships.

It is also felt that if possible such methods should aim at a range such that the large dilution and consequent multiplicative factors should be reduced.

(c) For normal commercial check purposes, as distinct from investigational studies, the present method as outlined agrees reasonable well with the comparison between existing methods.

(d) The charring method has given reasonable results.

8. REFERENCES.

(1) Berger, K.C. and Emil Truog. "Boron Tests and Determination for Soils and Plants". Boron Symposium. (The Williams and Wilkins Company) 1944, p.25 - 35, Reprinted from Soil Science, January, 1944.

(2) Piper, C.S. "Soil and Plant Analysis", 1944, p.316.

APPENDIX I.

Experimental Results Using "Eel" PE Colorimeter.

1. Calibration of Instrument.

Remarks: Pure gravimetric standards used.

Standard	P.E. Rdgs.	Range
0%	14.37	13.9 - 15.3
1×10^{-4} %B.	17.65	17.1 - 18.0
2×10^{-4} %B.	20.22	19.7 - 21.0
3	22.22	21.8 - 22.8
4	23.51	23.0 - 24.1
5	25.07	24.3 - 26.0
7	26.08	25.7 - 26.8
10	27.04	27.0 - 27.7
15	28.04	28.0 - 28.8
20	28.67	28.3 - 28.9

2. Analysis of Standard Wood Samples.

Remarks: Solution of boric acid of known concentration added to untreated shavings.

Reading	% Boric (Calculated)	% Boric (Added)
13.9	0	0
14.6	0	.1
15.8	.14	.2
17.2	.29	.3
17.7	.36	.4
18.6	.49	.5
18.9	.54	.6
20.2	.75	.8
21.5	.99	1.0
23.2	1.37	1.4

APPENDIX I. (Cont'd.)

3. Analysis of Wood Samples containing unknown % Boric.

Remarks: (a) Leaching method attempted here but interference caused by the varying natural colours of the leaching solution.

(b) As described, charring carried out. In this case 2½ grams of sawdust taken to 250 ml.

PE Rdg.	Species	% Boric (PE)	% Boric (DI)
17.1	Ivorywood	.05	.00
17.2	Ivorywood	.05	.06
17.8	Y. Walnut	.06	.00
18.2	Ivorywood	.07	.08
18.5	Ivorywood	.07	.03
19.1	Ivorywood	.09	.16
19.3	Ivorywood	.09	.00
19.5	Ivorywood	.10	.03
20.5	Red Tulip Oak	.13	.12
20.8	Nth. Silver Ash	.14	.05
22.5	Blush Alder	.21	.14
22.9	Red Tulip Oak	.21	.22
23.0	Nth. Silver Ash	.21	.22
23.2	Blush Alder	.22	.24
23.3	Red Tulip Oak	.22	.18
24.4	Sycamore	.26	.43
24.5	Rose Alder	.27	.34
25.0	Nth. Silver Ash	.30	.38
25.2	Sycamore	.32	.36
25.6	Blush Alder	.34	.34
25.8	Red Tulip Oak	.36	.47
25.9	Red Tulip Oak	.37	.30
26.1	Blush Alder	.40	.54
26.2	Yellow Walnut	.40	.51
26.2	Red Tulip Oak	.40	.49
27.2	Sassafras	.62	.63
27.8	Silky Oak	.82	1.28
27.8	Yellow Walnut	.81	.63

APPENDIX I. (Cont'd.)

4. Analysis of Treated Wood Samples.

Remarks: Charring process as before but final volume to 500 ml.

PE Rdg.	Species	% Boric (PE)	% Boric (DI)
15.6		.04	.02
16.0	Yellow Walnut	.05	.02
17.1	Ivorywood	.09	.00
17.2		.09	.00
17.8	Nth. Silky Oak	.12	.18
17.9	Queensland Maple	.13	.14
18.0	Yellow Walnut	.13	.11
19.4	Rose Apple	.20	.17
19.5	Yellow Walnut	.20	.22
19.6	Rose Butternut	.21	.16
20.2	Yellow Walnut	.24	.18
20.5	Red Tulip Oak	.24	.15
21.0	Nth. Sassafras	.29	.28
21.0	Rose Butternut	.29	.27
21.0	Blush Tulip Oak	.29	.30
21.3	Canary Beech	.30	.25
22.0	White Cheesewood	.35	.33
22.8	Red Tulip Oak	.40	.31
23.0	Nth. Silky Oak	.42	.44
24.2	Nth. Silky Oak	.51	.52
24.8	Red Tulip Oak	.57	.56
24.9	White Cheesewood	.59	.63
25.1	Yellow Walnut	.62	.75
25.8	Yellow Walnut	.72	.63
25.9	Blush Alder	.74	.72
26.0	White Cheesewood	.76	.96
26.2	Blush Alder	.80	.84
26.2	Blush Alder	.80	.83
26.9	White Cheesewood	1.05	1.05
26.9	White Cheesewood	1.05	1.05

APPENDIX I. (Cont'd.)

5. Variation in Quinalizarin Strength.

(a)

Strength Dilution	5 mg./litre PE Rdg.
1	18.7
2	20.5
3	23.2
4	25.2
5	25.1
7	26.8
10	28.8
15	28.8
20	30.0

(b)

Strength Dilution	10 mg./litre PE Rdg.
1	37.5
2	38.3
3	42.8
4	46.0
5	48.5
7	52.0
10	55
15	58
20	59

(c)

Strength Dilution	15 mg./litre PE Rdg.
0	43.2
1	48.2
2	55.2
3	59.2
5	67.0
7	73.5
10	80.0
15	84
20	87

(d)

Strength Dilution	20 mg./litre PE Rdg.
0	61.4
2	75
5	83
7	91
10	100+

A SUMMARY OF INVESTIGATIONS ON THE VAPOUR DRYING OF AUSTRALIAN GROWN TIMBERS*

At the last Forest Products Research Conference the principles of the vapour drying process were explained and the small experimental unit at the Division of Forest Products was described.

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

These studies have shown that the structural characteristics of species influences their behaviour very markedly when dried by the vapour process. Because of the scope of this work, comprehensive studies have so far been possible only on the collapsing "ash" type eucalypts, (E. gigantea of Tasmanian origin), myrtle beech (Nothofagus cunninghamii) and radiata pine (Pinus radiata).

Some of the results obtained, and conclusions reached (some of which are of an interim nature), are given hereunder.

Hardwoods (Pored Timbers)

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

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

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*Prepared by the Seasoning Section, Division of Forest Products, C.S.I.R.O.

Working fluid and working pressure. Three different working fluids have been used, namely, Stanvac K9 solvent (boiling point, 395°F.), mineral turpentine (boiling point, 360°F.); and perchlorethylene (boiling point, 270°F.). With each of these working fluids, studies were made with the drying cylinder maintained under four different pressures, namely, atmospheric, 6 to 8 lb. per sq. in., a vacuum of 15 in. of mercury, and a vacuum of 25 to 27 in. of mercury.

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

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

Heat input control. Several runs were carried out in which the wood sample temperatures were held at the comparatively low values of 180°F., 150°F. and 130°F. by regulating the heat input into the evaporator. These experiments were carried out under a vacuum of 28 in. of mercury with Stanvac K9 solvent and perchlorethylene as the working fluids. The drying quality of the samples improved progressively with reduction of wood temperature, quality suitable for joinery stock being produced at temperatures of 150°F. and 130°F. with perchlorethylene and Stanvac K9 solvent respectively. The drying times for the 1 in. thick stock from the green condition to 12 per cent. moisture content were 5 days (24 hours per day) for the run at 150°F. and 12 days for the run at 130°F.

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

The collapse susceptible "ash" eucalypts (which comprise about one quarter of the total sawn timber production of Australia), and myrtle beech, therefore, cannot be satisfactorily seasoned at the normally highly elevated temperatures used in vapour drying. Nevertheless, it has been established that by reducing the wood temperature considerably to minimize collapse, and by applying a high vacuum to facilitate drying at the lower temperature, this class of timber may be vapour dried with little degrade. Under these conditions such collapse as developed was largely removable by a normal reconditioning treatment.

It is interesting to note that when matched samples of these species were dried in orthodox laboratory kilns at similar wood temperatures to those which gave good drying quality in the vapour dried, severe degrade developed in the samples. Alternatively when the kiln conditions were adjusted to give a drying time of 5 days (to bring the drying time to a value comparable with that obtained with perchlorethylene under vacuum) the quality of drying was poor.

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

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

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

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

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

Softwoods (non-pored species). A study of the drying characteristics of radiata pine in 1 in. and 2 in. thicknesses, and in railway sleeper size (nominally 9 in. x 6 in. cross section) is in progress.

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

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

Subsequent pressure impregnations with creosote, designed to test quantities absorbed and depth of penetration in relation to amount of drying and moisture distribution obtained, were carried out at a pressure of 200 lb. per sq. in. for four hours following an initial vacuum of one hour absorption ranged from 19½ lb. to 31 lb. per cu. ft.

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

With respect to softwoods of a more impervious nature than radiata pine, such as the Australian cypress pine (Callitris glauca), limited work has shown these to be far less tolerant of the vapour drying process than the true pines. Work has not yet proceeded sufficiently for specific conclusions to have been reached concerning such species.

BLOOD PROTEINS FOR ADHESIVES *

Blood albumen has been used for bonding plywood in Europe and Asia for many years. It has also been used in the U.S.A., though not extensively. For glue manufacture blood serum is collected at slaughter houses and dried at a temperature below the coagulation point of the proteins. The dried blood albumen is almost completely soluble in water, though in preparing the glue a small amount of alkali is added, which completes the dispersion of the protein. Formulae have been devised for cold-setting glues, but blood albumen is mainly used for hot-press glues as a stronger and more water-resistant bond is obtained.

Blood albumen for glues is not produced in Australia, but dried whole blood for fertilizer is produced in large quantities. Because equipment for drying blood albumen at low temperatures is not at present available and would be costly to install, we have concentrated our attention on the possibility of preparing an adhesive from fertilizer blood.

In drying blood for fertilizer it is not necessary to avoid degradation of the protein, and the preliminary precipitation and drying are carried out at high temperatures. Whole blood is collected and brought to boiling point. The coagulated blood is allowed to settle and then transferred to a steam-jacketed drier where it is dried to about 8 per cent. moisture content. The temperature inside the drier is about 300°F. With this treatment it is not surprising that fertilizer blood has very low solubility and reactivity; samples obtained from several abattoirs were insoluble in 1 N. sodium hydroxide at room temperature.

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* Prepared by the Veneer and Gluing Section, Division of Forest Products, C.S.I.R.O.

It has been found possible, however, to obtain a degree of dispersion by heating in strong sodium hydroxide solution. After this treatment a gel can be obtained by the addition of formaldehyde, but not with calcium hydroxide. The blood-formaldehyde gel is not a strong one, indicating that the reactive groups freed by the partial alkaline hydrolysis are relatively few.

Up to the present we have not been able to prepare a glue which is satisfactory for bonding plywood. The formula we are using gives a rather low glue shear strength (about 250 lb./sq.in. under optimum conditions) and it is not suitable for mechanical spreading. The Utilization Section, however, has found another use for which it is well suited, viz. for bonding sawdust in the preparation of sawdust building boards. For this purpose the glue gives a satisfactory bond, it is easily mixed with sawdust and is cheap.

We have also tested unhydrolysed fertilizer blood as an extender for casein glues. As would be expected from its low solubility and its inertness, it contributes nothing to the strength of the bond. The addition of fertilizer blood in the proportion of 1 part to 3 parts of casein does not cause an excessive reduction in glue shear strength.

PROTEIN INVESTIGATIONS *

At the last Forest Products Research Conference reference was made, in a paper (1) entitled "Basic Aspects of Adhesion", to work which had been carried out on the formation of gels in alkaline protein dispersions. In particular, systems containing the principal milk protein, casein, had been studied in an endeavour to elucidate the fundamental physico-chemical mechanisms underlying the action of casein glues. It was stated that these studies might have applications beyond the adhesives field, on the one hand extending into the industrial fields of plastics, paper, paint and dairying, and on the other hand establishing contact with certain physiological problems involving the formation and structure of protein gels. In the past year these expectations have approached realization, and we report the co-operation that has been achieved with workers in other fields in the hope that our experiences may be of some value to members of State services who may recognize mutual advantage in establishing similar contacts on a technical level with relevant authorities in the various States. Before discussing the common problems that beset us, it may first be appropriate to refer to those aspects of the work which concern our special field: that of adhesives for wood.

Casein glues operate in highly alkaline solution, and studies have been continued to determine changes occurring in the protein molecule upon treatment with alkali. Results obtained by viscosity methods indicate that unfolding of the molecule from a globular to a linear form plays no significant part in the gelation mechanism. Solubility studies on alkali - modified casein have indicated

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* Prepared by the Veneer and Gluing Section, Division of Forest Products, C.S.I.R.O.

that permanent increase in solubility can be achieved under moderately alkaline conditions, but that more drastic treatment produces a marked decrease in solubility. Light absorption has also been used to characterize the molecular changes taking place and to relate them to the gelation process. Chemical studies have been made in an attempt to determine what specific structures in the protein molecule are concerned in gel formation. In particular various methods have been used to block specific groups, and the effect on gelation has been observed. Applications of the concepts and techniques developed in this work have been made to the methods of production of casein and their influence on the properties of the protein for industrial purposes, to the use of other proteins in adhesives, and to the stability of glued joints under various conditions of service.

As regards the relation of the casein studies to other industries, co-operation has been initiated principally with the field of dairying, mainly through the agency of Mr. G. Loftus Hills, Officer in Charge of the Dairy Research Section, C.S.I.R., and the work may be supported partly by this Section. It is too early to report any results of investigations in this direction, but some of the problems may be indicated briefly. Gel formation is a common phenomenon in the production and processing of dairy products, and in most cases it appears to be connected with the properties of casein, although the conditions under which gels form are neutral or slightly acid, rather than alkaline as for glues. Mr. Loftus Hills has listed the following gelation phenomena as some of those essential to dairy manufacture:- rennet coagulation in cheese making and casein precipitation, behaviour of casein in cheese processing, gelation in unsweetened condensed milk to prevent separation of fat globules during storage, coagulation of casein in acid casein production and in the manufacture of acid milk drinks, production of casein - formaldehyde plastics. Undesirable gelation phenomena include:- thickening during storage of sweetened condensed milk, thickening of unsweetened condensed milk and excessive coagulation during heat - sterilization, insolubility in dried milk. Work has now been commenced on the mechanism of rennet coagulation and on the thickening of condensed milk.

In the paper industry, casein dispersions are of importance in the coating of art papers such as are being manufactured in New South Wales. Discussions on these problems have been held with a representative of the firm concerned.

In the physiological field, one problem of protein gel formation concerns the reactions of fibrinogen leading to blood clotting. This mechanism shows some resemblances in its requirements to the rennet coagulation of casein. The subject has been discussed with the Director of the Baker Medical Research Institute, who is investigating medical problems connected with the behaviour of blood.

The examples given will serve to illustrate how fundamental problems of protein behaviour are common to various fields of industry and research. In the coming period we hope to be able to develop further co-operation so that any basic results may have maximum benefit.

References

(1) Proc. 4th Ann. For. Prod. Res. Conf. Vol. 2, pp. 236-244 (1949).

SILVICULTURE AND VENEER QUALITY

It is becoming increasingly evident that within perhaps the next few years the Australian plywood industry will be largely dependent on the utilization of trees of relatively small dimension now being grown in plantations, chiefly of coniferous species. During the past 12 months we have cut veneers from some hundreds of peeling blocks and have made observations on the effect on veneer quality of live knots, dead knots, pruning of branches from the trunk of the tree and on the amount of veneer which is adversely affected as a result of pruning. Observations have been made on hoop, radiata, slash and loblolly pines.

It has been reported previously that wide growth rings with extreme variations in physical properties, such as density and shrinkage, between early and late wood in Pinus taeda and Pinus caribaea give rise to buckling of veneers and of sheets of plywood made from these veneers. In radiata pine cores of fast early growth tend to be light and weak and the dogs are liable to tear out when thick veneers are being cut.

In general, live knots up to 1 in. diameter, if not closely grouped, have had little effect on peeling, drying and gluing of veneers. However in hoop pine logs peeled some knots caused severe gapping of a veneer knife, but similar knots caused only slight damage to a second knife. Larger knots, especially if closely grouped, may be accompanied by warping in the dry veneers. In all species, encased and other dead knots have a tendency to damage the knife and to fall out. The limited material so

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* Prepared by the Veneer Gluing Section, Division of Forest Products, C.S.I.R.O.

far examined shows that a minimum of probably $1\frac{1}{2}$ in. of wood, depending on the species and branch diameter, must be laid down over pruned branch stubs before veneer may be regarded as sufficiently defect-free to be classed as suitable for faces for plywood sheets. Observations on trees for which dates of silvicultural treatment are available and on others where the date of pruning has been estimated from ring counts show that the period for occlusion varies with species, knot diameter, tree diameter and rate of growth. Insufficient material has been examined to draw any conclusions but on stems of hoop pine with knots about 1 in. diameter pruned to an 8 in. diameter core there was still grain distortion when the log had grown to about 12 in. diameter over a period of 14 years. With radiata pine there was still grain distortion at 14 in. diameter in trees from which branches up to $1\frac{1}{2}$ in. diameter were pruned on a 10 in. core.

It is felt that the limited information now available is so interesting as to warrant an extension of the investigation into the utilization of pruned and thinned stands of conifers and such other species as show promise of being suitable for veneer and plywood manufacture. Should this be done it will be possible to obtain valuable information such as the diameter increment and period required for occlusion of branches, the relation between tree diameter, branch diameter, rate of growth and occlusion period and certain other factors which are certain to be observed as relevant during the course of further investigations. Valuable conclusions concerning desirable silvicultural treatment of stands being managed for the production of high grade veneer logs might be drawn from this information.

It is hoped that the representatives from various States will be able to indicate at the Conference the extent to which they would support further investigations by this Division by supplying for peeling and examination logs concerning which specific data and silvicultural treatment is available.

AN ELECTRICAL METHOD FOR ACCELERATING GLUING*

1. INTRODUCTION

The setting time of a chemically reactive adhesive decreases as the temperature rises. Production of glued assemblies may therefore be increased by supplying heat to the glue lines. This paper outlines some work carried out at the Division of Forest Products to investigate the feasibility of using metallic conductors heated by low voltage current as a source of heat for raising glue line temperature. The results of exploratory work were subsequently applied to the setting of casein glue lines in the assembly of plywood and timber frames as used in hollow core flush door manufacture.

2. THEORY

When an electric current is passed through a conductor its temperature rises under the influence of the current. When the conductor is in the form of a platen interleaved between assemblies of sheets of plywood and hollow core timber frames, heat from the platen is conducted through the plywood to the glue line on the frame. If the power supply remains constant the temperature of the glue line will rise uniformly and the rate of glue setting will be a function of the temperature of the glue, the rate increasing as the temperature rises.

3. DESIGN OF THE HEATING PLATENS

To eliminate the necessity for insulating the platens and leads and to minimize electrical hazards a voltage of 32 was used, this being the maximum permitted without insulation in the State of Victoria.

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* Prepared by the Veneer and Gluing Section, Division of Forest Products, C.S.I.R.O.

For economy and ease of working galvanized iron sheet was selected as the electrical conductor for the heating platens. A sheet measuring 44 in.x 28 in. was first used. It was found that with electrodes connected on diagonally opposite corners of the sheet neither current distribution nor heating of the sheet was uniform. To overcome this all points on each end of the 28 in. wide sheet were brought to equal potential by soldering a brass bar 1-1/4 in.x 3/16 in. along each end and two leads from the transformer were connected to the quarter points of each brass bar. The resistance of the sheet was low and in consequence the electrical current, even at two volts as used initially, was high and very heavy conducting leads wer were necessary to hold losses in the leads at a reasonable figure. To reduce the current and improve flexibility of the leads, the sheet was cut into three strips approximately 9 in. wide x 44 in. long. These strips were joined in series to form a conductor 11 ft. long x 9 in. wide. With the reduced width this composite sheet had excellent current distribution characteristics and it was found to be heated uniformly over the whole area. The increased resistance lowered the current and correspondingly reduced the size of the leads required.

Several panels were then prepared using this platen as a source of heat to accelerate the setting of glue pressed between a sheet of plywood and a timber frame in an hydraulic press with a platen area 3 ft.x 2 ft. Results being satisfactory, it was decided to proceed with the construction of additional platens to permit larger scale investigations. Six platens measuring 48 in.x 28 in. overall were then prepared for larger scale observations. Each platen consisted of three 48 in.x 9 in. strips joined together in series. The heating platens were placed in the hydraulic press and were connected in series with a 10 K.V.A. transformer, so giving in effect a five daylight press. An investigation was then carried out of the heating characteristics of the platens when used for gluing plywood faces on flush door frames at different total power inputs.

4. HOLLOW CORE DOOR GLUING EXPERIMENT

(a) Material

Each door frame measured 35 in.x 22 in. externally and was made up from ash eucalypt members of the following sizes:

Stiles:	35 in.x 1-1/2 in.x 3/4 in.
Rails:	19 in.x 1-1/2 in.x 3/4 in.
Subsidiary rails:	19 in.x 1/2 in.x 3/4 in. five per door.

Ash eucalypt plywood 35-1/2 in.x 22-1/2 in.x 3/16 in. was glued to these frames with a proprietary aircraft type casein glue.

(b) Method

A door assembly was placed in each daylight of the press, and a pressure of 100 lb./sq.in. of area of the frame of the timber core applied. Power was supplied until one of the desired temperatures, namely 130°F., 145°F., 160°F., 175°F. or 190°F., was reached in the glue line under observation, and then switched off. The assembly was retained in the press for a total time of 12 minutes.

Four runs were made, during each of which five doors were pressed. Thermocouples on the platen surfaces and in the glue lines were used to measure the temperatures. The operating conditions were as follows:
Voltage from transformer 20 volts, current through platens 610 - 470 amps., maximum power: 1.4 watts/sq.in. area of platen.

Galvanized iron has a high coefficient of thermal resistance and it was impossible to maintain constant power output from the transformer, power decreasing as the temperature rose in the conductor. Observations on the power supply from the electricity mains indicated that voltage varied appreciably during each day and in consequence it was impossible to maintain a constant total power input in the sheets used in the experiments.

(c) Testing the Glue Lines

Doors from each run were tested as follows:

(i) Racking tests

Each door was fixed at three corners in a horizontal plane and loaded at the fourth corner to four cwt. by 56 lb. increments. These tests were made eight days after the doors were pressed.

(ii) Glue line tests

Lap joint test specimens were prepared from similar positions in the stiles of each door. These lap joints were tested in an Avery testing machine 14 days after the doors were pressed.

(d) Discussion

The varying total power input during the runs enabled results to be analysed for a relationship between power supply and rise of temperature per minute in the glue line. It is estimated that only a small percentage of the total heat supplied by the platens was used in heating the glue line, the major portion heating the timber frame, and that little of the heat supplied was lost from the assembly by radiation and convection from the platen margins and edges, the total assembly being an excellent self insulator.

In planning the work it was hoped that in the four runs there would be five different initial degrees of cure of the glue lines in the door but the variability of the heating rat due to the constantly changing power prevented this from materializing so that a relation between strength and degree of curing was not obtained. The lap joint tests showed a slight tendency for higher strength figures with doors heated to the higher temperature and hence having the higher degree of initial cure. However, doors heated to 130°F. show strength figures of 750 lb./sq.in. in the glue line, which compares favourably with others heated to higher temperatures. Variations were so slight that further tests would be necessary to determine whether they are significant.

No door failed in the racking tests and on removal of the load the door returned to its original shape. It is considered that the strength of each door made in this experiment was at least as good as that obtained in normal commercial manufacture.

The removal from the press of assemblies with the surface at a high temperature caused a high wet bulb depression condition which resulted in rapid drying and a consequent tendency of the surface plies to shrink. The ash eucalypt plies tended to check under these severe conditions. The heating period adopted should therefore not be long enough for the panels to attain too high a temperature. Short periods in the press are also economically desirable from the point of view of rate of production. However, if this factor is not critical and the longer overall schedule is permissible, the current could be switched off earlier than in the case of a continuous heating schedule. During the remaining time that the panels are in the press, the temperature of the surfaces adjacent to the platens will tend to fall whilst the glue line continues to cure from the heat already supplied. Block stacking of doors on removal from the press would also assist in reducing the tendency of face veneers to check. A further point to be observed is that should the plywood or frame be made of collapse susceptible species which have not been fully reconditioned, some unevenness of the door surface is likely to be observed on cooling as a result of further reconditioning occurring in the press.

As racking tests and lap joint shear tests made several days after gluing were apparently unaffected by the pressing conditions, it would seem that the pressing time need only be sufficient to provide an initial cure strong enough to fix the plywood or frame with sufficient strength to withstand handling.

From these experiments a curve showing the rate of rise of the glue line temperature as a function of the power used per square inch of platen area has been prepared. This should constitute a valuable basis for designing future experiments and practical applications of electrical resistance strip heating methods for accelerating the setting of glue lines.

5. FABRICATION OF PLYWOOD

Three scout runs gluing Pinus radiata veneers arranged in a three ply construction have also been carried out. Six assemblies of the veneer were placed in each daylight and were successfully glued in 20 minutes.

The rate of rise of the temperature in the glue line furthest from the platens was 4-1/4°F. per minute. The press was not modified in any way for this work, the same platens being used as for the flush door experiment.

6. COMMERCIAL ADAPTATION

The main difficulties confronting successful commercial adaptation of this project are mechanical. In order to obtain the power required using a low voltage transformer, a high current must be carried in the press. This requires heavy leads and large areas of surface contact to prevent local heating.

Each type of assembly for which this method of heating is required will necessitate a separate design in order that the press may be quickly loaded and be an economic proposition.

The limited tests carried out using plywood assemblies showed that electrical resistance strip heating could be used for accelerating the setting of glue lines in a multiple plywood assembly but further work is necessary to determine just how feasible the method might be for commercial application.

7. CONCLUSION

It has been shown that the electrical resistance strip heating of hollow core flush door glue line is an effective method for accelerating production. By extrapolation of the test data it is estimated that 15 full sized doors may be glued in 10 minutes using a transformer of 70 K.V.A. capacity. It has been shown that 100 per cent. cure of the glue line need not be effected in the press and that pressing times need be only long enough to provide enough adhesion to ensure the members can withstand handling.

An important relationship has been obtained showing the rate of heating of the glue line as a function of the power dissipated in the heating platen.

TREE GROWTH STRESSES

II. THE DEVELOPMENT OF SHAKES AND OTHER VISUAL FAILURE IN TIMBER*

By

J. D. Boyd**

SUMMARY

The development of heart shakes is related to the growth stresses in trees and the disturbances caused by felling and cross-cutting.

In standing trees the development of critical ring tension in the region towards the pith of the tree is considered the most important factor.

In fallen trees and diametral planks (cut along a full diameter) the conversion of longitudinal strain energy into transverse stresses is the ultimate cause of failure. However, the presence of primary ring stresses, and a comparative weakness of the timber in the region of the pith are significant contributing factors.

In pored timbers of small diameter, the relative severity of development of heart shakes is attributed to their steep longitudinal strain gradient across a transverse section.

It is suggested that macroscopic compression failures in trees result from a combination of growth stresses and severe wind stresses.

Possible methods of minimizing the effect of growth stresses on the utilization of timber are discussed.

* This paper has been prepared for publication in the Australian Journal of Applied Science.

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1. INTRODUCTION

Occasionally in mature trees, the forester finds evidence which suggests that large shakes or radial cracks passing through the pith were developed during growth. More frequently these shakes open up suddenly as a result of felling or cross-cutting, at the same time making a sharp cracking noise which has given rise to the familiar term of "popping". The incidence of this phenomenon varies with the species, the age of the tree, and the locality; but the resulting degrade has such widespread effect on general milling practice and veneer peeling that investigations with a view to understanding the cause and reducing the consequences are justified.

Despite long-standing evidence of the problem and its economic significance, little effort has been made to solve it. In 1933, Koehler (1) reviewed some of the existing hypotheses. He showed that shakes were unlikely to develop as a result of shear failure of the tree under the influence of wind. Drying-out due to the heat generated during sawing was also discounted. The hypothesis that ring shakes developed because of weak bonding between the growth rings was shown to be unsound as failure frequently occurred within the ring, usually in the early wood. Although Koehler had no measurements of growth stresses upon which to base his ideas, he was of the opinion that such measurements would provide an explanation of the observed effects.

The first quantitative investigation of tree growth stresses was made by Jacobs (2). With a view to the solution of the problems of spring of planks, pinching of saws during milling, etc. he concentrated attention on the measurement of longitudinal stresses in trees. His investigations showed that longitudinal tensile stresses were developed at the periphery, and that longitudinal compressive reactions of increasing intensity existed in the area towards the pith. Later (3, 4) he noted the presence of significant stresses in a transverse plane across the tree.

In Part I (5) of this series Jacobs' experimental work on longitudinal stresses has been confirmed and the investigation of both longitudinal and transverse growth stresses carried a stage further. The various manifestations of growth stresses have been investigated separately and their relative significance measured and analysed. It has been shown that the development of tensions at the periphery as the tree grows would result in compressions of increasing intensity being developed towards the pith. Theoretically such longitudinal compressive forces can reach very high intensities towards the centre of large trees (Fig. 1). These intensities correspond to relatively large strains, and are higher than the wood can sustain. Though evidence of the development of large strains exists, the very high stresses are never reached, because much less severe ones cause the development of plastic conditions in the cell walls with consequent absorption of some of the forces, or other strain accommodation within the tree. The plastic condition of timber taken from near the pith of large trees has been shown by the stress-strain relationship when strains equal to those measured in the tree are reproduced in the same material in a testing machine. In general then, it might be expected that the physical adjustment in the wood cells imposed by this severe loading during growth would have a definite effect in changing the subsequent reactions of the timber.

Also, after investigating transverse growth stresses, the author has shown that a primary circumferential compression develops at the periphery of a growing tree and that this would induce circumferential or ring tensions which may reach critical intensities near the centre of large trees (5). The development of these ring stresses is evident when sawing across a disk. Towards the periphery a saw tends to bind, but towards the pith the cut opens out. It has been shown theoretically that corresponding radial tensile stresses might be expected. Experimentally these have been demonstrated, but generally neither the primary transverse compressions, nor the induced ring tensions are of sufficient intensity to cause failure of the wood in other than exceptionally weak tissue. In addition, experimental analysis has indicated that transverse stresses resulting from a change in cross-section of individual cells under the influence of longitudinal stresses are unimportant.

However, on cross-cutting a tree or log certain of the forces which contribute to the development of longitudinal stresses are released at the cross-cut face. Corresponding to the relief of longitudinal stresses the individual cells in the tree cross-section tend to return to their unstrained dimensions. This variable longitudinal strain recovery over the tree cross-section causes distortion of the transverse face and this effect will be described as that due to "strain energy". As a result of the conversion of longitudinal strain energy, transverse stresses of considerable magnitude are induced, and these may have a critical effect in causing end splitting of the log.

It is chiefly on the basis of the foregoing investigations and analyses by the author (5) that the following discussion is based. In principle, the discussion applies equally well to pored and non-pored timbers, but generally the development of growth stresses appears to be much more severe in the pored timbers (the so-called hardwoods), and causes corresponding difficulties in the problems associated with utilization. Because of the variable interactions of the various growth stress effects under different combinations of circumstances, it has been found convenient to treat three general cases - standing trees, fallen trees and diametral planks.

. SHAKES IN STANDING TREES

(a) The Effect of Primary Longitudinal Stresses

It has been shown that longitudinal owth stresses have a distribution changing from a maximum tension at the periphery to zero, and then rising to a maximum compression near the centre of a tree (2, 5). From the stability of a tree, it may be deduc d that the forces which produce these stresses balance across any transverse section. However the continuous variation of the force intensities across the section and their lack of simultaneous correspondence of unstrained state may, during conversion, cause some tissue to offer restraint to the full and complete reactions of the other (5). The process of cutting a beam from a log upsets the balance of forces and removes some restraint, so that longitudinal stresses originally present in the wood (when it formed part of a tree) may be relieved. However, these forces originally imposed changes of length (strain) on all wood elements throughout every transverse section, in proportion to the force intensity (stress) at the various points in the section. Upon relief of the internal forces length recovery occurs; but as the stress is non-uniform and follows a gradient from bark to pith, then one side of a beam tends to lengthen or shorten relative to the other (unless the beam section is balanced across the pith). The reaction of the beam takes place immediately it is freed from the restraint of adjacent tissue in the parent log, and the resulting curvature of the beam is known in the timber trade as "spring".

Jacobs (4) drew an analogy between the spring of a beam and the development of heart shakes in a log. He suggested that the sections of a log tended to spring apart as a reaction to the variable stress across the full tree section, and that this supposed action caused the end-splitting of the log. As internal longitudinal forces exist throughout the height of a tree (2), then on this hypothesis, it might be possible for a normal standing tree to be split from crown to roots. However, the comparison with a beam is not valid, because although longitudinal stresses are relieved at the cross-cut face of a log, the balance of the longitudinal forces across the transverse section is not upset, either at the cross-cut, or at any other section throughout the log (5). While this balance of longitudinal forces holds, no spring can occur, and end-splitting from this cause is impossible.

In a standing tree, disturbance of longitudinal forces due to cross-cutting is absent. Nevertheless, variation of the stresses may result from force absorption by plastic adjustment in the cell walls or other non-elastic action, and from the effect of fungi in causing "heart-rot" or other degrading of wood tissue. Generally, however, only a gradual and relatively small shift would be expected of the line about which forces of opposing nature balance in the cross-section. Except in rare cases an unstable out-of-balance of longitudinal forces appears unlikely.

Thus the development of heart-shakes as a result of the existence of longitudinal internal forces in a tree, is doubtful.

(b) The Effect of Primary Circumferential Stresses

Measurements of strain on disks cut from a number of species of pored timber, and from trees of different diameter (5), support the statement by Jacobs (4) that a relatively constant rate of peripheral, circumferential stress is developed in the new wood as trees grow in diameter. The effect of this would be to induce ring tensions of increasing magnitude in the area towards the pith. It has been shown (5) that the ring tension at any position may be represented by the equation

$$T = 2.3S \times (\log_{10}a - \log_{10}b) \frac{E_T}{E_R} - S$$

where "T" is the ring tensile stress (lb./sq.in.) at radius "b" in. in a tree of outside radius "a" in., "S" is the peripheral ring compressive stress (lb./sq.in.), and E_T and E_R represent the elastic moduli for forces applied in the tangential and radial directions respectively. For a tree of diameter 24 in. assuming "S" has the value of 350 lb./sq. in. (4), the stress distribution across a diameter may be theoretically represented by Figure 2(a). A similar curve for a tree of diameter 48 in. tree is shown in Figure 2(b). From the nature of the curves, and the fact that the tensile strength of timber in a direction perpendicular to the grain may be as low as a few hundred lb./sq.in., it will be seen that the ring tension in the region of the pith of large standing trees may reach values which could readily cause the timber there to fail so as to produce heart shakes.

It has been shown that primary circumferential stresses have the effect of inducing radially directed tensile stresses (5). Such stresses tend to cause separation of the wood along or between the growth rings, rather than across radial planes through the pith, that is, they would tend to develop ring shakes. Measurements indicate that the radial stress in eucalypts is likely to be of the order of 100 to 200 lb./sq.in., and is generally insufficient to cause failure. Nevertheless, ring shakes have been observed occasionally in felled trees, both as the predominant failure, or in combination with heart shakes. In such cases it is probable that failure was caused by an abnormal local weakness of the timber (possibly resulting from injury during growth) rather than a normally critical stress. Usually the ring shakes are small and associated with a gum vein or other structural defect. Any other cracks generally follow a radial direction.

(c) The Secondary Effect of Longitudinal Stresses

Stresses are induced in a cross-sectional plane as a result of primary longitudinal forces. The determination of the pattern of the transverse stress distribution is very complex (5). In a general way, however, it can be said that towards the pith of the tree, longitudinal compressive stresses would induce ring and radial tensions. Similarly, towards the periphery, longitudinal tensile stresses would induce ring and radial compressions. Because of the variation of restraint or rigidity of the wood tissue on either side of a particular radial position, the strain over a full transverse section is unlikely to be a constant multiple (Poisson's ratio) of the strain in a longitudinal plane. However, it is probable that any modification would have the effect of reducing the extreme values calculated on this basis. Even without this reduction, the maximum tension induced in the region of the pith has been deduced as probably of the order of magnitude of 30 lb./sq.in. only (5). As the corresponding strength of sound timber may be many times that value, generally this source of stress must be considered as of minor significance in the development of heart shakes.

(d) Total Stress Contributory to the Development of Heart Shakes in Standing Trees

Summarizing the manifestations of stresses which have been separately described and which may be contributory to the development of heart shakes (as distinct from seasoning checks) in standing timber, it is considered that primary circumferential stresses are probably the most significant. The small transverse effect of longitudinal stresses appears of minor importance, except where the ring stress resulting from primary circumferential stress may have approached a critical value.

3. DEVELOPMENT OF HEART SHAKES IN FALLEN TIMBER

As a result of felling or cross-cutting, the balance of internal forces in a log is varied somewhat from that of a standing tree.

Investigations of primary longitudinal stresses have shown that these are relieved at the cross-cut, and partially relieved for some distance beyond it (5). This condition results in a certain quantity of longitudinal strain energy being converted into transverse force at the cross-cut face, and as a consequence, very severe tensile stresses may be induced in the direction of the growth rings and in the region of the pith. These stresses depend upon the intensity of longitudinal growth forces within the tree and the length of the log, but when added to other stresses present, frequently are sufficient to cause the development of severe heart shakes. Typical development of heart shakes in an Australian eucalypt is shown in Plate 1.

As pointed out earlier, spring in a log does not generally result from the existence of internal longitudinal forces.

Spring can occur only in the extreme case in which a shake has first opened up right across a diameter, and the longitudinal forces therefore become unbalanced in the resulting sections of the log. In this case, the spring of the sections of the log in the process of re-balance of the forces across their respective cross sections, may cause further significant relief of longitudinal stress. As a corresponding increment of strain energy is converted at the transverse face, the additional stresses induced may cause splitting to continue.

Change in cross section of individual wood cells as primary longitudinal stress is relieved at a cross-cut may induce transverse stresses contributing to the development of heart shakes. Cells tend to return to their unstrained condition, but the relief of cross-sectional strain cannot be achieved in all cells simultaneously (5) and the full relief of tension towards the pith would be resisted by the development of compression in the cells towards the periphery. Thus, the effect of cross-cutting would be to reduce the intensity of ring tension which results from longitudinal forces in an undisturbed tree, but not to eliminate it. Consequently, considering only this particular stress effect, there would be a corresponding small reduction in the susceptibility of the log to the development of heart shakes.

It has been shown that the transverse stresses resulting from the transformation of longitudinal strain energy at the face of a cross-cut may be of such critical intensity as to cause heart shakes to develop (5). In logs, this factor must be regarded as of major significance.

Primary circumferential stress intensities have been considered in respect to the development of shakes in standing trees. It has been shown that the effects are not changed by felling or cross-cutting (5).

Summarizing, primary circumferential stresses of considerable intensity may be present and tend to develop heart shakes. To these stresses small transverse stress residuals of the relief of longitudinal stress may be added. Usually however, the critical stress increment arises from the conversion of longitudinal strain energy into transverse stresses at the cross-cut. The intensity of these combined forces in relation to the strength of the timber in a transverse plane and perpendicular to a radius from the pith controls the severity of development of heart shakes.

4. DEVELOPMENT OF HEART SHAKES IN DIAMETRAL PLANKS

When investigating longitudinal growth stresses, Jacobs (2) cut planks across the full diameter of the tree, that is, planks including the pith in their centre of width. In the initial stages of the experiment, short lengths of the full log sections were left attached to the ends of the planks. When the full log section was cut off, and therefore the restraint imposed by it removed, the planks from trees of appreciable size split down the centre, sometimes with explosive violence. Similar splitting occurs when planks are sawn from logs by gang saws. This phenomenon may be analysed in relation to the fundamental growth stresses in the tree.

In experiments similar to those of Jacobs, the effect of removal of the full log sections from the ends of a beam caused a change in the balance of forces. If a rectangle representing the beam cross-section is superimposed on a circle, representingthe original tree section, it will be noted that proportionally much more of the area which was subject to intense longitudinal compressive stress (near the centre of the tree) is included in the beam, in relation to its total area, than is the case with the log. Consequently, forces are no longer balanced on any cross-section, and the whole of the centre of the beam tends to elongate relative to the outside until a new balance is reached. In addition to this movement the strain energy effect previously described can occur. In the region of the cross-cut face, the total of these two effects would be similar to that in a full log; but the resistance to the development of a heart shake is relatively much less. In the diametral plane containing the thickness of the beam, virtually all restraint previously exercised by the lower stressed section of the full log has been removed, and the beam may split across its thickness and along the pith.

In a diametral beam, the cross-sectional area adjustment of cells, subsequent to the release of longitudinal stresses, can take place with relatively little restraint. Consequently, the residual transverse stresses probably are smaller than in a standing tree or log, and thus the tendency for heart shakes to open may be somewhat lessened.

Because of cuts across the growth rings, primary circumferential stresses would be considerably disturbed in reducing a log to a beam. Except in the close proximity of the pith, where the growth rings are complete, substantial relief of transverse stress might be expected.

In general, the resistance offered by a beam of this nature to splitting from the end and down the centre is small. The relatively low strength under test of wood from the region of the pith is well known, and it is probably a consequence both of the severe longitudinal strain developed in this area in the standing tree, and also the long duration of the associated high intensity growth stresses.

In relation to splits opening from the end and running along the centre of a plank, Jacobs (2) stated that "the fact that the mouth of the crack closes when the short section containing it is sawn from a plank", and that "the crack may be extended by sawing off part of the split sides shows that in the undisturbed stem fibre tension has some cumulative effect in a longitudinal direction. This is in contrast to the behaviour of deflected beams which may be sawn into small pieces without affecting the spring. The explanation of this anomaly lies in the fact that in the undisturbed tree, the wood is in tension or compression; when small beams are cut the tension is released".

It is considered that on the basis of experiments (5, 2), this explanation is unsatisfactory. The fact that a long thin strip (called a "beam" above) can be cut into short lengths, without disturbing the radius of curvature of its spring under the influence of the differential stresses throughout its radial thickness, shows that in general there is no cumulative effect of forces in the longitudinal direction. Longitudinal forces are almost completely relieved in a strip allowed to spring freely, if its thickness radially is small. In any case, any residual longitudinal forces are balanced and cross-cutting does not disturb the balance and its related curvature. By contrast, widely varying but balanced longitudinal forces of appreciable magnitude would be held by the restraint of each on the other in a diametral plank. Consequently, considerable strain energy is stored in it. In such a plank the extension of the crack consequent on the making of a new cross-cut part way along the original crack may be attributed to the transformation to transverse stresses at the section of some of the stored longitudinal strain energy. The partial closure of the mouth of a crack in a short section cut off from the parent beam, and containing a split along most of its length, can be ascribed to the transformation of strain energy at the new cross-cut producing stresses tending to open a crack there. Usually the residual strain energy released from such a small piece when it is cut from the end of a plank would not induce transverse stresses of sufficient magnitude to open a new crack, but the reaction would tend to cause a reversal of the deflection of the previously split and springing sections. This explanation is supported by Jacobs's statement that, by continual removal of the split section, "it was possible to split a 10 ft. plank to within one or two feet of the visible limit of the shake at the opposite end". The reason why splitting ceases at this stage is probably that insufficient longitudinal strain energy remains in the plank to provide the necessary increment of splitting force.

Summarizing factors significant in the splitting of diametral planks, it appears that the relief of longitudinal stress and the consequent conversion of its corresponding strain energy into transverse forces is an important factor. Although residual primary transverse stresses are less intense than in a tree or log it might be expected that all stresses combined are more severe in relation to the resistance of the wood to splitting through the critical pith section. In this zone the combined transverse tensile stresses would be a maximum. After initial splitting, the spring of the two halves tends to release substantial additional longitudinal strain energy and continue the splitting.

5. DEVELOPMENT OF MACROSCOPIC COMPRESSION FAILURES IN TREES

Certain timbers occaionally exhibit abnormalities very similar in appearance and reaction to the failures induced in wood subject to compression in a testing machine. These are evidently present in the tree as it stands in the forest and are revealed on conversion. Such timber may be so weak as to fall apart at the abnormalities when sawn into small sections, or to snap there at a very low stress if given a sharp knock. This peculiarity or local wood failure has been known in the trade by such names as, thunder-shake, lightning-shake, heart-shake, heart-break, cross-break, upset and macroscopic compression failure.

Rendle (6) discussed the phenomenon at some length. He discarded the theory that lightning or thunder could be responsible agencies, and suggested that differential shrinkage is an unlikely cause. Though he found it difficult to explain the usual gradual reduction of associated fibre distortions towards the end of the failure line on the bark side, generally he favoured the hypothesis that extremely severe winds may have caused the development of compression of sufficient intensity to account for the failures. He realized, however, that if the end of the failure had been the outside of the tree at the time, then the most extreme evidence of distortions might have been expected there. At the same time, although he noted a general association with "spongy heart" and "brittle heart", he was unable to explain it.

Characteristics of this phenomenon are illustrated in Plate 2. The first four figures represent end-matched specimens of New Guinea rosewood (Pterocarpus indicus Willd.). On Plate 2, Figure 1 it is possible to trace the transverse failure plane induced by severe longitudinal compression in a testing machine. Plate 2, Figure 2 shows a failure plane which existed within the tree and was revealed after milling the timber. On bending the specimen shown in Figure 2 of Plate 2 it fractured along the existing failure plane and showed a brittle texture. This is shown in Plate 2, Figure 3. Cross-bending after artificially inducing a compression failure of the type shown in Plate 2, Figure 1 produces a similarly textured failure. Plate 2, Figure 4 illustrates a normal bending failure in the same material. In Plate 2, Figure 5 a natural compression failure in Eucalyptus regnans F.v.M. is shown.

Examination under the microscope of natural compression failures of this type has revealed similar characteristics to those of artificial failures (6). In addition however, Rendle points out that sometimes a large number of individual fibre failures (microscopic compression failures) may be present throughout specimens containing naturally induced macroscopic compression failures. Except in very special types of artificially induced compression failure, individual fibre failures do not occur in positions beyond the immediate vicinity of the macroscopic failure plane.

Under the influence of excessively strong winds, it is possible that a tree may bend to such a degree as to develop critical compressive stresses in the wood near the bark on the inside of the bend. If these were the only significant stresses present, a compression failure developing in severity towards the bark might result. With subsequent growth of the tree this could be overgrown with sound tissue, and subsequently appear as a failure remote from the outside of the tree. However, as Rendle states, failure planes usually do not suddenly end in a position of severe fibre distortion, but tend gradually to merge into sound tissue.

If the stress distribution which arises naturally from the growth characteristics of a tree (2,5), is superimposed on that which results from excessive bending under the influence of wind an interesting combination results. It is represented qualitatively by Fig. 3. The theoretical growth stress distribution in a tree is shown at position (a), and at position (b), the stress distribution resulting from bending is illustrated. These two effects are combined at position (c).

It will be noted that as a result of the superposition, the compressive stresses throughout one side of the tree are increased considerably. In the area towards the pith of the tree, the wood may have been weakened by the imposition of intense growth stresses over a long period, and could conceivably fail under the new concentration of compressive stress, producing an abnormality of the type described. The actual compressive stress towards the outside will depend largely on the severity of the wind stress; but because of the lower growth stress and the shorter period under the influence of growth forces, the timber in this zone will generally be more resistant to failure under the same total stress than wood towards the pith. Thus, the tendency to failure will in many cases be reduced gradually towards the outside of the tree (at this stage of the growth); and give rise to the more usual "fade-out" of the failure plane. However, in exceptional cases the wind stress may be sufficient to force even the relatively strong peripheral tissue to fail and so produce the characteristic of an abrupt ending to the failure plane.

6. DISCUSSION OF THE SIGNIFICANCE OF SHAKES IN TIMBER UTILIZATION

In the light of the data and analyses available on growth stresses (4, 5), and also the foregoing discussion, it may be of value to discuss the significance of shakes in timber utilization in general.

(a) The Comparative Development of Heart Shakes in Young Trees and Mature Trees of the Same Species

The current and growing practice of utilizing forest thinnings for case stock etc. tends to draw attention to claims of comparatively greater development of heart shakes ("popping") in this size of stem, as compared with more mature trees.

The investigation of longitudinal heart compression made by Jacobs (4) reveals that the rate of change of compression (and therefore the rate of change in the theoretical amount of elastic strain recovery) diminishes rapidly as a tree grows from a diameter of 5 to 10 in. approximately. On cross-cutting, it appears that the effect of the quickly changing rate of longitudinal compression would be to induce a related high intensity ring tension (due to the transformation of longitudinal strain energy at the cross-cut face). In young trees, the relatively short duration of natural growth stressing would give rise to less dispersion of the applied longitudinal forces in plastic reaction of the individual wood cell walls than occurs in older or larger trees, that is, less energy is irrecoverable. Thus on felling or cross-cutting trees of say, 10 in. diameter and less, there may be a greater intensity of ring tension developed from this energy source than is the case with larger trees. It has been shown that the addition of these stresses to those arising from a primary transverse source is the critical factor in the development of heart shakes (5).

With increasing diameter beyond the 10 in. size class, primary transverse stresses become greater in the critical zone near the pith; but other opposing factors may more than compensate for this apparently greater predisposition to development of shakes.

As the age of the tree increases, there is a corresponding increase in the longitudinal compressive forces transferred to the core, and the duration of their application. Ultimately this may cause considerable plastic flow, with consequent modification of the wood structure, or it may give rise to the development of the cell wall deformations found in zones of degrade timber frequently referred to as "brittle heart" (4). The plastically absorbed forces are virtually non-recoverable, and therefore the proportion of recoverable strain energy would ultimately fall appreciably below that of young trees, and may cause a reduction in the tendency to develop severe shakes. Judged on the elastic reactionsin a testing machine of material from near the periphery and near the pith of a tree, the cell wall changes may also have the effect of reducing the elastic moduli for the material, so that there is a correspondingly reduced imposition of transverse stress for every remaining unit of longitudinal strain.

The factors set out above may readily account for proportionately more severe development of heart shakes in young, as compared with mature trees of the same species. However the relationship may be changed by the effect of varying rates of growth, or other ecological aspects and give rise to diverse characteristics in different districts.

Because shakes are caused by stresses originally present in the growing tree, it is felt that they cannot be eliminated in the mill conversion of existing timber. However, a better appreciation of the nature of tree growth stresses and their effects under varying conditions, may lead to a lessening of resultant degrade, and a greater yield in conversion.

(b) Methods of Conversion of Immature Trees in Milling

Because of the rapid changes in the rate of longitudinal compression of the heart of eucalypts during the early years in the life of the tree, and also the higher proportion of elastic strain recovery as compared with mature trees, beams from young trees generally show a high degree of spring during mill conversion. In normal mill practice this leads to movement of the log on the saw bench, with consequent variations in thickness of sawn planks, degrade and wastage. In addition, there may be a physical danger to the mill personnel.

In South Africa, these difficulties are being overcome, to some degree, by a technique of gang-sawing. This was first applied at the Forest Products Institute, Pretoria West, and it is stated to be very successful in the milling of young eucalypts. Practical application of the gang-sawing technique to the problem is now being made in Victoria, Australia. However, if full depth boards (cut right through the log) are required, splitting or shattering along the pith may cause appreciable degrade in the central boards, and give rise to severe spring in the split sections, together with the need for additional edging.

The tendency for central shattering arises from the extreme range of growth stresses normally existing between the outside edges and the centre of the plank cross-section - a condition which increases in severity from outside to centre of the log. It is possible that a modified sawing technique may reduce the range of stresses to be dealt with in any plank from a particular log, and so reduce the central shattering or splitting tendency. The Swedish method of tandem gang-sawing, besides giving greater recovery of merchantable timber (claimed to be 8 to 10 per cent. in Swedish practice), may have definite value in reducing the shattering due to growth stresses.

With tandem gang-saws, the first frame is arranged to cut the outside slabs and boards as indicated in Fig. 4(a). The central log section may then be turned on its side and passed through the second saw frame to cut more slabs and boards requiring edging, together with a group of square edged pieces as shown in Fig. 4(b). Possibly a similar cutting plan could be followed with advantage while using a rapidly adjustable circular saw edger, or a combination of edger and gang-saw.

The relative success of gang-sawing may be attributed to a principle of balanced cutting. A single cut from the side of the log upsets the balance of growth forces, and therefore causes spring in both the log and edged piece. However, by making longitudinal cuts in pairs symmetrically placed about the pith of the log, the tendency to spring is approximately balanced about its centre, and movement is reduced to a minimum. At the same time, the movements of the planks are under good control. Thus, straight cuts are possible, yeilding planks of uniform thickness and better grade.

After cutting to boards on the gang-saws, advantage may result if the timber is stacked and seasoned before edging and further conversion. By the employment of a proper stacking technique, warp and cupping of the boards may be reduced to a minimum, and the tendency to spring reduced during seasoning. In this way, a satisfactory grade of material may be obtained in wide boards. Subsequently these can be converted to smaller sizes as required.

(c) <u>Stock-piling of Logs for General Milling</u>

Where logs are stock-piled to off-set deficiency in supply during the wet season, appreciable degrade can occur. With time, it is likely "elastic after-effects" or limited creep or plastic recovery augment the quantity of longitudinal strain energy, converted to transverse stresses at the cross-cut face, and so increase the development of shakes. At the same time, drying out of the log occurs (particularly near the ends if these are uncoated), with the consequent development of checks from the periphery. The drying checks weaken the resistance of the cross section to transverse growth stresses, and cause greater concentrations of all stresses present. The result is a considerably augmented tendency for continuation of the shakes, first across the full section, and then in depth along the log. Such splitting of the log must lead to appreciable waste of timber in milling.

If logs are stock-piled in such a manner as to eliminate drying-out, or reduce it to a minimum, much of this degrade could be eliminated, as normal heart shakes on freshly cut logs do not cause comparable degrade in general milling practice.

(d) Veneer Logs

In veneer logs, degrade may be very serious if logs are stock-piled under free drying conditions for any appreciable time. In fresh cut logs for standard length lathes, the extent of shake development probably cannot be controlled significantly before logs are placed in the heating bath. Slow heating, heating from the ends, rather than the sides, and possibly from the core outwards, may cause a relief of growth stresses present, by encouraging plastic accommodation of strain in the wood cells. Thus the increase in transverse stress due to a temperature rise in the log may be offset, and the normal tendency to continued splitting reduced. Consideration might also be given to slow uniform heating of long logs, and subsequently cutting to lathe lengths. This may limit the more severe splitting to the end sections of the parent log.

Koehler (1) pointed out that thorough heating in hot water would cause green wood to expand tangentially to a greater degree than radially. In a thin disk, such treatment tends to produce peripheral ring compression and radial tension. In a log heated from the outside, the greater peripheral temperature tends to produce differential swelling, and may cause ring tensions of appreciable intensity to develop in the region of the core, in much the same way as results from primary transverse growth stresses. Consequently the development of heart shakes would tend to be increased. Thus, control of heating is a necessary part of control of heart shakes in veneer logs.

(e) Silvicultural Aspects of the Development of Shakes

At this stage it is difficult to suggest that silvicultural control could eliminate, or even substantially reduce the stresses which normally develop during the growth of clear symmetrical trees. Nevertheless, much degrade in milling results from trees which are not straight, from the effects of reaction wood, from stress concentrations due to the presence of knots, and from variations in tree cross-section away from the ideal circular shape. Possibly, too, there are environmental factors which may greatly influence the rate of growth, the development of growth stresses, and the structural ability of the tree to resist the stresses which can be expected to develop in it. Thus, on the long-term view of timber utilization, great value may result from attention to ecological and silvicultural aspects of the problem of tree growth stresses.

It has been pointed out that the development of spring and of heart shakes may be relatively more severe in young trees than in more mature ones. Consequently the practice of growing trees as large as possible in the shortest possible time should be carefully considered in relation to the utilization problems which may result. On the other hand, older trees tend to greater development of degrade tissue in the region of their pith. Consequently considerable investigation may be required before a harvesting policy is adopted.

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CELL WALL STRUCTURE AND THE PROPERTIES OF WOOD*

In this paper it is proposed to discuss the influence of cell wall organization upon some properties of wood. For this purpose the following factors need to be considered.

1. Texture of the Cell-Wall.

The cell walls of tracheids consist mainly of cellulose (50 per cent. - 60 per cent.) together with lesser amounts of lignin and hemicelluloses. The cellulose molecules may be up to 50,000 Å in length and over limited regions of their length are arranged parallel to one another to form crystalline regions or "micelles". The micelles are 50 - 60 Å in lateral dimensions and are at least 600 Å in length. However the micellar system is continuous in the direction of the micelle length as the molecules may form part of more than one micelle. Laterally they are separated by the inter-micellar spaces which are 10 - 100 Å wide and in which are located other cell wall constituents such as lignin, hemicellulose and mineral matter.

2. The Cell Wall Organization of Tracheid and Ray Cells.

In softwoods more than 90 per cent. of the wood volume is composed of tracheids and the remainder of other tissue elements, mainly wood rays. Because of this, attention is to be confined to a consideration of the cell wall organization of these elements.

(a) Tracheids. The cell wall of mature tracheids consists of the primary wall and the secondary wall which is formed after the dimensional changes of differentiation have ceased.

* Prepared by the Wood Structure Section, Division of Forest Products, C.S.I.R.O.

The secondary wall consists of three layers in which the structural units of cellulose - the micelles - are spirally arranged (see Forest Products Newsletter 180, Fig. 8). The middle layer S_2 is probably of greatest importance since it is highest in cellulose content and in the latewood is considerably thicker than either S_3 or S_1.

(b) Rays. In ray cells there is often only one thickening layer in which the micelles are oriented spirally at an angle of about 60° to the cell length.

3. The Dependence of Cell Wall Organization upon Cell Dimensions.

For the layers S_1 and S_2 of the secondary cell wall of tracheids (Fig. 1) it has been demonstrated that the angle of spiral micellar orientation (θ, Fig. 1) can be related to the cell length (L) by a relation of the form -

$$L = a + b \cot \theta$$

where a and b are constant, i.e. in long cells the spiral orientation is steep (θ is small) whereas in short cells the spiral orientation is flat (θ is large). The orientation in the primary wall is independent of cell dimensions.

4. Dependence of Properties upon Cell Wall Organization.

Two properties of wood will be considered.

(a) Breaking Load in Tension Parallel to Grain. If a single cell is considered to be loaded in tension, the components of the stress act as a pressure between adjacent regions of the spiral micellar system, as a shear between these regions and as an axial tension. Failure in the fibre may involve either separation of the micellar system parallel to the direction of orientation or at right angles to it. Both types of failure have been observed.

Separation of adjacent regions of the micellar system parallel to the direction of orientation occurs more readily in cells where θ is large (i.e. in short cells) than in those in which θ is small (i.e. long cells) because the forces responsible for the lateral cohesion of the micellar system are smaller than the primary valency forces responsible for cohesion of the system parallel to the direction of orientation. Tests on isolated single tracheids confirm this, in that long tracheids were observed to give a higher breaking load in tension than short tracheids.

Extension of these concepts from single tracheids to a tissue such as wood is greatly complicated as it is necessary to take into account the nature of intercellular adhesion as well as other factors.

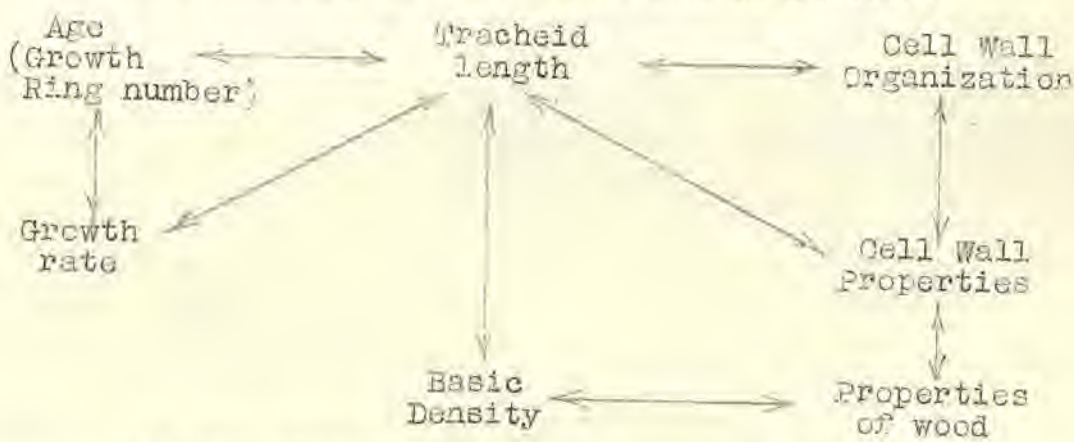
(b) Shrinkage during Drying. In water saturated cells the water is located mainly between the micelles in the lateral direction. Thus on drying removal of water causes a decrease in the degree of lateral separation of the micelles so that shrinkage is maximum perpendicular to the direction of orientation. In accordance with these considerations it might be expected that in short cells in which θ is large, a relatively high longitudinal and low tangential shrinkage would exist, whereas the reverse would be the case in long cells in which θ is small.

5. Variation in Tracheid Length in Conifer Stems with Reference to Radial Growth.

At any level in a conifer stem the tracheid length increases in the first 10-50 successive rings from the pith and then remains more or less constant. Within a growth ring the tracheid length increases from the base of the tree to a maximum some distance up the stem and again decreases towards the crown. At any arbitrary level the tracheid length is also influenced by the radial growth rate (i.e. by the ring width). This arises from the fact that increased radial growth rate involves an increased number of tangential and transverse divisions in the cambium so that although more cells are produced radially they are of shorter length.

6. General.

In addition to the factors outlined above the properties of wood are also related to its basic density which is determined by the cell dimensions of the wood, the wall thickness and growth rate. The interrelation of the various factors may be summarized as follows:



In the present series of experiments the variation of breaking load in tension and of shrinkage have been studied in successive growth rings of conifer stems, so that genetically similar material is compared. Using this approach wood composed of cells of gradually differing organization can be studied and the influence of organization upon the above properties can be assessed. In view of the points outlined above the following trends would be expected. (Fig.1)

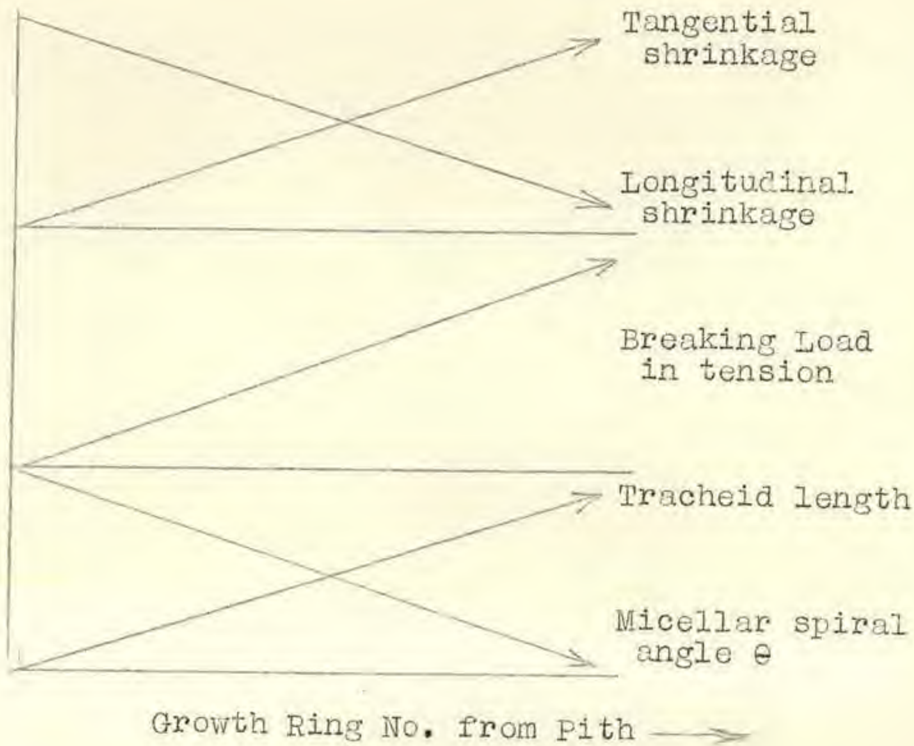


Fig.1.

Evidence supporting these conclusions will be presented.

SAPWOOD/HEARTWOOD.*

Last year the development of gum and tyloses, and the importance of the ray cells were considered and an hypothesis put forward to explain how heartwood is formed when the ray cells die.

Briefly to recapitulate: Whether a tree develops a coloured heartwood or not depends on whether the ray cells contain any extractives that can escape from the cells when they die and permeate the intercellular and intermicellar spaces of the wood.

The woods examined that produce a coloured heartwood all contain some substance - tannin, resin, gum, etc. - in the ray cells; those which are colourless throughout have few or no extractives in the ray cells. Examples of these two types are the eucalypts, wattles, oak, etc. in the first class, and milky pine, kurrajong and Tasmanian sassafras in the second.

To yet a third group belongs a number of trees examined recently - carabeen, crabapple, grey persimmon and possibly N.S.W. sassafras. In these it has been found that at the periphery of the stem the ray cells contained few extractives but as sections further in towards the pith were examined more and more ray cells were found to contain them.

The formation of heartwood in the first group of woods is due, it is believed, to a combined action of injury, and the autotoxic effect of the release of extractives from damaged ray cells. This injury is very often caused by fungi, and in many woods examined fungal

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* Prepared by the Section of Wood Structure, Division of Forest Products, C.S.I.R.O.

activity has been found extremely close to the heartwood-sapwood line at which the ray cells die; this is well shown in material of myrtle beech from Tasmania. In this species, as was shown by a tree of "whipstick" myrtle from Guilford, the cells can live to a great age. (In the northern hemisphere beech is reported to be a sapwood tree). But once fungus etc. has gained an entrace the dead cells release extractives which are autotoxic and cause increased metabolism and finally death of adjacent cells. There is thus a chain of reactions which is started by some external factor, but which becomes independent of it. In old trunks of myrtle beech three zones can be distinguished, the starch filled sapwood, a zone of inner sapwood with less starch, in which budding tyloses occur, and the dead heartwood. It has been found that where the fungal acti:ity (as judged by blackening of the wood) was very active, this zone was narrow and fungal hyphae could be found in cells very close to the living ones, but where the fungal activity was slower the starch depleted zone was wider and the fungal hyphae were always some distance behind the sapwood-heartwood line. From this it was inferred that in the former area the fungus was an active agent in causing the death of the ray cells, while in the latter the death of the cells was caused by the autotoxic action of the extractives. The loss of starch may be accelerated in the former case by the fungus itself, and starvation may be another factor which can cause the death of the ray cells.

It is suspected that the complete absence of heartwood from woods of the second class may be due to the fact that even if the ray cells die there are few extractives to escape from the cells, and therefore little alteration of the other elements of the wood, no colour and no resistance to the penetration of preservatives. Furthermore, there is no autotoxic effect spreading from the dead cells and therefore any dead area remains localized and will not spread without attack by fungi or bacteria. When pathological heartwood is formed in such trees, as in Tasmanian sassafras, the discoloration must be caused by action of the fungus.

To the third group of trees belong those which accumulate extractives throughout their lives so that the tannin filled cells increase in number from the youngest to the oldest cells. By the time the tree has grown to a considerable size the majority of cells contain extractives and injury or fungus which causes death of the ray cells will produce similar autotoxic reactions to those found in the first class of wood. If the extractives prove toxic the heartwood may form automatically as in the first class of wood, and be independant of fungal activity, if not, the fungus may be the lethal factor in which case the fungal zone line will coincide with the heartwood sapwood line.

Two woods have recently been examined which are difficult to fit into the above scheme. Grey persimmon has proved so far to be a sapwood tree, with starch containing cells and living nuclei at the pith. Yet this tree showed a distinct colour zone halfway through the radius, giving an inner core of pinkish wood which simulates heartwood and an outer pale coloured wood that is clearly sapwood. Yet in both zones the ray and parenchyma cells are alive and the only difference between the two zones is the increase of extractives in the inner zone, in which tannins are present in the parenchyma as well as in the ray cells, though in the soluble form always found in sapwood and not in the solid darkened form associated with heartwood. In certain areas this wood also had patches of black heart, the dark, brittle coal-like material associated with ebony. This is stated by Griffoen (1933) to resemble closely the early stages of brown coal formation and fossilization and to be the result of bacterial action. In the material of Diospyros examined the black areas comprised, in the early stages, vessels and fibres only, the living cells of the rays and parenchyma appearing in sharp contrast in stained sections. In later stages of attack, in which fungal hyphae could also be observed, the ray and parenchyma cells were dead and the tannins present in solid form. On these areas the ray and parenchyma also showed signs of the deposition of the coal-like materials.

The other wood which could not easily be classed with any of the others was Longetia swainii (Euphorbiaceae). In this wood the sapwood is highly coloured, bright pink when cut and deepening to orange on exposure. On examining sections which had been fixed in formalic acetic alcohol it was found that not only the ray cells, but also the lumina of the fibres and the parenchyma were filled with soluble tannin. This is the first wood which has shown such a state. The tannin was in solution in the cell lumina and not dispersed through the cell walls as in heartwood. Furthermore, the ray and parenchyma cells were alive. No explanation has yet been found for this.

N.S.W. sassafras appeared to be another tree like Diospyros in type, having an inner core of darker coloured wood, which was nevertheless living sapwood. The material available did not go into the centre of the tree.

UTILIZATION OF QUEENSLAND BUILDING AND COOPERAGE TIMBERS*

1. Objectives.

These can best be stated with regard to building timbers:-

(a) To encourage the use of the widest possible range of species.

(b) To use these for building members where the best service will be given.

(c) To encourage the use of all grades of timber within the limitations of efficiency.

In the Cooperage field the aim is to find local timber, in commercial availability, suitable for casks manufacture.

2. Methods and Results.

(A) BUILDING TIMBERS.

Since the end of World War II in 1945, it has become apparent that Queensland has ceased to have a surplus of timber for export, and that local sawn timber production cannot meet the internal demand. In these circumstances the milling of as many native timbers as possible to reduce the necessity to import becomes highly desirable. With a Wartime lag of some 30,000 houses, the most important aspect is that of building timbers both for framing and sheeting.

Many timbers are available in open forests and scrub country which are not well known to sawmillers, and practically unknown to architects and builders. As a result, the Forest Products Research Branch has been inundated with requests for information on the qualities of these woods.

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* Prepared by the Department of Forestry, Queensland.

The properties which are most significant for building purposes are durability with regard to decay and Lyctus attack in the sapwood, strength, hardness, weight and colour, and the Branch began to grade all available species under these heads. Following this the timbers were arranged into groups suitable for use in different parts of a wooden house from the ground up. The result was Q.F.S. Pamphlet No.2 "South Queensland Building Timbers and Specifications for their Use" published in 1947. This paper contained details of over one hundred timbers with the building uses recommended for each.

North Queensland building woods already had been covered in less detail in Pamphlet No.1 in 1939, but the great demand for this paper during the war now has exhausted supplies. The revised edition, now in the hands of the Printer, contains over 170 species and follows the layout of Pamphlet No.2. Armed with these two papers, sawmillers, plymillers, joinery manufacturers, architects, builders and home owners need have no fears regarding the best uses of Queensland woods in the home.

HARDWOODS. Prejudice of sawmillers and resistance to change to improved methods are among the foremost difficulties in the way of better utilization of some hardwoods, notably Turpentine, Brush Box, Scribbly Gum, and Rose Gum.

Turpentine was once known as "Inch-a-night" and "Canoewood", because its capacity for shrinkage (much less than Mountain Ash) compared unfavourably with Ironbark and Tallowwood. Well seasoned and dressed, Luster (Syncarpia laurifolia) is now a very popular flooring timber, but Turpentine (S. laurifolia) is still a "second class", species.

Brush Box and Scribbly Gum are excluded, irrespective of grade, by the Queensland Housing Commission's official specifications while the majority of homes contain a considerable proportion of one or both of these useful woods. In the former the prejudice is against the greater shrinkage (about 10 per cent.) and warping of twisted grained material, and in the latter the gum veins are unsightly. It does not appear to be appreciated that the above three woods have a special advantage in practical immunity of the sapwood to Lyctus attack.

In Scribbly Gum, warping of scantlings containing "heart" is also a source of trouble. In every log a liberal "pipe" is allowed in Forestry measurements to sawmillers, but, unfortunately, many saw and sell this defective material.

In Rose Gum also, "heart" wood is usually fit only for cases, and this timber carries a prejudice because of so called "excessive" shrinkage. At a recent grading demonstration sawmill salesmen graded defect-free scantlings of Rose Gum to B. Class on species alone.

These difficulties can best be met by up to date instruction of the people concerned and encouragement in the adoption of practical and efficient grading standards.

In this field a splendid opportunity was offered last year by the appointment by the Queensland Government of a Commission to enquire into the sawmilling, plywood and joinery industries. On this was represented senior officers of the Forestry Sub-Department, Queensland Housing Commission, and Prices Branch, with a magistrate as Chairman.

Evidence by Forestry officers showed the weaknesses of existing grading rules in official price lists and advocated the adoption of standard grading, while an officer of the Standards Association of Australia gave particulars of the timber standards then available. Sawmillers realized the need for improvement and requested the S.A.A. Queensland Joint Committee on Timber to review (E) O.54-1942 with regard to house scantlings so that they could make recommendations to the Timber Commission.

As a result of this work the Commission recommended the adoption of the draft for building scantlings prepared by the S.A.A. Queensland Committee, and this now forms part of the official price list for hardwoods, together with Standard Grading Rules O.3 for flooring. The latter needs revision and simplification to meet timber conditions in Queensland.

This is the greatest advance in the adoption of Standard timber grades in Queensland during the past twenty years, and the grades which have now become law are a definite improvement upon (E) O.54, particularly in the limitation of Lyctus susceptible "sapwood".

<u>HARDWOOD THINNINGS</u>. The cutting of surplus small girth hardwood trees from forest areas under Sylvical treatment in the Brisbane and Gympie districts has raised the problem of the best means of disposing of the logs. The species represented are mostly Brush Box, Turpentine, Gympie Messmate, Red Mahogany, Spotted Gum and Ironbark, with a G.B.H. averaging about 36 inches.

As many of the species are unsuitable for poles and posts because of wide sapwoods of low durability when untreated, it was thought that the best means of disposal would be as saw logs.

A considerable number were sawn under "mill study" conditions for flooring and chamfer boards, and to date the evidence suggests that good building material can be produced provided that the collapsible "hearts" are avoided, and all boards are sawn free from Lyctus susceptible sapwood. The latter can be upgraded by boric treatment. Seasoning losses and cutting costs have not yet been established.

<u>OTHER BUILDING TIMBERS</u>. There is need for a more practical approach to the use of new species of local timbers in wooden homes. Sawmillers themselves are responsible for much of the prejudice which attaches to "scrubwood rubbish". Illogically, well known species such as Queensland Maple, Silky Oak, Hoop Pine and Crow's Ash, which grow in the same "scrubs" are not included as "srubwoods". Lack of knowledge of the properties of many timbers has too long been made an excuse for "knocking" woods which require only proper treatment and intelligent use.

Thirty years ago the Standard Queensland timber home consisted of "hardwood" external wood frames standing upon "hardwood" stumps, roofed over Hoop Pine rafters, battens and ceiling joists, and sheeted externally with flawless Pine chamfer boards. The steps, railings and external dressed-and-shot semi-seasoned flooring were of "hardwood", while more flawless dressed pine was used internally for studs, bolt rails, joinery and sheeting for walls, partitions and ceilings.

Today the pine has given place to hardwood and Cypress throughout, with the exception of trimmings. Many people still believe that "scrubwoods", most of which are more durable than the once popular Pine, are not fit for house construction.

No doubt the past unwise inclusion of Lyctus susceptible sapwood and lack of adequate seasoning in "scrubwood" boards, have created prejudice through sad experience, but boric acid has conquered Lyctus, and the millions of super feet of Tulip Oak and other miscellaneous timbers can now take a prominent place in house building.

For years one Brisbane sawmiller has been producing about one million super feet per annum of boric treated seasoned dressed flooring and mouldings in formerly despised "scrubwoods", and this lead is being followed by northern sawmillers who are producing dependable material in both floorings and wall sheeting. If and when the dressed timber market is satisfied there is no good reason why properly treated or sapwood free scrubwoods should not be used generally for internal framing.

This development has been provided for, among the harder and stronger jungle species, in Q.F.S. building timber pamphlets, with the suggestion that the softer and weaker types should find just use in internal sheeting, joinery and mouldings.

These timbers are usually both stronger and more durable than knotty overseas Pines, Spruces and Firs which are now being imported in "prefab" houses. They also compare more than favourably with the Calymmaderus susceptible Hoop Pine which we once esteemed so highly for home building.

While the adoption of the modified (E) .054 grades for scantlings is satisfactory for "South Queensland Scrubwoods" in the official price lists, the sapwood restrictions for immunized dressed flooring and lining under standard grades 0.3 - 1940 are impractical and unnecessary for dry timber in completely protected situations.

The service records of boric treated internal floors in several thousands of Brisbane homes built since the war strongly support the case for the omission of restrictions on <u>non-susceptible</u> sapwood in "scrubwoods" for inside use. Who would be brave enough to contend that these are not as good, if not better than, the Hoop Pine floors which we thought so splendid before the Hoop Pine Beetles (Calymmaderus incisus) found them?

<u>(B) COOPERAGE TIMBERS.</u>

Since the prices of imported Oak (Quercus spp.) staves have reached the sky, coopers have shown much more zeal in their endeavours to make casks from local woods. The most urgent demand is for timbers suitable for beer, wine and rum casks, particularly for stave material. Sound wood of non-bending quality can be used for the flat heading. A wide assortment of jungle species from Pink Poplar to Tulip Oak is already in use for tallow casks in place of the Hoop Pine which once was said to be irreplacable.

Apart from good steam-bending quality which necessitates careful selection for straight grained material, timber used in beer cask staves and heading must not leak under internal gas pressures of more than 20 lbs. per sq. inch. Manufacturers test the finished casks at pressures considerably above this.

As the alcoholic content of beer is comparatively low, internal pitching can be used, and the possibility of woody flavours spoiling the liquor is not so great as in the case of wine. Yel[illegible] staves have given excellent service in beer ca[illegible] over many years with heading either of this wood or Rose Mahogany. The difficulty now is to find the Yellowwood. Possibly New South Wales can do better with regard to supply in "Long Jack" (Yellowwood).

Satinay beer casks made by Mercer Pty. Ltd., Brisbane, are still "on the road" giving good service. Although considerable supplies of this wood are available ex Fraser Island from the two large sawmills at Maryborough, Queensland, a very high proportion of this has wavy or interlocked fibres on the radial face, and breaks short in bending. The key to success is in the selection of younger straight grained timber, usually from smaller logs, and being content with a very low percentage of "stave" grade timber.

The final hurdle is the steam bending of this very hard and strong timber in which only Mercer Ltd., appear to have been successful.

Some of the Tulip Oaks (Argyrodendron spp.), which bend well under steam, are being used successfully for beer cask staves, but more care is required with regard to exposure to prevent deep radial checking of back sawn staves. Although A. peralatum is considered suitable, it is probable that the newly described Mackay species (A. diversifolium) which is easiest to peel for plywood, is the best. Full tests on A. actinophyllum, most common on the New South Wales border, should be worth while, particularly for New South Wales, where the timber appears to be more plentiful.

In Queensland only the Tulip Oaks have attracted interest for wine casks and a prominent South Australian wine manufacturer recently visited North Queensland seeking stave supplies of A. peralatum. Wine casks are increasing in demand because of the entry into the country of many "New Australians" who use larger quantities of this beverage.

No local timber has yet given satisfaction for rum casks, and while the palates of rum drinkers remain so sensitive, it would appear that imports of European or American Oak must continue.

3. Conclusions and Future Developments.

(A) BUILDING TIMBERS.

(1) Prejudice and bad grading is retarding the better utilization of some hardwoods.

(2) Greater use of standard grades will materially increase the effective use of building timbers.

(3) The sawn product of small hardwood thinnings is suitable for dressed building lines provided that "heart" and Lyctus susceptible sapwood is avoided.

(4) More use can be made of "scrubwoods" in building if properly graded and treated where necessary for Lyctus susceptible sapwood.

(B) COOPERAGE TIMBERS.

With proper selection for stave quality, Queensland can supply considerable quantities of timber suitable for beer and wine casks, but no success has been achieved with rum casks.

Future work should continue along educational lines to reduce prejudice and develop good grading and manufacturing practice.

BOX TESTING *

The box testing and container development work has got under way rather slowly at the Division principally due to staff changes and shortages of staff.

Efforts have been made to interest industry in the equipment and this has met with some response from the more advanced manufacturers.

One such project for a box manufacturer has been the testing of three types of cases fastened with staples instead of nails.

The three types were (a) cannery case
(b) export apple case
(c) dried fruit case

Staples instead of nails enable a much stronger box to be made from thinner timber than usual.

The boxes in question were made from mountain ash (<u>E. regnans</u>) plus fibreboard in the case of type C. It is doubtful if staples could be used successfully with the denser hardwoods such as blackbutt, mainly because of difficulties in driving them.

The stapled boxes were found to be very satisfactory in types (a) and (b), but in case (c) the attachment of fibre board to timber using staples was not satisfactory. A report has been written on this work.

The major part of box testing work has been in developing field lug boxes, chiefly for use in the Murrumbidgee Irrigation Area. Here the extreme climate reduces the life of conventional field lugs very markedly.

Tests have been completed on the type of field

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* Prepared by the Division of Wood Technology, New South Wales.

lug in use and the reasons for premature failure noted.

The effect of humidity changes on nailed joints in these boxes has been studied. Tests carried out show that the holding power of simple driven nails is reduced by 75% - 90% on cycling between 15% and 6.5% moisture content using alpine ash and mountain gum, timbers which are used for lug construction on the area.

The strength of clinched nails however, is not reduced to this degree, the loss in strength being of the order of only 20% - 30%.

Two satisfactory types of field lug have been developed for trial in the area. One type has cleated heads and the nails holding the cleats are clinched.

The other type has a head made either by linderman jointing, gluing or corrugated fasteners. The sides are held on with nails and a binding wire strained in a saw kerf around the head and held with staples.

Both types of box are relatively unaffected by climate changes and give far superior life, as measured by a fictitious load in the rumbler tester.

Both types of box can be made either of ash type eucalyptus or radiata pine. A progress report on this work is being written.

Economics of lug box utilisation

A start has been made on the collection of data for a study of this problem. Since lug boxes represent a considerable capital outlay in the fruit growing industry and consume considerable quantities of timber, a proper study of the most economic construction of lug to be used is well worthwhile. It is necessary to determine whether it is cheaper in the end to use an expensive lug or whether a cheaper first cost but shorter lifed lug is really a sounder proposition.

Some data for this survey from the M. I. A. Bathurst apple district and Gosford citrus area are to hand, but it is proposed to gather further data from areas in this State and to secure data from other States. Information from the apple areas of Tasmania, from Goulburn and Murray Valley in Victoria would be particularly welcome.

A working plan is being prepared and the co-operation of other States in furnishing data will be sought.

SURVEY OF TANNING MATERIALS*

At the 2nd Annual Forest Products Conference held in Melbourne in November, 1947, Dr. Cohen reported on the inadequacy of our information concerning tannin containing species in Australia. He pointed out that Coghill's C.S.I.R. Bulletin No. 32 was unsatisfactory on a number of grounds viz.: (a) authenticity of samples reported (b) extreme variations in tan content for some species which could be due to enzyme action, oxidation or leaching (c) the omission of some species and (d) the fact that no indication is given of the chemical nature of the tannins, their degree of fixation by leather and the properties of such leather.

Conference decided that it would be desirable to carry out an Australia wide survey but no machinery was created to co-ordinate the work and as a result little work has been done along the lines suggested by Dr. Cohen.

In the course of its attempts to use tannins from N.S.W. species the Division of Wood Technology has analysed for tannin a large number of bark and wood samples from a number of species. These results are reported in detail below. Most of the Black Wattle results have been published but it was considered desirable to report all figures in detail in the hope that they may be of use if Bulletin 32 is revised.

Our original purpose in doing this work was in relation to the planting of Black Wattle and the utilization for tanning purposes of the barks of the Black and White Cypress Pines. The development of a process for the manufacture of building boards by treating tannin containing sawdusts and barks with formaldehyde has intensified our interest in the variation in tannin content within a species,

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*Prepared by the Division of Wood Technology, N.S.W.

the nature of the tannin and the development of accurate and rapid methods of determining catechol type tannins in sawmill wastes. Before the bark or sawdust of a species can be seriously considered as raw material for this type of building board a large number of tannin analyses will need to be done and this information could be made available to interested bodies.

Acacia mollissima bark.

Locality	Collected	Tans	Non-tans	Moisture	Type of tan	Authority	Other Remarks
Benandra S.F.	June, 1948.	35.7 30.6 28.6 28.3 35.1 38.5 32.0 43.5 35.5 34.0 47.6 39.6 41.3 38.5 42.5 42.3 38.9 37.4 40.1 34.9	11.5 11.9 12.5 9.3 9.9 11.6 10.1 10.0 10.9 10.5 10.6 9.2 10.5 8.8 7.9 8.3 7.8 7.8 8.3 7.9	11.5	Catechol	D.W.T.	Bark samples in all cases taken between 2' and 3' from ground. 4" to 5" diam. trees; average height 25'; estimated age 10-12 years.
Boyne S.F.	June, 1948.	34.0 31.4 36.7 44.3 35.7 41.3 38.9 39.3 41.3	11.6 11.8 12.1 10.6 12.1 10.8 12.1 10.9 12.4	11.5	Catechol	D.W.T.	Bark samples in all cases taken between 2' and 3' from ground. 4" to 5" diam. trees; average height 25'; estimated age 10-12 years.
Acacia pycnantha bark.							
South Aust.	May, 1949.	29.2 25.2	-- --	11.5 11.5	Catechol	D.W.T.	
Wagga	Oct., 1949.	34.6	11.9	11.3		D.W.T.	Colour 5 Red, 5.3 yellow. Whole bark of 6 year old tree.

Acacia irrorata bark.

Locality	Collected	Tans	Non-tans	Moisture	Type of tan	Authority	Other Remarks
Mt.Mitchell S.F.	Oct., 1945.	39.6	9.2	14.0	Catechol	Tanning School	) Butt bark from 7" diam. tree) 24' high.
		34.1	9.0	14.0			) Butt bark from 4" diam. tree.
Acacia felicifolia bark.							
Mangrove Mountain	1949	40.1	8.6	14.0	Catechol	D.W.T.	Bark submitted by farmer.
Euc. maculata sawdust (North Coast).							
Macksville	November, 1949.	3.5	3.6	14.6	Catechol-pyrogallol.	D.W.T.	Sawdust collected at Mobile Mill, fresh from saw.
Euc. microcorys sawdust.							
Macksville	November, 1949.	9.5	3.5	12.7	Pyrogallol	D.W.T.	As above.
Tristania conferta sawdust.							
Macksville	November, 1949.	1.4	1.8	14.2	Mixed	D.W.T.	As above.
Syncarpia laurifolia sawdust.							
Macksville	November, 1949.	6.3	3.1	19.1	Mixed	D.W.T.	As above.
Euc. corymbosa sawdust.							
Macksville	November, 1949.	3.9	2.0	15.3	Mixed	D.W.T.	As above.
Euc. resinifera sawdust.							
Macksville	November, 1949.	3.1	1.2	18.6	Mixed	D.W.T.	As above.

Locality	Collected	Tans	Non-tans	Moisture	Type of tan	Authority	Other Remarks
	Euc. dalrympleana sawdust.						
Oberon	February, 1950.	4.9	2.5	19.1	Mixed	D.W.T.	Sawdust forwarded from Timber Industries Ltd.
Oberon	December, 1949.	4.3	1.9	11.0	Mixed	D.W.T.	
	Euc. dalrympleana bark.						
Oberon	February, 1950.	3.4	6.4	10.3	Catechol	D.W.T.	As above.
	Euc. grandis sawdust.						
Macksville	November, 1949.	4.7	1.2	19.4	Mixed	D.W.T.	Sawdust collected fresh from saw.
	Euc. rostrata sawdust.						
Mathoura	November, 1948	6.2 4.6	8.3 2.0	9.4 9.3	Mixed	D.W.T.	Sawdust
	Euc. rostrata bark.						
Mathoura	October, 1949.	11.5	5.1	13.3	Catechol	D.W.T.	Fresh from tree.
	Euc. obliqua sawdust.						
Tumut	June, 1950.	1.5	2.1	24.6	---	D.W.T.	
	P. caribaea bark.						
Banyabba S.F.	June, 1950.	5.4	2.7	14.6	Catechol	D.W.T.	Bark obtained from plantation thinnings at mill.
	P. radiata bark.						
Wagga	January, 1950.	27.2	7.1	12.9	Catechol	D.W.T.	Bark collected from logs at sawmill.
	Euc. diversicolor bark.						
Western Australia	November, 1948.	12.0	6.8	14.0	Catechol	Tanning School.	Flown from Western Australia fresh from tree.

Euc. astringens.

Locality	Collected	Tans	Non-tans	Moisture	Type of tan	Authority	Other Remarks
Western Australia	October, 1948.	41.8	14.3	11.2	Catechol	Tanning School	
Callitris calcarata bark.							
Pilliga Scrub.	1946.	21.2 23.6 18.1 22.2	5.0 4.2 4.6 5.2	14.0	Catechol	Purs & Anderson	Mature trees.
Coonabarabran S.F.	April, 1949.	9.9	5.8	11.5	Catechol	D.W.T.	Thinning 4" diameter.
Cooper S.F.		9.5	6.6				" 4" "
Yarrigan S.F.		20.3	8.3				" 5" "
Wittembra S.F.		15.2	7.1				" 4" "
Yearenan S.F.		13.0	6.6				" 4" "
Tummallallo S.F.		20.1	8.2				" 4" " Mean of 4 analyses
Yarrigan S.F.		19.9	4.6				7" diam. tree, dead 2 years.
Yearenan S.F.		8.3	4.9				8" diam. tree, dead 6 years.
Wittenbra S.F.		11.5	6.1				7" diam. tree, dead 3 years.
Private Property Pilliga		4.2	4.8				12" diam. tree, ring barked 20 years
Private Property Pilliga		9.4	4.4				8" diam. tree, ring barked about 12 years.
Coonabarabran	February, 1949.	12.3 9.4 14.4	5.4 5.4 5.8	11.1 11.1 11.4	Catechol	D.W.T.	Bark taken from sawlogs at mill.
Callitris glauca bark.							
Gwabegar	October, 1949.	9.2 10.6 11.5 10.6	7.9 6.9 7.6 8.4	9.4 9.6 7.6 9.0	Catechol	D.W.T.	Bark taken from sawlogs at mill.

Euc. maculata sawdust (South Coast).

Locality	Collected	Tans	Non-tans	Moisture	Type of tan	Authority	Other Remarks
Bermagui	May, 1950.	5.4	2.6	11.5	Mixed - Catechol & pyrogallol	D.W.T.	Sawdust collected at mills, fresh from saw.
Narooma		3.5	2.0				
Nelligen West		2.7	2.5				
Reedy Creek		3.5	2.6				
Wandandian		1.3	1.7				
Benandra S.F.		1.3	1.4				
Wandanian		1.5	2.0				
Kioloa S.F.		1.9	1.6				
Boyne S.F.		0.4	1.2				
Tomerong		3.3	2.5				
Boyne S.F.		0.6	1.8				
Flat Rock		2.4	1.6				
Tomerong		3.4	2.1				

CORK FROM THE BARK OF THE PAPER BARKED TEA TREE*

The paper barked tea trees occur extensively in most States of Australia and are found in New Zealand and on islands scattered throughout the Pacific. The broad-leaved paper barked tea tree, known to foresters as Melaleuca leucadendron occurs extensively on the coastal flats north of Sydney and extends well into Queensland.

The insulating properties of the paper bark have been known for many years and a common practice in country areas has been the use of the bark in the manufacture of home-made coolers for food storage. In the '90's of last century, Maiden records the fact that piccaninnies were wrapped in the bark by their mothers to keep them warm.

In 1947 a Sydney manufacturer approached the Division of Wood Technology for suggestions for a cork substitute for the insulation of his hot water heaters. Among other materials paper bark from Melaleuca leucadendron was suggested and a quantity was obtained from the north coast for trial. Thermal conductivity tests were carried out by the Building Research Section of the C.S.I.R.O. using a guarded hot plate apparatus. Loosely shredded material which had been allowed to air dry was used and gave the following results estimated to be within 10%:

DENSITY	CONDUCTIVITY
lb./cu.ft.	B.T.U./sq.ft./hr./deg.F/in.
7.4	0.28
5.7	0.26
4.2	0.29

These results were so interesting that the paper bark was examined microscopically and found to contain a high proportion of cork cells similar in appearance to those examined in the bark of the cork oak. It was decided to

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* Prepared by the Division of Wood Technology, N.S.W.

prepare a sample of flour from the paper bark and to submit this to a Sydney firm of linoleum manufacturers for trial. Laboratory samples of linoleum were made using cork flour and paper bark flour. These appeared to be identical in all respects and the linoleum manufacturers ordered half a ton of the flour for more thorough trials from Mr. D. K. Hammond of Taree. At the time of writing 30 yards of linoleum have been made and are now being stoved. This material will be subjected to service tests and should it prove to be similar to linoleum made from cork oak flour there is no doubt that ultimately paper bark will be used in the manufacture of high quality linoleum.

When flour is produced from the bark an oversize fraction is obtained which consists of small, thin platelets approximately 1/8 in. square. The density of this material, in an air dried condition, is 3-1/2 lb./cu. ft. If this material is pressed at temperatures of approximately 160°C. and pressures of about 50 p.s.i. it can be formed into thin sheets or thick blocks which should find uses for gaskets and insulating blocks respectively.

Further conductivity tests are required to verify the work done by the Building Research Section of C.S.I.R.O. and the Division is building a guarded hot plate apparatus in order to carry out these tests.

Studies of the anatomy of the paper bark have been commenced and chemical work is in progress to identify the various extractives of the bark. The Forestry Commission has included Tea tree types in its aerial survey of north coast forest resources and field work has commenced with the object of investigating methods of barking, rates of growth, stripping costs and growth rates of the various species. It is also proposed to examine other paper barked species.

The purchase of Australia's cork supplies from Spain and Portugal involves dollar expenditure and local users find difficulty in obtaining all their requirements. It is impossible at this stage to predict how much of Australia's cork requirements can be supplied from the paper barked tea tree but it seems probable that a basis exists for the establishment of a considerable industry.

SOME PROBLEMS OF THE ESSENTIAL OIL INDUSTRY IN NEW SOUTH WALES*

The following note is intended to indicate present trends within N.S.W., to outline the type of research required and the steps being taken in N.S.W. to meet the situation. It does not claim to be comprehensive and is put forward with the idea of stimulating discussion from interested delegates.

EUCALYPTUS OILS

The Volume of Production

From humble beginnings the production of Eucalyptus Oils has developed into a considerable industry, not only in N.S.W. but also, to a lesser extent, in Victoria and South Australia. It is difficult to assess accurately the total production of these oils in Australia because part of it comes from private property. An estimate made in 1943 by Penfold and Morrison gave the total annual production for Australia as about 230,000 gallons based on figures supplied by distillers. Of this total it is estimated that at least 80,000 gallons were produced in New South Wales.

When the war ended America and Britain increased their imports of Australian oil and in 1946 the United States imported 96,300 gallons of oil mainly from Australia. The high prices being paid together with the heavy demand led to a large increase in production in New South Wales and in 1947 the Division of Wood Technology estimated that 213,000 gallons were produced in that State alone, largely from areas under the control of the Forestry Commission. United States imports in 1947, however, dropped by 35,000 gallons, leaving a large surplus of oil within Australia. Prices dropped

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*Prepared by the Division of Wood Technology, N.S.W.

sharply and in New South Wales production came almost to a standstill and men left the industry for more congenial and better paid work. Many of these distillers have not returned and to-day there is a shortage of all types of oil. This is reflected in the present prices being paid for oil at the still. The following table indicates the price per lb. paid at the still for industrial and medicinal oils from 1941.

Year	Industrial		Medicinal	
	E. phellandra	E. dives (type)	E. dives (var. C.) E. australiana.	E. poly-bractea.
1941	9d.	11d.	1/6d.	1/7d.
1943 (Fixed by Prices Comm.)	1/7d.	1/8d.	2/6d.	3/0d.
1946 (Fixed by Prices Comm.)	2.1d.	2/2d.	3/0d.	3/6d.
1950	4/0d.	5/0d.	4/0d.	not known.

In order to stabilise their raw materials position some firms, dependent on Eucalyptus oils, are going to considerable expense. e.g. Plaimar Ltd., a Western Australian Company, has bought out Mr. A.J. Bedwell's interest in New South Wales. All Eucalyptus dives (type) oil from areas held under license by Bedwell or his agents now goes to Western Australia where it is used to manufacture thymol, menthol and menthone. Most of this oil was previously exported by Bedwell. Plaimar Ltd. has appointed a chemist to look after oil processing and production and has retained Mr. Lane-poole to advise on the forestry aspects of the work.

F.H. Faulding and Co. Ltd. has purchased 500 acres of land in the Camden district in New South Wales and has commenced the planting of Eucalyptus australiana to make sure of further supplies. The same firm has also made application for special leases on the South coast of N.S.W. It is intended to build accommodation for workmen and carry out forest improvement if permission is granted. It is also known that the Nightingale Supply Co. is considering the establishment of plantations.

Method of Production

In New South Wales as in the other States, the nature of the country and the extent of the oil stands have determined the type of distillation plant used. In hilly areas, to minimise the carrying of leaf long distances, the stills consist of one or two 400-gallon square ships tanks which can readily be moved from time to time. On flat terrain it has been found more economical to use large permanent distillation plants and to increase haulage distances. In New South Wales these large stills are comparatively rare but in Victoria and South Australia they are the rule rather than the exception. The small stills are inefficient because they are direct fired and require more labour per gallon of oil produced. They are a constant scource of fire danger and their inaccessibility makes it difficult for forest officers to inspect them for breaches of the regulations designed to minimise this risk.

In New South Wales the agents and bush managers of the oil firms know more about potential areas capable of being worked for oil than do the Commission's Officers. To date the returns to the Commission by way of stumpage have been insufficient to offset the cost of efficiently supervising areas being cut for oil or to open new stands. Staff position is such, also, that no labour can be spared for this work and consequently many aspects of this important industry based on a minor forest product are unsatisfactory. New South Wales, more than any other State, has a special responsibility to this industry since its species yield better oils in higher yields than those found elsewhere. The Division of Wood Technology is attempting to investigate certain aspects of the industry which require research and the Commission has endorsed, in principle, a plan for the management of one of the best areas in the State - the Yellowin Valley, an area of some 5,000 acres adjoining Bago State Forest. The management plan for this area has as its main aim the elimination of undesirable species and the production of eucalyptus oil, poles and sawlogs from the peppermints and red stringybark respectively. It is proposed to establish a central distillation plant and to road the area for the extraction of leaf, timber and for fire protection purposes. Research planned will attempt to answer the following main problems.

1. The effect of various methods of lopping on the life of coppice - producing stump.
2. The best cutting rotation to maintain high oil yields per acre.
3. The extent to which oil yield and quality varies with harvesting at different seasons of the year.
4. The effect of fertilizer on oil yield.

In co-operation with the Division of Forest Management, the Division of Wood Technology has commenced an experiment in the Blackheath sub-district with the object of determining a method of converting poor timber stands to pure stands of the oil producing species Euc. dives. This work will also attempt to determine the effect of super phosphate on leaf production.

Minor Eucalypt Species

Pilot plantings have been made of a high yielding form of Euc. macarthuri at Penrose S.F. mainly with the object of determining whether it will give high yields in its new environment. The results of this work will determine whether further plantings are made.

Two Queensland species Euc. citriodora and Euc. staigeriana have been planted experimentally on ½ acre plots in northern forests. These species will soon be ready for harvesting and their behaviour as an oil crop will determine the Commission's attitude to further plantings.

Tea Tree Oils.

The only tea tree oil produced commercially in N.S.W. is that from the narrow leaved tea tree Melaleuca alternifolia. Production probably does not exceed more than a few hundred gallons per annum, mostly from private property. The Commission has established a 10 acre plantation of this species from selected seed in order to determine its silvicultural requirements, methods of lopping, and best espacement and cutting rotation consistent with high leaf yields per acre.

Leptospermum citratum, the lemon scented tea tree, contains a leaf oil high in citral. 14 acres have been planted on poor soil within a Pinus caribaea plantation with a similar object to that outlined for M. alternifolia.

Melaleuca leucadendron

Recently officers of the Division located trees of this species containing nerolidol and nerolidol and linalool. Seedlings raised from these parent trees are ready to be planted on a 0.6 acre plot at Cumberland National Forest near Sydney to find out if they produce similar oils.

PLATE 1

Development of heart-shakes in ends of logs.

PLATE 2

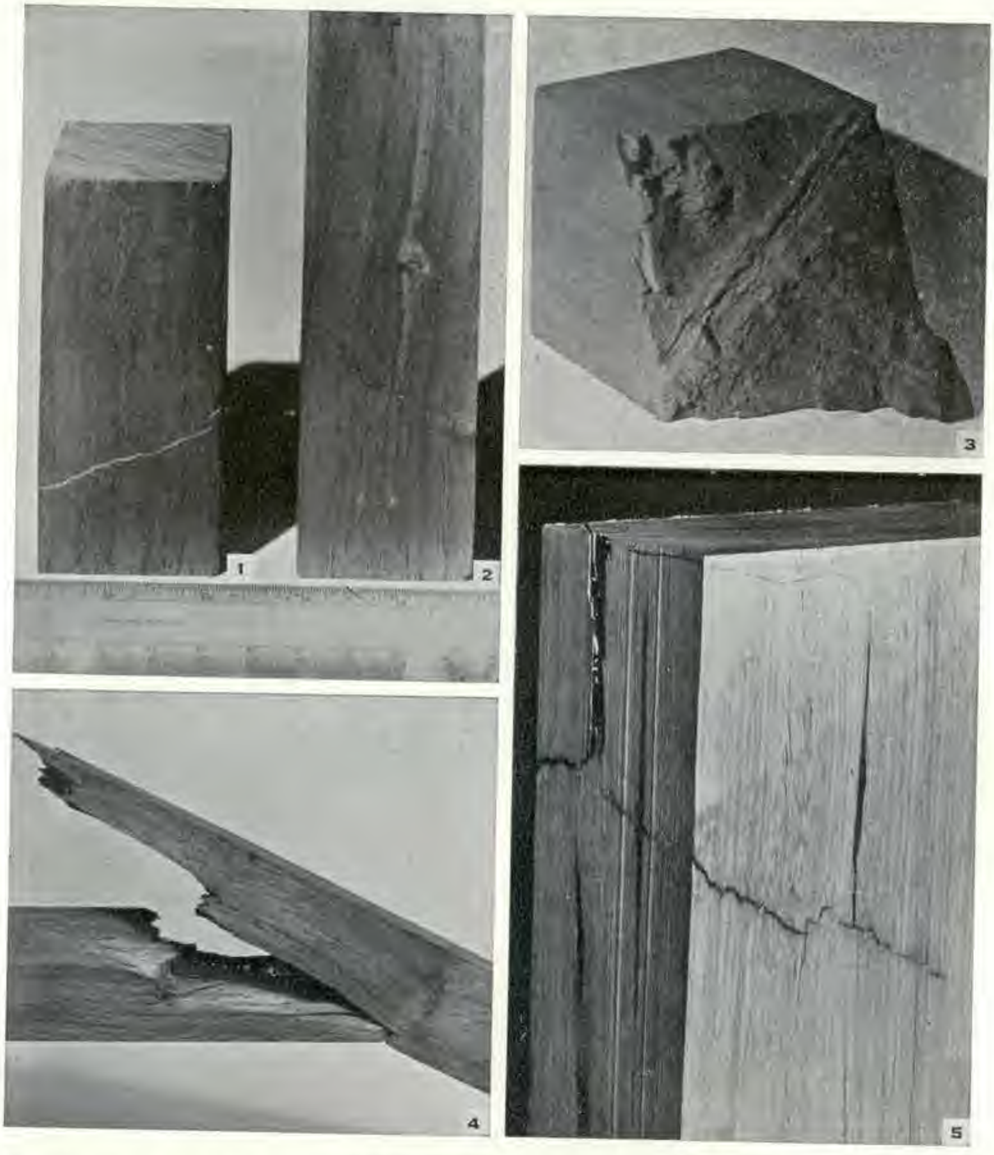

Fig. 1.—An artificially induced compression failure. Fig. 2.—A naturally induced compression failure. Fig. 3.—The texture of a secondary bending failure in the specimen shown in Figure 2. Fig. 4.—Normal type of bending failure. Fig. 5.—Another example of a naturally induced compression failure.

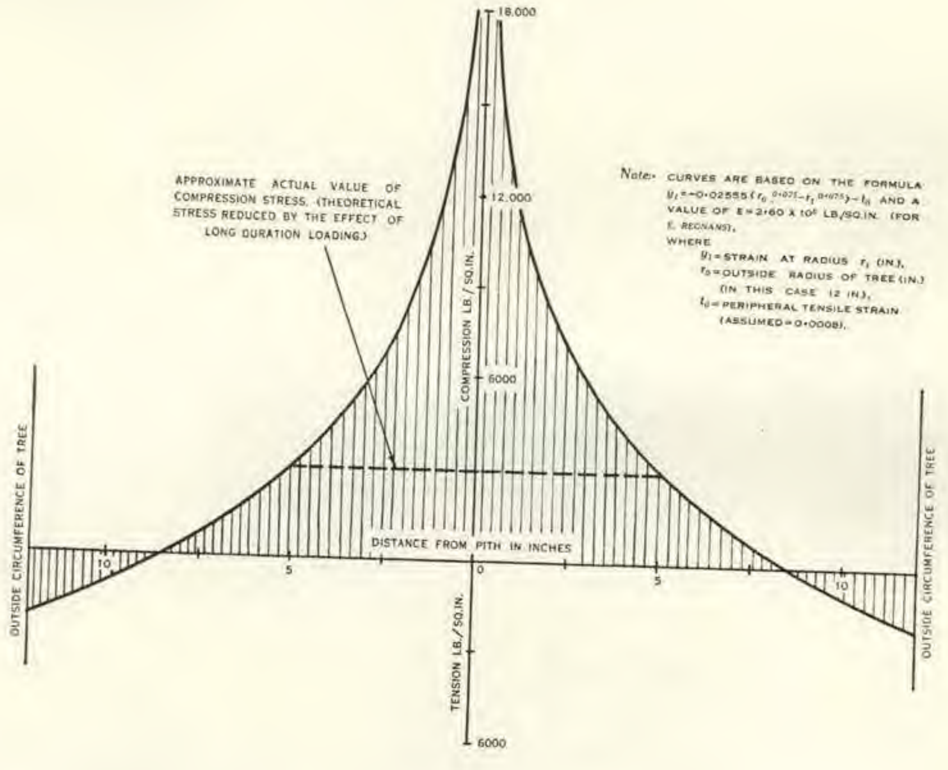

Fig. 1.—Theoretical evaluation of longitudinal stresses in trees.

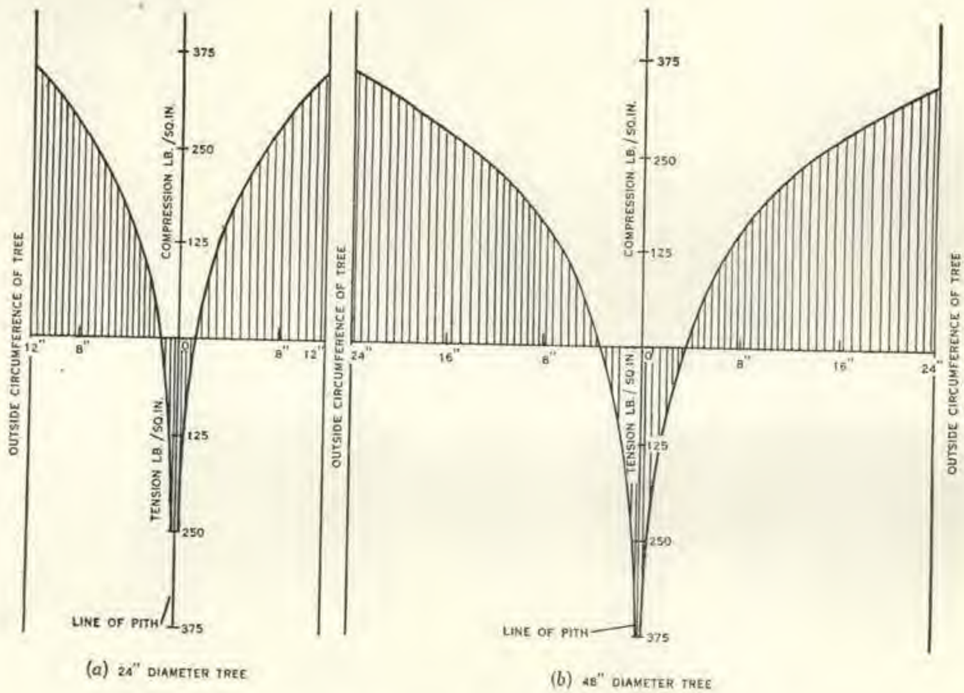

Fig. 2.—Theoretical evaluation of primary ring growth stress in trees.

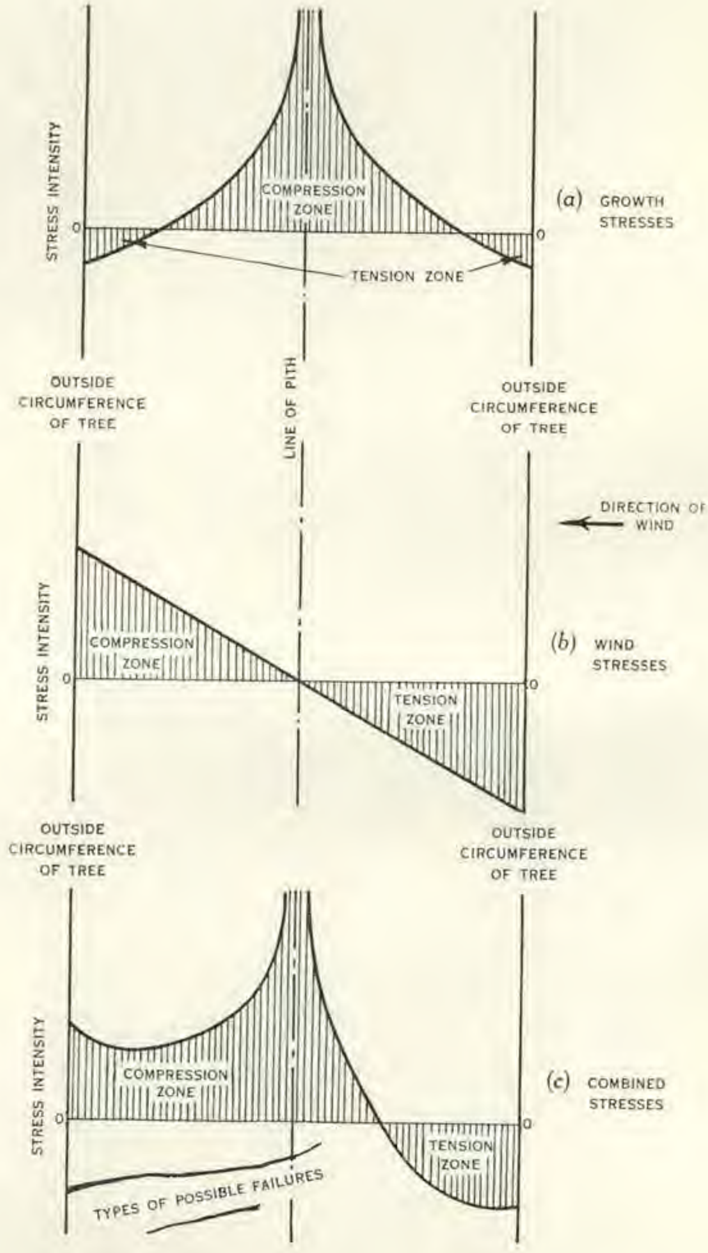

Fig. 3.—Theoretical distribution of longitudinal stress in trees subject to severe wind stresses.

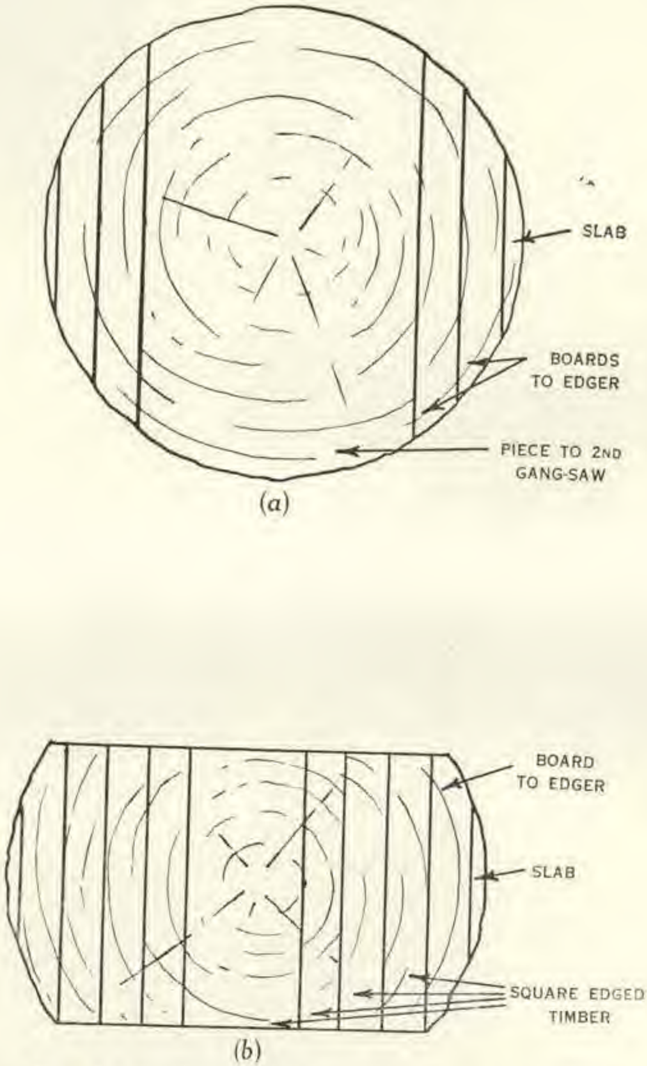

Fig. 4.—Cutting plan for tandem gang-saw mill.
(a) First gang-saw cutting arrangement.
(b) Second gang-saw cutting arrangement.

PROCEEDINGS

FIFTH ANNUAL

FOREST PRODUCTS RESEARCH CONFERENCE

HELD AT

THE DIVISION OF FOREST PRODUCTS,

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION,

MELBOURNE

OCTOBER 9-13, 1950

VOLUME 2

DIVISION OF FOREST PRODUCTS
COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION
MELBOURNE

VOLUME II

NOTE: Volume I includes pre-prints of papers which were collected, assembled and circulated to the representatives some weeks before the conference. For convenience the papers were assembled in order of agenda item numbers. Volume II records the discussion and also includes additional technical material which was presented at the conference.

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VOLUME I

VOLUME II

THE FIFTH ANNUAL FOREST PRODUCTS RESEARCH CONFERENCE

The Conference was held at the Division of Forest Products, Commonwealth Scientific and Industrial Research Organization, Melbourne, October 9th - 13th inclusive, 1950.

REPRESENTATION

Commonwealth Forestry and Timber Bureau	Mr. H.R. Gray Mr. J.P. Hauser
Commonwealth Department of External Territories, New Guinea Administration, Department of Forestry	Mr. J.B. McAdam
Forestry Commission of N.S.W., Division of Wood Technology	Mr. E.B. Huddleston Mr. L.K. Bryant Mr. E.R. Fogl
Queensland Forestry Department	Mr. C.J.J. Watson Mr. K.V. Cokley Mr. G. Littler
Victorian Forestry Commission	Mr. C.J. Irvine
Tasmanian Forestry Commission	Mr. H. Payne Mr. T.G. Walduck
Woods and Forests Department of South Australia	Mr. J. Thomas
Forests Department of Western Australia	Mr. G.E. Brockway
Defence Research Laboratories, Department of Supply	Mr. J.M. West Mr. K.L. Bussell
Division of Forest Products, C.S.I.R.O.	Mr. S.A. Clarke and Officers
Division of Entomology, C.S.I.R.O.	Mr. F.J. Gay
Building Research Liaison Service of Department of Works and Housing	Mr. R.E. Banks Mr. W.P. Brown
Forestry School, University of Melbourne	Mr. J.H. Chinner
Division of Industrial Chemistry, C.S.I.R.O.	Mr. L.K. Dalton Dr. J.S. Fitzgerald
Division of Building Materials, C.S.I.R.O.	Mr. B. M. Holmes
Dairy Research Section, C.S.I.R.O.	Mr. A.J. Lawrence
Associated Timber Industries of Western Australia	Mr. F. Gregson

(Chairman: Mr. S. A. Clarke, Division of Forest Products, C.S.I.R.O.)

PROGRAMME AND TIME TABLE

Monday, 9th October

2.15 p.m. Assembly of delegates.

2.30 p.m. Official opening (Dr. I. Clunies Ross).

1. Impressions received on an overseas visit (G. W. Wright).

Summary of major activities during the past year by Division of Forest Products and State Services.

Recording of the conference.

2. Nomenclature.
3. Standard terms and definitions.
4. Building boards.

Tuesday, 10th October

9.30 a.m.

5. Railway sleepers.
6. Preservation investigations.
7. Termite investigations.

2.00 p.m.

9. Paints and lacquers.
8. Borer investigations.
10. Moisture content of timber.

Wednesday, 11th October

8.30 a.m.

Visit to the kraft pulp and paper mill of Australian Paper Manufacturers at Maryvale. (All day visit)

Thursday, 12th October

9.30 a.m.

11. Vapour drying.
12. Pre-driers.
13. Adhesives.

14. Composite-wood Corresponding Committee.

15. Plywood.

2.00 p.m.

Impressions received on overseas visit by W. E. Cohen.

16. Growth studies.

17. Saw-milling.

18. Building research.

5.40 p.m.

Bus leaves for University.

6.00 p.m. Official dinner at University Union.

Friday, 13th October

9.30 a.m.

19.A. Battery separators.

B. Utilization of Queensland building and cooperage timbers.

C. Box testing.

D. Survey of tanning materials.

E. Cork from the bark of the paper barked tea tree.

F. Volatile oil industry.

G. Utilization of sawdust.

H. Phyto chemical register.

J. Collection of material.

K. Use of State facilities for mechanical testing.

L. Education in wood technology.

M. Translations.

N. Publications.

OFFICIAL OPENING OF CONFERENCE

by

DR. I. CLUNIES ROSS, CHAIRMAN, C.S.I.R.O.

Dr. Clunies Ross was introduced by the Chairman, Mr. S. A. Clarke, Chief of the Division of Forest Products.

Dr. I. Clunies Ross: From an examination of your Agenda I am sure that you will have much profitable discussion. I am very pleased to see that you have a comprehensive representation of practically all Commonwealth and State forest products research authorities and all Forest Services including that of New Guinea. There will be as much pooling of knowledge as it is possible to get in the Australian Commonwealth.

I am not sure of the purpose of a Conference such as this. The Executive of C.S.I.R.O. find that it is becoming difficult to provide enough officers to attend the multiplicity of Conferences which are held these days. I feel that at the end of a Conference run in the right way it should be possible to define certain fields of agreement that have been reached. I hope that we might eventually see a report of this Conference which will do that in the form of an abridged version of the Proceedings. I look forward to hearing in due course what has transpired at the Conference.

Mr. Clarke said we do try to make our Conference something more than purely an exchange of information. We allocate fields of work. We are trying to form, in addition, a number of corresponding committees which will enable us to keep more closely in touch and to get more tangible results from our Conference. We can show tangible results in the fields of preservation, seasoning and contact work in connection with research to assist industry generally. This is our 5th Annual Conference and we are trying all the time to make them of greater value. A lot of time has in the past been spent in describing work which could be covered by reports issued previous to the Conference. This has been done this year in the form of pre-circulated papers.

The delegates are now invited to review their Departments' activities for the past year.

Mr. Huddleston, N.S.W. Forestry Commission, Division of Wood Technology, said that their general contact work had continued. An officer had been appointed to take charge of timber testing, and investigations had continued in the field of chemistry of forest products. Experimental work on the bonding of sawdust by the reaction of included tannins and formaldehyde has progressed and it has become evident that there were other agents contributing to the bonding action. The survey of tannin producing materials has continued; progress of an exploratory nature has been made in investigating essential oils. A notable development had been the production of a type of cork board from tea tree bark. The Division of Wood Technology provided assistance in the installation and operation of equipment for the preservative treatment of timber. It has developed methods of analysis for fluorides in timber (a project allocated to us two years ago). Good results had been obtained with weed killers designed to control mistletoe and lantana and weeds in seasoning yards. It was proposed to continue these investigations this year without any major additions.

The New South Wales vote for Forest Products investigation was reduced to £33,000, and it has been suggested in New South Wales that the Commonwealth should do more of the work actually being done by the State, and that other States without research or utilization staff may be receiving advantages in this respect. Reference was made to the New South Wales Division's efforts to obtain finance and it was suggested that the other States should be more active in this matter. It was suggested that the Division of Forest Products could assist with more problems if it were relieved of routine work.

Mr. Watson, Queensland Forestry Department, said that his Department had been concerned with finding substitutes for hoop pine from lesser known Queensland species. Pine cut has dropped from 150,000,000 s.ft. to 50,000,000 s.ft. and although previously looking for markets, they are now looking for the timbers to market. With the importation of timbers from New Zealand and Sweden, and ply logs from the islands, it had been necessary to assist industry in using these species. In the course of the year 1200 samples were identified.

More preservation plants are in the course of erection for the treatment of lyctus susceptible timbers for use in joinery, furniture and plywood. The passing of the Timber Users Protection Act and the advent of summer have involved more work on this subject.

The use of lyctus susceptible timbers in building frames had become a problem in Queensland. A publication covering 100 additional North Queensland species was being published to show their main uses in house building.

Mr. Payne, Tasmanian Forestry Commission, mentioned the need of his Commission to rely on the Division of Forest

Products for advice on technical matters, as they still lacked research staff. He expressed the opinion that the Annual Conference afforded good opportunity to discuss problems and assured Dr. Clunies Ross that the Forest Products Conferences were of special value to the States in which utilization staff was limited. He considered the technical discussions of greatest value.

Mr. Irvine, Victorian Forestry Commission, pointed out that his Commission also lacked staff for research work. They had, however, contributed towards the cost of the high pressure treatment cylinder being installed at the Division of Forest Products.

Mr. McAdam, New Guinea Department of Forestry, said that he lacked staff in New Guinea. Recently the position of Forest Engineer had been advertised, but no suitable application had been received. The training of a utilization officer from existing staff might have to be considered. He had benefited very much from the identifications provided by the Division of Forest Products. The New Guinea problem of utilization was very complex due to the numerous species and lack of local market. He hoped to develop paper making from mixed tropical species.

Mr. Thomas, South Australia, Woods and Forestry Department, said that utilization in South Australia was virtually restricted to Pinus radiata. His Department had no utilization branch and relied on the Division of Forest Products for assistance in these matters.

Mr. Gray, Commonwealth Forestry and Timber Bureau, referred to the value of the Conference to the Forestry and Timber Bureau, to foresters and to organizations dealing with timber.

Mr. Gregson, Western Australia, Timber Industries was introduced to the conference by Mr. Clarke who said that although there was no precedent, he felt, as a result of his earlier visit to Western Australia, that Mr. Gregson's presence at the Conference may assist timber utilization in Western Australia. The Conference approved of this decision.

Mr. Gregson said that he was surprised to find lack of staff on utilization problems in other States. Industry in the West was very concerned at lack of investigational work in that State and the desirability for discussion of utilization extension was very apparent.

1. REPORT ON OVERSEAS VISITS

Mr. G. W. Wright of Division of Forest Products gave a brief outline of his visit to several European countries and America during the period July to December, 1949. He attended the first F.A.O. conference in Mechanical Wood Technology held at Geneva during late August and early September, 1949. Other subjects of particular interest during his overseas visit included the production of granular waste-synthetic resin boards and products, and Scandinavian sawmilling methods. Details of these are reported under the appropriate subject headings.

Dr. W. E. Cohen of Division of Forest Products gave a brief outline of his visit to Europe during the period June to November, 1949. He attended the 3rd World Forestry Conference held at Helsinki, Finland; the 1st International Congress of Biochemistry at Cambridge, England; the meeting of the F.A.O. Technical Committee on Wood Chemistry at Brussels, Belgium; the 15th meeting of the International Union of Pure and Applied Chemistry at

Amsterdam and the Macro-molecule Colloqium at Amsterdam. Of particular interest was his mention of the comparatively large amount of money spent on forest products pulp and paper research by both the Government and industries in the Scandinavian countries.

2. NOMENCLATURE

A. AUSTRALIAN TIMBERS

Mr. Turnbull: The revision of Australian Standard No. 0.2 has been under consideration for a long time. The Division of Forest Products has proposed that some inconsistencies in naming should be corrected, and to that end it has been necessary to ascertain whether it would be possible for each genus to be given a distinctive trade name. Some progress has been made in the preparation of a list of genera; also progress has been made in listing the species within each genus that might be embraced by the standard nomenclature. The extent of conflict between genera has been examined, and a tentatively preferred common name indicated for a considerable number of genera; the species within each have been listed, and in this connection we have worked through Acacia, Brachychiton, Callitris, Cryptcarya, Cupana, Daphynandra, Elaeocrapus, Endiandra, Eugenia, Dysoxylum, Evodia, Flindersia, Sideroxylon, Tristania.

We do not propose to upset common names of long standing that have become firmly established. Where a timber is not yet admitted to the standard list, we propose to recommend names in accordance with certain principles. Some changes in the current standard names may be suggested, provided that -

(a) little progress has been made in the adoption of the current standard name;

(b) a change would not seriously upset marketing; or

(c) the change would reduce conflict.

The standardizing of nomenclature is really a job for the Sectional Committees on Wood Technology of the S.A.A. However, before these committees become active on the subject, it would be preferable for the Division of Forest Products and the forestry authorities to be generally agreed on the scope of the list, and to have settled as many differences as possible relating to individual timbers. It is proposed that the Division of Forest Products undertake the preparatory work in consultation with the forestry services.

The F.A.O. Regional Office at Bangkok is working on nomenclature of timbers of south eastern Asia. In their first draft they have included many Australian timbers. They raised objections to the use of names such as Ash, Basswood, Box, Maple, Oak, Walnut etc., for timbers that do not belong to the genera bearing these names in the Northern Hemisphere. They proposed grouping as far as possible. We have sent by our representative, Mr. C. S. Elliot, our comments on the F.A.O. draft, and pointed out that in very many instances the timbers for which they request alternative names are never likely to be represented in export trade, and that their naming is an Australian domestic problem. We have also asked that the basis for grouping should be carefully examined so that the identity of woods differing in some important characteristic will be preserved.

Mr. Huddleston recalled that at last conference it had been agreed that this work should be continued until the draft was completed. He thought that there was no hurry for this compared with the standard for imported timbers.

He moved that work should continue in the Division of Forest Products.

Mr. Watson seconded this proposal.

In respect to discussion on Australian Nomenclature difficulties, he considered that the common names in the State having the bulk of the supply of the species should be favoured. He believed generally that names already standardized should be left alone, if possible, because both Queensland and New South Wales had used this standard in their Timber Treatment Acts.

Mr. McAdam considered as a general principle the best name is the species name. Choosing a group name would be a weakness as properties and uses of specific species are well known.

Mr. Turnbull emphasised that the intention was to retain specific distinguishing names under the group names.

Mr. McAdam commented that generic names are often better.

Mr. Turnbull agreed that this might be the case where the name was easy as in Pinus radiata.

Mr. Payne said that he agreed with Mr. McAdam that recognition of properties was important. He appreciated Mr. Turnbull's task in getting at accepted names and felt that if it were forced it might defeat its purpose. He said a species became known through its specific uses; this method of nomenclature was the best, e.g. Wandoo.

Mr. Clarke pointed out that the alternative to Mr. Turnbull's proposals would be a tremendous number of unrelated names.

Mr. Turnbull said that we were using common names wherever possible, but showing some preference for generic names.

Mr. Brockway Species E. calophylla was known as red gum in Western Australia. To avoid confusion with eastern States, they had selected the native name of 'marri', and this was well associated with specific uses.

Mr. Clarke pointed out that there are a number of species with several names, each of which applies to other species in other districts. In such case, a new name is desirable, preferably one with a generic significance.

RESOLUTION: That Mr. Turnbull continue the review of nomenclature of Australian timbers as he proposed, and that established names were not to be disregarded unless absolutely essential. - Carried.

B. TIMBER IMPORTED INTO AUSTRALIA

Mr. Gray pointed out that nomenclature was becoming a more urgent matter because of the likelihood of new timbers being imported from non dollar sources in Europe, Africa and the Pacific. He said that the matter was being discussed at Bangkok and discussion now might be premature. He suggested further, that in preparation for future action, a sub-committee be appointed to keep the matter under review.

Mr. Huddleston agreed with the forming of a sub-committee, but said that in view of the lyctus susceptibility of some of these imported species, and the fact that the Timber Marketing Act in New South Wales was about to be amended, some action should be taken at once. Subsequent amendments to the Act would be confusing.

Mr. Clarke asked if the proposed list already circulated would meet New South Wales requirements.

Mr. Huddleston pointed out that this list was tentative and asked if it could be made an Australian standard immediately.

Mr. Watson said that Queensland wanted it as an Australian standard. He considered that it could then be added to the Timber Users Protection Act as now gazetted.

Mr. Gray suggested that the matter should be deferred until Mr. C. S. Elliot's return from Bangkok, as the decisions of the Conference there would be likely to affect our own.

Mr. Clarke asked "Do you agree with Mr. Gray?"

Mr. Huddleston asked why the tentative list could not be referred to the Standards Association.

Mr. Turnbull remarked that Mr. Elliot would be back in 10 days.

Dr. Dadswell asked if we would be any further advanced after the Conference, as there are some 20 dipterocarpeae and 3 shoreas, and he did not see how the lyctus susceptible species could be separated.

Mr. Huddleston and Mr. Watson said that if these timbers were sold as a group, and if any were susceptible, the group would require treatment.

Mr. Clarke proposed that we should proceed with Standards Association and incorporate Mr. Elliot's suggestions when available.

Mr. McAdam asked if he could have a copy of Mr. Elliot's list subsequent to the visit.

Dr. Dadswell said that it contained no New Guinea names.

RESOLUTION: That action on the nomenclature of timbers imported into Australia and reference of the tentative list to the Standards should be based on discussions between Mr. Gray and Mr. Huddleston, and these would take into account any matters arising from Mr. C. S. Elliot's representations at the Bangkok Conference.

3. STANDARD TERMS AND DEFINITIONS USED IN FOREST PRODUCTS RESEARCH

Mr. Turnbull: Following the circulation of lists of terms to each State, comments have been reviewed and a list of terms to be covered by the standard has been prepared. The definitions have been written, submitted to the Staff of Division of Forest Products, and to each State. Comments have been collated and the revised draft is now with the Publications Officer of Division of Forest Products awaiting editing. It is hoped that the draft will be finalized and typed within a few weeks.

Mr. Clarke reminded the Conference that this was part of an Empire activity, and said that the definitions would be forwarded to Canada for comment.

4. BUILDING BOARDS

A. INDUSTRY REPORT

Mr. Gray stated that during the survey made by the Commonwealth Forestry and Timber Bureau, types of building board which were outside the Bureau's field of enquiry were encountered. He suggested therefore that the subject of the Bureau's survey be called "fibre boards".

Mr. Hauser: It was resolved at the last Conference that there was a need for a market survey dealing with building boards, and it was requested that the Forestry and Timber Bureau carry out this survey. Accordingly, this summarized interim report is submitted of information obtained in the survey to date.

The aim of the survey is to obtain information of future market prospects of the various types of fibreboards, to find which sections of the market use the boards on the grounds of technical advantage, and which sections use them because of factors of price and availability, to obtain quantitative estimates of current and future demand, and to ascertain any trends of substitution or replacement of other materials by fibreboards or vice versa.

At the present stage the survey has been completed for Victoria and steps are being taken to extend it to the other States.

Victoria

The 1949 consumption of hardboard in Victoria was 19 million square feet (3/16 in. basis), of which the various fields of consumption were:-

1. The building industry, which consumed 10,730,000 square feet, or 58 per cent. of the total quantity available. This 58 per cent. may be subdivided into 21 per cent. in dwellings and 37 per cent. in other building work. These uses can be further dissected into external walls, internal linings and joinery. In addition, small quantities of concrete form board are being used. Approximately half of the Australian hardboard used in building is tempered material which is used externally and for kitchen and bathroom dadoes.
2. The furniture industry, which consumed 16 per cent. of the quantities available, but did not use tempered board to any great extent. It has been found that

hardboard is rapidly gaining a solid market in the furniture industry for two main reasons -

(a) Supplies are low of suitable plywood of reasonable price.

(b) Hardboard has been found very suitable for mass production techniques of furniture manufacture.

3. Joinery, apart from that carried out by builders, consumed 10 per cent. of the quantities available and, adding this portion to builders' joinery, it is estimated that joinery actually consumed 25 per cent. of the total quantities available. The type of board required for joinery depends to a certain extent upon the type of work being done, but although the demand for the tempered stronger material is good, approximately 66 per cent. of the demand in this industry does not require great strength and the thinner boards would be suitable.

4. Renovation and general interior work represents a relatively small consumption (about 4 per cent.) of hardboard, and the type of board required varies with the job being undertaken.

5. Shop and office fitting is another small consuming section, the consumption being approximately 5 per cent. of total quantities available. The type of usage is very similar to that of joinery, except that there is more partition and lining work carried out.

6. Other miscellaneous uses, which are relatively small, are advertising, where hardboard is being found suitable for small signs and advertising models, motor body building, refrigeration, ship fitting and caravan construction. These uses together comprise approximately 7 per cent. of total usage.

In 1949 the consumption of insulating board in

Victoria was almost 7 million square feet (1/2 in. basis), which was divided into the various fields of consumption in the following way :-

1. The building industry consumed almost 5 million square feet of insulating board, or 72 per cent. of the total quantity available, of which 24 per cent. went into dwellings, mostly ceiling lining, and 48 per cent. into other building work.
2. Renovation - 9 per cent.
3. Joinery - 7 per cent.
4. Shop and office fitting - 6 per cent.
5. Miscellaneous, including refrigeration - 6 per cent.

The current demand for insulating board is little higher than current consumption, and the fact that insulating boards were brought off the list of duty free imports in June of this year significantly illustrates this point.

Bases of use: The different uses to which hardboard and insulating board are put depend mainly on any technical advantages over other materials, and price and availability factors affecting these materials.

1. Uses depending on technical advantages -

Hardboard	Insulating Board
Kitchen and bathroom dadoes	Partitions requiring insulation
Partitions	Sleepout linings
Enamelled joinery	
Bar and counter tops	
Bus and van linings	
Indoor signs	
Advertising models	

2. Uses depending on factors of price and availability -

Hardboard	Insulating Board
Wall and ceiling linings	Ceiling linings
Cupboards, counter sides, benches etc.	Wall and ceiling insulations
Furniture	Insulation in refrigeration.
External sheeting	
Outdoor signs	
Caravan construction	
Concrete forming.	

The above does not cover the complete range of use of fibreboards, but includes the main uses and distinguishes the reasons for usage. There are many usages within the two classes to which fibreboard or other materials are eminently suitable under special circumstances, such as the use of hardboard in temporary prefabricated huts, with a lining of insulating board.

Australia

It is well known that the present consumption of fibreboards in Australia is well under the current demand and, although it is stated that for certain types of usage double the quantity available could be absorbed, the overall shortage in 1949 has been assessed at 20 - 25 per cent. of the demand in that year. It is estimated that larger quantities will be available in 1950, but meantime demand has increased and it is considered that the market will be under supplied to the extent of 30 per cent. during 1950.

The table below shows the quantities available of hardboard and insulating board sub-divided between local production and imports for the year 1949, and an estimate for 1950:

	Quantity Available		
	Local Production	Imports	Total
	(Square feet)		
1949			
Hardboard (3/16 in. basis)	58,700,000	11,700,000	70,400,000
Insulating board (1/2 in. basis)	19,600,000	6,700,000	26,300,000
1950			
Hardboard (3/16 in. basis)	75,000,000	17,000,000	92,000,000
Insulating board (1/2 in. basis)	30,000,000	9,000,000	39,000,000

Concealed factors affecting the current demand are price and quality, for a certain section requires a board of higher quality than imported boards, while some sections prefer to use other materials than to pay the high price for the thinner less suitable imported boards. These remarks are generally applicable to hardboard only.

As the greatest single avenue of use of building fibreboards is in the building industry and detailed information is available of building programmes up to 1955, that year has been taken for the most forward demand estimates. In arriving at these estimates, cognisance has been taken of the probable importation of prefabricated houses. In other consuming industries the probable increases in population, together with estimates made of future employment, are the main factors on which the statements of future demand are based.

The demand in Victoria for hardboard by 1955 is estimated at 50 million square feet, and insulating board at 17 million square feet. The other main consuming States are New South Wales and Queensland. New South Wales demand for hardboard by 1955 is estimated at 65 million square feet compared with the 1949 consumption of 31 million square feet, and insulating board 19 million square feet compared with the 1949 consumption of 10 million square feet. In Queensland demand by 1955 is estimated at 25 million square feet and 10 million square feet for hardboard and insulating board respectively, while 1949 consumption was 7 million square feet and 3½ million square feet respectively.

Total future demand of hardboard in Australia is estimated at between 150 and 160 million square feet by 1955, and for insulating board approximately 50 million square feet.

A dissection of the demand into types of hardboard to be required by 1955 has been attempted and a tentative figure arrived at is that 50 per cent. to 60 per cent. of total production should be tempered and approximately 40 per cent. of total production should be of 1/8 in.

thickness. In addition, from opinions gathered throughout the consuming industries, there will be a probable demand for at least 10 million square feet of double sided 1/8 in. hardboard. In the case of insulating board it is considered that 50 per cent. of production could be of 5/16 in. thickness, although this is dependent upon the qualities of the boards being produced.

The term "building fibreboard" has been adopted in place of "building board" for the following reasons:-

1. The term "Building Board Survey" could be taken to apply to the usage of these materials in the building industry only, while approximately 35 per cent. of their usage is in other industries. For obvious reasons it was considered expedient to include all uses of fibreboards (other than container fibreboard) in one survey.
2. The term "building board" could embrace such materials as plaster sheeting and gypsum wallboard - materials which are not covered by this survey.

Mr. Clarke complimented the Forestry and Timber Bureau on the detailed nature of their statement. He suggested that the estimated consumption figures for 1955 might be excessive.

Mr. Huddleston pointed out that the steadily increasing population would absorb much of anticipated increase.

Mr. Hauser said that an increase in consumption would result from more carpenters becoming available through emigration. Builders favour use of fibre boards and would use them more if labour were available.

Mr. Bryant said that he understood that the British Artificial Resin Company's process was to be used in the production of boards at 5 plants in Western Australia within the next 5 years. Waste from tannin extraction would be used. He asked if Mr. Clarke had any further knowledge of this project.

Mr. Clarke: No.

Mr. Watson said that the Housing Commission had used fibre boards in Queensland but because the high humidity had caused buckling they had not been regarded as satisfactory. However, it appeared that these boards could be used for a type of knock down case in this State.

Mr. Clarke referred to the estimate for 1955, given by Mr. Hauser, in which it was stated that 40 per cent. of requirements would be required in 1/8 in. thickness for the furniture trade, and pointed out that it should be 3/16 in. as required by the Australian standard.

Mr. Huddleston said that regulations could be varied, and that they had been in this case.

Mr. Grey stressed that the information given was only a summary, and that a more complete report was being prepared on the utilization of building boards in Victoria.

Mr. Huddleston said that he was glad that the survey was to be extended to the other States.

Mr. Cokley enquired as to how closely the work of the Bureau was associated with similar work by the Division of Industrial Development.

Mr. Hauser replied that it was divided on the basis of fibre and other types of building board.

B. EXPERIMENTS BY THE DIVISION OF WOOD TECHNOLOGY, NEW SOUTH WALES

Note: A technical paper on this subject - titled "Building Boards from Forest Waste" and numbered 4B - has been printed in Vol.1. The discussion follows -

Mr. Bryant said that due to the undesirable publicity which had been given to the tannin formaldehyde process, the idea had spread in New South Wales that this process could be applied to a wide variety of species. This was not so. The most favourable species were radiata pine and white cypress pine. A high percentage of bark had to be added to the sawdust of each to produce a satisfactory board. He felt that the work would be a positive contribution to the utilization of these two species. The first progress report was in course of preparation.

Mr. Clarke said he was not surprised to find that better results had been obtained with the use of ground bark as the tannin would then be more freely available. The tannin in the sawdust was enclosed within the cell lumen and could not readily react to assist in bonding particles of sawdust. He said that attempts to bond jarrah had been tried years ago, and that adhesion had been improved by grinding the sawdust and using high pressures.

Mr. Bryant said that he was unfamiliar with Western Australia species. He had observed that in New South Wales, North Coast spotted gum seemed to contain more tannin than South Coast material. Tannin was a biological material which varies within the species. Fifteen tannin analyses had been made on samples of radiata bark, and in all cases tannin content was over 15 per cent. Before the process could be applied to a species in a particular region, a tannin survey should be carried out.

Mr. Clarke said he thought that radiata bark available at the company "Cellulose Australia" contained 12 per cent. tannin.

Mr. Bryant said that the New South Wales Division had received samples from this company's hydraulic barker. These had ranged from 12-24 per cent. tannin content.

Mr. Turnbull asked if modulus of rupture in excess of 2000-2500 lb./sq.in. had been obtained, and pointed out that commercial hardboards of Australian manufacture had modulus of rupture of 6000 lb./sq.in. and imported hardboards 4000 lb./sq.in.

Mr. Bryant said that modulus of rupture of 4000 lb./sq.in. had been obtained by increasing the percentage of bark, but that the board had become more brittle. He thought Masonite was too strong and that opportunities existed for using hardboards with lower strength properties.

Mr. Clarke said that material with modulus of rupture of 2000 lb./sq.in. seemed more suitable for core stock, and that Swedish boards of 4000-4500 lb./sq.in. were regarded as inferior to Masonite.

Mr. Bryant expressed the opinion that no higher values of modulus of rupture would be obtained for these species.

Mr. Kloot said that he had read Mr. Bryant's report and asked to be excused for extracting the phrase "too weak" and asking the question rhetorically "too weak for what?". The modulus of rupture quoted for Masonite was 6000 lb./sq.in., actually this was at 1½ per cent. moisture content (m.c.); it was nearer 5300 lb./sq.in. at normal equilibrium moisture content (e.m.c.). Comparisons between boards should only be made on a basis of equal thickness. If the D.W.T. made its board 3/8 in. thick and compared it with 3/16 in. thick board, load capacity, stiffness and puncture would be greater and it would be more serviceable than Masonite. Two thicknesses of Cane-ite are equivalent to 3/16 in. Masonite and have twice the puncture resistance of the hardboard. Care should be exercised in comparing mechanical properties independent of size. Thickness must be taken into account. It is believed that prejudice against imported building board existed among builders. This could arise through the imported material being 1/8 in. thick instead of 3/16 in.

An important point was the suitability of fibre boards to do specific jobs. This question had recently arisen in discussion with the C.E.B.S. A tentative list of 20 characteristics of desirable features in fibre boards had been prepared. They had only considered the question of boards in buildings; however, the list could be modified to include joinery uses. A great variety of levels will exist for any property, and therefore it is rash to say that any board is too weak.

The problem of utilizing wood waste lies behind the making of these boards. If a board can be made economically, its uses will have to be explored with regard to its properties.

Research within the Division on fibre board has indicated the desirability of a wide knowledge of the mechanical properties of as many fibre boards as possible. This research is continuing with two objectives:

(1) To obtain design data for engineers.
(2) To obtain a background of knowledge of properties so that if a body such as the Standards Association decides to draw up standards, we shall be in a position to assist.

Mr. Wright asked if 1-2 per cent. of a urea resin had been added to the tannin formaldehyde boards in an attempt to improve strength properties.

Mr. Bryant said that urea had been tried up to 2 per cent. Its presence did not seem beneficial and tests were discontinued.

Mr. Clarke enquired if the tannin formaldehyde reaction was the best means of producing a board of this modulus of rupture (2000 lb./sq.in.). Could it be done by defiberizing the sawdust?

Mr. Turnbull replied that fibre boards from defiberized sawdust could be made having this modulus of rupture, but he was working to obtain greater values.

Mr. Clarke said that he thought the relative costs of the two processes should be assessed.

C. EXPERIMENTAL WORK WITHIN THE DIVISION

(i) Pulp Building Boards

Mr. Turnbull: Two sets of plates were received with the attrition mill - a coarse lug type (A) and a fine grooved type (B). Plates (A) will break up all sizes of chip and produce from raw chips a broken match stick type of product, and from steamed chips a stringy product. The match-like material has no binding characteristics, but the stringy material can be made into boards of medium strength and coarse appearance.

The fine plates (B) become quickly plugged, if fed with chips in raw or treated condition. The pattern is now regarded as unsuitable for use on material direct from commercial types of chippers. Their use is limited to refining the output of the coarse plates.

Because of the loss of fibre length in the coarse grinding of raw chips, steaming has been considered desirable prior to coarse grinding, and most of our runs have followed the sequence (1) steaming (2) coarse grinding (3) fine grinding. Fractionating after coarse grinding has been attempted, and the coarse fraction and fine fraction made into boards separately, and we have also re-run the coarse fraction through the fine plates. The lack of screens of suitable capacity and openings has limited this work, and the conditions in the engineering trade are such that a local order for screens placed 18 months ago is still not supplied. Instead of screening, we have preferred multiple running through fine plates, and have set these as close as possible to defiberize to a commercial degree. A range of pulps was prepared and sent to New Zealand and tests there confirmed the opinion that our equipment was not pulping steamed chips as finely as commercial double disc attrition mills were pulping raw chips.

The preparation of other patterns of plate has been considered. We suggested a combination of lugs in the centre and grooves near the periphery, but pattern makers were reluctant to proceed. Investigators in U.S.A. advised that a pattern with a spiral arrangement of grooves seldom plugged and gave good results. Their pattern has been magnified and segmented to suit our mill, and castings were ordered nine months ago. Meanwhile the makers recommended a pattern with radially arranged grooves. Trials of these have been undertaken with raw and steamed chips. At an early stage in one pass they effectively reduced steamed chips to a grade of pulp resembling that previously obtained by the double operation of coarse followed by fine grinding. Later the plates began to clog with steamed chips. Suspecting that uneven clearance might be responsible, we arranged for re-machining of the plates to an accuracy of .001 in., and for the moving parts of the mill to be balanced and re-aligned. After reassembly, the setting was improved but clearances vary more than .005 in., and the clogging tendency persists. We have worked back through the stages of feeding (1) raw, (2) boiled, (3) lightly steamed and (4) severely steamed chips in an attempt to find the critical condition causing blockage. Interesting results have been obtained by feeding pre-steamed chips and admitting steam without flushing water to the mill. A pre-treatment of steaming at 167°C. for 15 minutes has enabled a satisfactory pulp to be produced with a single pass through the radially grooved plates.

It has not yet been possible to set the mill for running at medium or fast rates of feed without trouble, and it is difficult to reproduce a particular grade of fibre.

A beater is desirable to attain uniformity of pulp by secondary treatment. A ball mill has been tried, but it produced poor draining characteristics in the pulp and reduced length of fibre without increasing strength. Attempts to convert the ball mill to a rod mill were unsuccessful because of the unsuitable relation between length and diameter of the container. A paddle type beater in which chips can be held under steam pressure was brought into operation, but before enough results could be produced for analysis it was deemed unsafe.

A Somerville screen recently arrived, and with this we hope to develop the technique of evaluating pulps immediately after grinding.

By hot pressing at temperatures between 300 and 350°F., and applying pressures between 300 and 350 lb./sq.in., for 20 minutes we converted the multiple run pulp into boards with qualities generally similar to commercial hardboards. The pressure should be applied slowly to allow escape of steam.

We have attempted to reduce the pressing period. When full pressure has been applied quickly, a plane of weakness commonly develops about mid-depth. Increase of both temperature and pressure have been considered, but as our laboratory press cannot be loaded above 350 lb./sq.in., suitable platens must be set up in another press before work at the higher pressures can proceed. Increase of temperature introduces a tendency to water burn. The possibility of eliminating this fault by breathing during the pressing cycle is under investigation. The technique consists of releasing pressure one or more times while approaching maximum conditions so as to allow escape of steam. The effect of varying the pressing period is to increase strength with time up to 15 minutes, but an extension to 30 minutes gives no corresponding increase in strength. The optimum conditions of pressing to ensure full consolidation of the boards without water-burn in minimum time have yet to be found. Effective control is difficult as the board springs back if the release is too early, and if the steam is trapped, it may cause a plane of weakness near the centre, or a water burn at the surface.

Briefly then, our findings at present are -

Chips pre-steamed at 167°C. will ultimately give boards of good mechanical strength.

Chips so treated can be defiberized in one pass through radially grooved plates in the attrition mill.

Boards pressed for not less than 15 minutes at 300 lb./sq.in. at about 350°F. will give satisfactory strength.

Temperatures higher than 350°F. have not improved strength or overcome some structural defects.

Further work on pressing conditions is necessary to reduce pressing time and overcome defects.

There was no discussion.

(ii) Sawdust - Resin Products

Mr. Gottstein: During the year laboratory work on this project was continued within the limits of staff availability. At the request of the U.S.A. Forest Products Research Society, Portland, a paper reporting work to date was prepared for presentation at the 1950 meeting. This paper - titled "Some Studies of Synthetic Resin Combinations for Hardboard Manufacture" - covers laboratory work on small samples and gives test results showing effects of a number of factors on board properties.

The analysis of the results of the laboratory work and an examination of overseas and local conditions has made it apparent that further experimental work is essential. With this in view, the design of a laboratory mixer and of pressing forms is being undertaken. In further work it is proposed to use resin syrup and powders and an endeavour will be made to produce low density boards at low resin concentrations. It is proposed also to make a study of the effect of the physical shape of the particles used on end properties of the board and at the same time obtain data which will enable reasonably accurate estimates of production costs.

A firm of paper manufacturers which has been experiencing considerable difficulty with wooden paper roll plugs due to breakage losses and other factors, has asked for our assistance. The problem is regarded as of considerable importance as some 100,000 plugs are required annually. A mould design was prepared for making blanks with sawdust resin mixes. This mould, with some modification, has been used to produce plugs over a range of densities, setting times and moisture contents. Mould modification was necessitated by the very poor flow characteristics of the sawdust-resin mix. Difficulties were finally overcome by the use of a double ram technique, i.e., using a ram at each end of the cylinder instead of a single ram as in the initial design. A number of plugs has been given commercial testing and favourable reports have been received.

A careful study of the rate of temperature rise during pressing has been made by a centrally placed thermocouple. This shows a rather remarkable effect of moisture content in the plugs, which are $2\frac{1}{2}$ in. long by $2\frac{1}{8}$ in. final diameter. Sawdust at $2\frac{1}{2}$ per cent. moisture content rises to mould temperature in 5 minutes, at 10 per cent. moisture content in 50 minutes and at 20 per cent. moisture content in 80 minutes. Thus close moisture content control is necessary. The work has been of sufficient promise to justify preparation of a mould suitable for larger paper plugs.

Preliminary work also has been undertaken with the production of small boards using Tomlinson carbon dioxide precipitated lignin. The use of lignin alone appeared to be completely ineffective, but additions of small amounts of paraformaldehyde and ammonium chloride are being investigated. An interesting result obtained here was a 40°F. rise above platen temperature at a centrally placed thermocouple. Presumably this was due to exothermic reactions.

(iii) Sawdust-Blood Protein Boards

Mr. Hebblethwaite: Investigations into bonding sawdust with blood albumen to form a building board have been in progress for nearly one year. Examination and testing of the first sample boards showed that a material of good puncture resistance could be made at low pressures and temperatures, and with a short pressing cycle. These results, together with the low cost of fertilizer blood, were factors sufficiently promising to warrant more detailed investigation. A working plan was designed to study the effect of blood content, sawdust grade, pressure and temperature on puncture resistance and hardness. Laboratory work has been carried out according to the working plan and from analysis of the results obtained we feel that we have gained a satisfactory knowledge of the conditions for formation of sawdust-blood albumen boards.

Admixture of the blood and sawdust has not been a problem-experimental mixes have been made with a standard pattern glue mixer without tending to overload the machine. Present indications are that the mix could be formed into boards on existing types of commercial plywood presses without extensive modification to the platens. A slight tendency towards buckling has been observed, but recent small scale tests have indicated how this may be overcome and further tests on a large scale are being undertaken.

The board has no objectionable odour after pressing and samples stored in the laboratory during the last 10 months have shown no visible signs of deterioration. Although it may not be possible to make the board as stable as boards formed from sawdust and synthetic resins, it is believed that it will be serviceable under conditions in which laminates bound with hot press or cold setting casein adhesives are used. Hexamine is added to the blood albumen and during hot pressing this breaks down and liberates formalin, which combines with the protein to bring about the well known hardening process. Consideration of the properties and likely cost of manufacture of this material have led to the opinion that it should not be classed as a hardboard, but should be employed in the core stock field.

Recent experimental work has been directed towards methods of introducing the material into the press, the technique of pressing, and the production of veneer faced boards. Indications are that the damp blood sawdust mix can be manually introduced into the press without preliminary preparation by expensive equipment. More extensive service testing and examination of probable production costs are the next steps to be taken in the investigations. If it is produced commercially there is no doubt this board will have a field of application.

Mr. Cokley asked how blood board compared in physical properties with resin boards and commercial hardboards.

Mr. Hebblethwaite replied that for this class of board the puncture test is regarded as the best criterion. We have found that a sawdust blood board 5/8 in. thick has higher puncture resistance than 3/16 in. Masonite.

Mr. Bryant asked for the modulus of rupture figures.

Mr. Hebblethwaite replied that on the early boards the figure was between 3,000 and 4,000 lb./sq.in.

Mr. Bryant stated that a firm in Newcastle is using urea formaldehyde glues for bonding sawdust into commercial panels. He felt that they would be interested in a cheaper binder and he would be glad to have a sample and to pass on information regarding its production.

Mr. Wright said that a sample of the Newcastle product "Vencore" has been received by this Division. It has a sawdust base core and is faced on both sides with 3 ply. The price is reported to be 3/5d. per sq. ft. From the size of press we guess that the production is about 3 tons per day.

Mr. Huddleston added that the price of 3/5d. includes that of a decorative face veneer. The Education Department recently obtained a quote for finished panels and this board was about half the price of a completely finished panel with wooden core stock. The establishment cost of the Vencore factory is believed to have been high because of faulty engineering - a consultant experimented at the expense of the Company. The drying plant was not engineered early enough and the trials of different systems have been costly.

Mr. Wright suggested that the prices for these and the other products that have been discussed are not the only factors controlling use. There appears to be a place for various products in the market.

Mr. Bryant stated that the establishment cost of the Vencore factory is understood to have been about £50,000.

Mr. Huddleston added that about £20,000 of the above sum would probably not be required for the establishment of a second plant. He agreed with Mr. Kloot that careful consideration must be given to the application of pressed board. There should be fields of use for each type described.

Regarding the New South Wales tannin-formaldehyde boards, this work developed because bark is a major problem, particularly with cypress pine. The edgings of cypress carry a high percentage of bark which is burnt. If this can be turned to profitable use, it would pay to manufacture from bark alone. The board differs significantly from Masonite and C.S.R. hardboard, particularly in its reaction with water. The bulking of the bark board is only a fraction of that of Masonite and this suggests an exterior application. The furniture industry wants boards of low strength and good surface hardness. Notwithstanding the cost of resin, it may be advantageous to develop sawdust resin boards to cater for certain uses. The estimates of the Forestry and Timber Bureau indicate an unsatisfied demand and probably all types of board would find application.

Mr. Clarke stated that the discussions were useful guides in planning research. Mr. Hauser's information is of great value. Investigations should now be planned so that the lines of work carried out in one place do not overlap work carried out elsewhere. There would be an advantage in próceeding as quickly as possible to reach finality on the respective products now under examination by the different interests.

Mr. Huddleston said that probably at least one firm would be in commercial production of tannin formaldehyde boards within 12 months.

Mr. Payne stated that there is a need for greater information on the technical properties and the reliable fields of use for different types of board. The Tasmanian Department was recently asked by a building contractor whether C.S.R. hardboard would be suitable for joinery. In the absence of data to the contrary, it appeared suitable for such use, but when the flush fronts of cupboards had been manufactured with hardboard and coated with 4 coats of enamel, scuffing occurred at the corners. There were no grounds for anticipating this development. How can users be warned of unsuitable applications such as these?

Mr. Bryant said this difference in scuffing is evident between C.S.R. board and Masonite. Recently much inferior C.S.R. board was disposed of as seconds.

Mr. Huddleston added that it appeared that C.S.R. hardboard should be protected with edging strips.

Mr. Payne said that knowledge of such requirements should be available to those expected to advise on the use of such boards.

Mr. McAdam asked if blood supplies had been investigated.

Mr. Gordon replied that practically all supplies of blood are being bought by the fertilizer industry at relatively low cost. The offer of a more attractive price by board manufacturing interests would probably assure supplies to them. It is possible any resultant shortage in the fertilizer supply could be met with alternative materials.

(iv) Overseas Practice in the Production of Waste Wood-Synthetic Resin and Cement Boards and Products

Mr. Wright: Many analyses have been made to show that in some fields of wood processing 15 to 20 per cent. only of the sawmill log reaches the final end use. As this problem of waste wood utilization faces Australia just as much as other countries, and as considerable attention is now being given to it overseas, it was considered an examination of overseas work would prove valuable.

In this field I was able to investigate only wood waste-synthetic resin combinations in England, Switzerland and Sweden, and waste wood-Portland cement combinations in Switzerland.

The general picture obtained was that the more successful waste wood-resin plants were concentrating on the thicker products from about 1/2 in. to 1 in. thick. These had a good sale as core stock and panels, or for purposes for which thinner 1/4 in. boards were not satisfactory. It is believed that production cost of the thicker boards compared favourably with that for core stock made by the more orthodox methods from solid timber. Where plant production was confined to the thinner sizes, so that competition with typical fibre based or felted hard boards was, or had been, involved, the plants concerned did not seem to have made much headway. It is doubtful whether the production costs of the thinner boards using synthetic resin binders could compete with that of the felted hardboards of similar thickness.

It was also noticeable that, whereas the thicker board appeared to remain flat and dimensionally stable during handling and storage, the thinner boards tended to distort to an appreciable degree. This was particularly noticed in chip or shavings boards, in which the wood particles tended to orient parallel to the board face.

It is believed that a permanent field in industry has been, or can fairly readily be established for granular wood-bonded products. The particular forms of the granular wood and binder used - whether sawdust, shavings, veneer waste etc. on the one hand or synthetic resins, animal or protein glue, blood, tannins, etc. on the other hand - will of course, depend on local conditions.

Wood waste-synthetic resin combinations

(a) Switzerland

In Switzerland the outstanding wood waste-resin product examined was Novopan, which is produced in Zurich by Novopan A.G. It is an extremely attractive board or panel. It has a core of lightly processed wood chips (about half the thickness and half the length of a match stick) bonded with urea formaldehyde resin. The core is faced on both surfaces with a thin layer of hard pressed shavings of extreme thinness, and these also are bonded with synthetic resin. The plant produced about one ton per day. It was claimed that the cost of plant installation was about 2 million Swiss francs, which was then approximately equal to £150,000 sterling. On this basis the plant cost was about £6,500 sterling per ton of production per day. Novopan is sold in Switzerland at prices ranging from about 1/- a square foot for 8 mm. (5/16 in.) thick stock to about 1/9d. per square foot for 25 mm. (1 in.) thick stock.

At the time of my visit American engineers were examining the plant and production processes have now been engineered along American lines by the Wonderwood Corporation of California. Production in the U.S.A. under the name Wonderbord is being undertaken by the American Plywood Corporation who are building a plant to produce 50 million square feet per annum on the 3/8 in. thick basis.

(b) <u>England</u>

In England a number of factories, namely Jicwood Pty. Ltd., British Plimber, British Artificial Resin Co. Ltd., Metropolitan Plywood Company and Borst Bros., were found to be in commercial production of shavings or granular wood-resin boards. I inspected production methods of British Plimber and Jicwood Pty. Ltd., and discussed production methods with Moulded Components Pty. Ltd., who have now ceased production.

At British Plimber and Jicwood Pty. Ltd., the production rate approximated 20 tons per day (i.e. approx. 8,500 square feet per day in 8 ft.x 4 ft.x 3/4 in. thick boards) which was claimed to be about the minimum economic size for a commercial plant. It was found that the production of one ton required about 25 man-hours, including all operations from the receipt of incoming waste to the despatch of the finished article. Details of equipment used, mix proportions and production techniques were obtained and are available to any who are specifically interested.

From the figures quoted it was clear that the overall cost of equipment installed at these plants was not less than £60,000, so that with boiler plant, buildings etc., installation costs would be not less than £75,000 to £100,000.

This gives a plant installation cost of at least £4000-£5000 per ton of production per day. The retail price of Plimber ranged from about 1/- per square foot for 3/8 in. thick board to 1/5d. per square foot for 7/8 in. board. The urea resin cost was 7d. per lb. when in the form of a liquid with 72 per cent. of solids.

(c) Sweden

The Svenska Cellulose A.B. at Kramfors, has installed a waste wood resin board plant to produce, on a two shift basis, some 3½ million square feet per annum in the form of 10 ft.x 5 ft.x 3/4 in. board. It was claimed that this plant was operating on a semi-commercial scale. The Swedish authorities interviewed claimed a plant for continuous commercial operation should have a minimum capacity of from 4 million to 5 million square feet per annum (say, 25 tons per day).

The retail price of the plain unfaced board produced was quoted at about 1/2d. per square foot, the urea resin cost being about 1/1d. per lb. on a solid basis.

Waste wood-Portland cement products

The waste wood-Portland cement product examined was a building material called Durisol. It is manufactured at Dietikon near Zurich, Switzerland. Plants are also established in Belgium and Denmark. It is prepared from wood shavings with Portland cement used as the binder. The product is made in a number of forms including wall slabs and building blocks for exterior and internal wall construction, ceiling slabs, etc. Durisol A. G. is some 10 years old and has about 60 works employees and 20 staff including engineers, draftsmen and clerks. The plant appeared to be well established.

The wood shavings for the manufacture of this product are drawn from a radius of some 60 miles, the average cost landed at the factory being the equivalent of about 5/6d. per cubic yard. The wood waste-cement slabs are produced either as plain slabs, or with one face coated with a neat cement rendering and the other with a plaster rendering, or with both faces plaster coated. The longer edges of the rectangular slabs are tongued and grooved to give a high standard of jointing without any separate junctioning arrangement. The principle of allowing free movement for a product including such hygroscopic material as wood, is also allowed for in construction. No evidence of warping was seen and the building examined appeared to be entirely satisfactory. Houses constructed with cement rendered hollow bricks of this material were inspected. These looked very attractive.

The selling price of the unfaced slabs was given as ranging from about 2/10d. per square yard in 3 cm. (1 3/16 in.) thickness to about 5/6d. per square yard in the 6 cm. (2 3/8 in.) thickness. The faced slabs ready for erection as external walls cost about 15/- per square yard. It was claimed construction costs for buildings constructed of this material was about 7 per cent. less than that for brick buildings.

Details of manufacturing techniques and the mix proportions are available on enquiry.

5. RAILWAY SLEEPERS

A. AUSTRALIAN STANDARDS

Mr. Turnbull: Following a recommendation of last Year's conference, the Division of Forest Products prepared a working plan for grading studies to be undertaken on permanent way railway sleepers. This working plan (sub-project U.7-0) has been distributed to the States, and we hope that work may proceed shortly in New South Wales, Queensland, Victoria and Tasmania. It is understood that the recently issued standard for railway sleepers in Western Australia covers the situation there, and that South Australia is not yet ready to prepare a standard for radiata pine sleepers.

To simplify the analysis of data, we proposed that a punch card be used for field recording. We have found, however, that the punching and printing of such cards is expensive and that printing is likely to be unduly delayed. In addition, our Statistical Section advises that punched cards are satisfactory only when a few hundred are handled at one time. At the suggestion of the statisticians, we have looked into the possibilities of using cards of the 'Hollerith' type. We find that these can be readily adapted to the needs of the sleeper investigation, and that analysis is likely to be greatly simplified if they are used. Firms experienced in their use advise us to prepare a printed field sheet arranged in such a way as to simplify the transference of field data on to a coded Hollerith card by punching. Consequently we have drafted a new field sheet embracing the range of defects and other details formerly set out on our draft sleeper investigation field card. We propose to proceed with the printing of this field sheet as soon as the States can indicate the number they are likely to require. The number should be fixed by the maximum number of sleeper examinations. Our suggestion is that New South Wales, Victoria, Queensland and Tasmania should examine as many sleepers as possible (minimum 2,000). Western Australia is already provided for and South Australia has been omitted because P. radiata will be subject to a specification to be drafted later.

Mr. Huddleston said that the working plan, subject to modifications, is satisfactory but 2,000 sleepers per State are too few. In New South Wales and probably elsewhere, the standard of sleeper accepted varies with supply. When the supply is short, the inspector's interpretation of the specification is lenient, and the standard of sleepers drops off until the plate-layers reject them as unsatisfactory. This brings about a tightening of the specification. As we are taking inspectors' standards as as our own and their standards are variable, an adequate sample of sleepers over a number of periods would be needed. As mills produce 500 to 700 per week, it is suggested that a week's production be examined at three or four periods through the year to determine the variability taking place in the acceptance standard. These 2,000 sleepers would suffice for sampling the North Coast, but other districts have different timber species and to sample all districts it is estimated that 10,000 to 12,000 sheets would be required by New South Wales.

Mr. Watson indicated that the Queensland Railways and the Q.F.S. regard the problem as urgent. Species previously unacceptable have been creosoted to determine how they behave in service. Discussion with the railways should indicate the number of sheets required.

Mr. Irvine suggested that assistance in Victoria would be given to the field part of the investigation.

Mr. Clarke said that it appeared 20,000 to 25,000 sheets were necessary. He asked if our present punched card system could be used.

Mr. Turnbull replied that when numbers exceed 200, our card system is very cumbersome, whereas the Holerith system accommodates thousands.

Mr. Huddleston felt that instead of adopting inspectors' variable standards, a specification should be drafted defining size of defects, their position, and under what circumstances sleepers are acceptable.

Mr. Turnbull said it appears that 25,000 sheets would be satisfactory.

B. HIGH PRESSURE PRESERVATION TREATMENT, AND
C. FIELD TEST

Note: A technical paper on this subject - titled "Rail Sleeper Treatment and Specification" and numbered 5B - has been printed in Vol.1. The discussion follows -

Mr. Tack suggested that Items 5B and 5C be treated together. He reported that the Division's high pressure cylinder was tested in Sydney to a pressure of 1,500 lb./sq.in. and the method of door sealing proved quite successful.

A resume was given of the proposed sleeper treatments in the various States. It was stated that sleepers will be seasoned only enough to give 6 to 8 lb./cu. ft. uptake, and satisfactory end penetration. A request was made to Western Australia for a 1/2 gallon sample of the creosote oil and fuel oil mixture they intend using for surface treatment.

Mr. McAdam asked the cost of the high pressure cylinder and its installation.

Mr. Tack replied that the cylinder cost £1,200 and the total installation cost including cylinder and auxiliary equipment is not expected to exceed £2,500. On a commercial scale the larger cylinder needed, together with auxiliary equipment, may cost approximately £8,000. The relatively short treatment schedules prepared for the high pressure impregnation project tend to compensate for the small charge of timber and high cost of the equipment relative to similar equipment for low pressure treatment of softwoods.

Mr. Boyd pointed out that there are physical limits to the diameter of such a high pressure cylinder. These are the thickness of steel which could be fabricated and the welding, the X-ray and heat treatment facilities available. There is no theoretical limit to the length. The firm constructing the Division's cylinder have equipment for rolling and welding 2½ in. thick steel which would allow a cylinder of some 4 to 5 ft. diameter to be constructed to withstand a pressure of 1,000 lb./sq.in. This is possibly the largest unit which could be manufactured in Australia at present.

Mr. McAdam asked if in view of the shortage of durable timbers in New Guinea, other New Guinea timbers could be included in the test?

Mr. Tack replied that an estimate of the treatment requirements of New Guinea species could be made from a few small scale, low pressure tests.

Mr. Clarke asked whether the specification for sleepers to be used in the high pressure treatment investigation was satisfactory.

ASSENT

Mr. Gregson asked at what stage was it proposed to dock sleepers.

Mr. Tack said when moisture conditions are judged to be suitable for adequate end penetration of preservative.

Mr. Gregson stated that the proposed end-coating is a departure from railway practice. This may confuse interpretation of tests.

Mr. Tack replied that conditions are not exactly parallel in the field, but the object of end-coating is to control end drying and end splitting. To obviate docking, the use of soluble end coatings is being investigated. One possibility - "Preservax" - is soluble in creosote, and would not interfere with treatment. To reduce end splitting it is hoped to encourage end-coating as normal field practice.

Mr. Clarke asked whether, instead of docking three inches from the end of each sleeper, 1/2 in. would be sufficient?

Mr. Tack replied that probably it would not, as end checks would be longer than that.

Mr. Clarke suggested that as checks were present in sleepers cut for service in the ordinary way they should not be excluded from the test sleepers.

Mr. Da Costa asked if it would be possible to encourage docking of split ends in all sleepers in service?

Mr. Clarke said that it may be.

Mr. Dale stated that checking is a variable which is hard to control, especially as the source of supply of timber is uncertain. At each end 3 in. extra length has been provided for docking to allow for possible omission of end-coating in field.

Mr. Gottstein added that 3 in. was selected as being approximate maximum length of end checks.

Mr. Clarke asked what was to happen at the North Melbourne yard. Were all sleepers coated?

Mr. Tack said sleepers will be coated as soon as possible after cutting.

Mr. Irvine: All should be coated in the field where the damage otherwise occurs.

Mr. Clarke asked whether uncoated sleepers could be included in the test.

Mr. Wright suggested that the experiment had two aspects - the effect of moisture content on end penetration and, the effect of end checks on service life.

Mr. Tack said that a test of the effect of end splits on treatment would not provide a fair comparison between treatments unless all sleepers had the same degree of checking and other mechanical defects.

Mr. Clarke asked whether small cracks or end drying checks were disadvantageous?

Mr. Tack replied that trouble arose through subsequent increase in the size of checks.

Mr. Clarke suggested that checks did not matter in dealing with treated sleepers, as they would be filled with creosote.

Mr. Chinner asked whether preservation is possible through an end-coat.

Mr. Clarke replied that it would be possible through some end coats.

Mr. Dale added that satisfactory penetration through "Preservax" is probable as penetration is achieved through each coat on timber treated in open tanks.

Mr. Chinner stated that he was in agreement with Gregson that if the condition of sleepers at the beginning of the test is not likely to be met with in practice, the results are impractical.

Mr. Clarke added that this was so unless end-coating and docking become established as normal practices. As there are two ends to the sleepers, could the two treatments be compared in the same sleeper?

Mr. Tack replied that this would be unsatisfactory because one end would fail before the other, and that the life of the better treatment would be unknown.

Mr. Clarke suggested that the matter be left with Mr. Tack and that some sleepers should not be end-coated.

D. THE MECHANICAL FAILURE OF RAILWAY SLEEPERS

Mr. Dale: Since the last Conference we have worked on a number of aspects previously discussed. Others remain untouched. End-coatings have received special attention. A field inspection has shown that very considerable end splitting occurs in warm, dry weather and that end-coating at the stump would be necessary to prevent this. After eliminating a number of coatings by moisture barrier and exposure tests, we set up 2 stacks of sawn E. obliqua sleepers. One of these was open piled and the other block stacked to check the effectiveness of three promising coatings. Many otherwise good coatings were ruled out by considerations of ease of application, drying time, pot life, cost, etc.

To date the best of the three selected coatings is a wax type coat, applied hot. This is effective in stopping end checking,but does not prevent the spread of checks across the end from the other surfaces. While it is too early to be sure it seems probable that end coats by themselves will not be of much use. However in association with surface coatings they may have considerable value. Overseas findings bear this out.

The possibility of surface coatings reducing weathering breakdown is to be investigated by means of a large scale exposure test of various treatments to be set up at Highett. Overseas interest in this possibility is increasing, both for pressure treated and untreated ties. Promising results have been obtained from sleepers which have been pressure treated with coal-tar and which have formed tarry coatings on their surfaces. Sleepers treated with asphalt base coatings have also shown promise.

While pressure treatment with oily mixtures will undoubtedly reduce "weathering" the possibilities of greasy or bituminous base coatings, particularly in dry areas with low decay hazard, are worthy of more attention. It is hoped that one large scale field trial will be commenced shortly.

The exposure tests at Highett will cover mechanical treatments such as stitch bolts, dowels and also "roofing" or bevelling of the upper surface, and slotting the sleeper ends. The tests will be applied to quarter and back sawn sleepers and will possibly include hewn sleepers to compare weathering differences. It is interesting that some scout tests of quarter-sawn sleepers of E. obliqua show considerable surface corrugation resulting from collapse, but less checking than the backsawn surfaces. The effect of collapse in susceptible species may offset other possible advantages of the quartersawn sleeper.

Apart from three or four track inspections, little field work has been done, but in the next year it is hoped to make a survey of moisture contents of sleepers in the track in Victoria. Already information has been obtained on track temperatures, using thermocouples set in the track behind the Division. Last summer (not a hot one), rail and sleeper temperatures up to 150°F. were recorded. This corresponds to surface e.m.c's of 3 per cent. A continuous record of temperatures was obtained with a portable 6 point instrument. Moisture contents will be measured in winter and summer, using a resistance type meter on permanent electrodes set in a large number of sleepers throughout Victoria. The data obtained will give a better indication of the dimensional and moisture changes and thermal stresses which probably contribute towards failure of sleepers in service.

Rail fastenings have also received special attention. In particular, a number of tests have been made on the lateral shear resistance of the common cut spike fastening, with and without rail plates. Spikes by themselves have a surprisingly low shear resistance even in dense timbers, but we have improved this considerably by using 2½ in. shear plates on the spikes. The practical possibilities of this method will need to be determined from track tests.

It is hoped soon to start an investigation of the strains set up by spike driving. This will be related to exposure tests in which a study will be made of the propagation of splits resulting from spike driving.

Mr. Clarke suggested that sleeper investigations be extended to other States. In particular the work on shear plates could be handled by the States.

Mr. Watson agreed and felt that results in Victoria may not compare with similar tests in Queensland, where spikes are often badly cut.

Mr. Payne was doubtful of the help the Tasmanian Government might give, but he felt collaboration with the State Railways would be possible.

Mr. Clarke emphasized that any such test should include the active participation of the Forestry Services. It was suggested that Mr. Cooper might be a good contact with the Railways. The shear plate test should not be very elaborate but would require a suitable section of track relaid on arrangement with the Railways, and then subsequent inspections.

Mr. Payne said he would endeavour to arrange it.

Mr. Dale stated that in drying tests using different end-coats, better coats slow down the rate of drying and reduce end checking.

Mr. Wright suggested using sawcuts to simulate end checks in sleepers and so accommodate strains which develop on drying.

Mr. Bryant asked where the saw cuts would be made.

Mr. Wright replied that the position would vary.

Mr. Tack reminded delegates that preservation would have an effect in preventing end checking. In this regard the total absorption of preservative is probably not critical, but adequate penetration is necessary.

Mr. Bryant felt that Mr. Huddleston would be interested in having tests installed in New South Wales.

Mr. Clarke summed up by saying that the mechanical tests on sleepers will be spread among the States.

6. PRESERVATION INVESTIGATIONS

A. POLES

Mr. Tack: At the last Conference it was decided that the new Pole Bulletin should be produced during the coming year, and that a pole questionnaire should be forwarded to the various States with the object of extending or setting up new pole tests in New South Wales, Queensland and New Guinea. However, with the absence abroad of Mr. N. Tamblyn, Officer in Charge of the Preservation Section, the vacancy of another Research Officer position and the demands of our current research, field and contact work, it has been impossible to complete the programme. Because it has been necessary to defer pole inspections and re-treatments both in Victoria and New South Wales until early next year, it is considered desirable that the pole bulletin and questionnaire should not be issued until after these inspections.

Mr. Fogl asked for an estimate of when the bulletin would appear.

Mr. Tack replied that it would be within the twelve months following the pole inspections.

B. CROSS-ARM SURVEY

Mr. Beesley: In co-operation with the P.M.G.'s Department a survey was started in 1947 to determine the principal causes of failure of crossarms in service throughout Australia, to consider the possibilities of modifying P.M.G. specifications so as to admit a wider range of timber grades without lowering the expected life and to suggest preservatives or other improved practices to counteract the chief hazards.

So far inspections have been completed in three States (Western Australia, Victoria and New South Wales) and one report has been prepared. Arrangements are in hand for inspections in the remaining States, commencing with Queensland.

The main conclusions reached, as a result of the survey in Western Australia, may be summarized as follows:-

(1) Karri arms (about 75 per cent. of the total inspected) failed principally from decay (43 per cent.), termite attack (29 per cent.) and splitting (22 per cent.). Of the 674 karri arms inspected only 7 per cent. were considered as not having reached the end of their useful service life.

(2) Jarrah arms (about 20 per cent. of the total inspected) failed principally from splitting (40 per cent.), decay (22 per cent.) and termite attack (11 per cent.). Of the 163 jarrah arms inspected over 40 per cent. were considered as still fit for service.

(3) With both karri and jarrah, the importance of splitting as a cause of failure was related to rainfall,

becoming increasingly severe with decrease in rainfall. On the other hand decay assumed greatest importance in areas of highest rainfall.

The principal recommendations made in the report were:

(a) Thorough impregnation of arms with an oil-type preservative for protection against decay and termite attack. Oils have an additional beneficial effect in retarding the mechanical breakdown caused by splitting and weathering. A conservative estimate suggests that failure to apply preservative treatment is causing an annual loss of £11,000 in Western Australia alone.

(b) As a temporary measure the immediate treatment of all new karri arms with a "light oil solvent" preservative was suggested. Since the useful life of a crossarm is to some extent dependent upon the life of the pole it is essential that the maximum life of poles should be ensured by treatment.

(c) Improved seasoning practice and the end-coating of all arms immediately after cutting were also recommended.

The results of the inspections in Victoria and New South Wales have not yet been fully analysed, but a rough summary indicates that the general pattern of crossarm behaviour does not differ greatly from that in Western Australia.

The principal timbers used in Victoria appear to be mountain ash, messmate and bluegum (constituting over 90 per cent. of all arms recovered). For each species decay accounted for about 50 per cent. of the failures, whilst splitting was responsible for 33 per cent., 34 per cent., and 39 per cent., respectively. About 20 - 25 per cent. of the recovered arms were considered as fit for further service. Corresponding figures for jarrah and tallowwood, which made up about 10 per cent. of the total, are splitting 63 per cent., decay 16 per cent. and still serviceable 62 per cent.

In New South Wales, three stations in the southern part of the State of New South Wales averaged 50 per cent. for splitting, 20 per cent. each for decay and termite attack and 29 per cent. still serviceable.

The data from these two inspections has been handed to the Section of Mathematical Statistics for sorting with Hollerith punch-card equipment.

The inspection of recovered arms in Queensland has been tentatively arranged for about April, 1951. The P.M.G. have been asked to collect between 1,500 and 2,000 arms; in depots at Cairns, Townsville, Rockhampton, Toowoomba, Nambour, Maryborough and Brisbane.

Some interesting minor tests have been put in hand as a result of the survey to date.-

From Western Australia jarrah and karri arms (50 of each) are to be supplied for treatability testing under high pressure, and will be compared with messmate from Victoria and blackbutt from New South Wales.

From Victoria, about 30 arms (mixed species) will be given seasoning tests to examine factors causing splitting. These may be followed by mechanical tests as well.

After the Division's high pressure cylinder is in operation, it is planned to conduct a large scale service test to examine the effect of impregnation on crossarm behaviour. Details of this test have not yet been decided upon and suggestions will be welcomed.

Arising out of the survey so far, a few points are worthy of comment. The incidence of splitting and its seriousness is not generally realized and any steps that can be taken to reduce this will have real economic advantage. Durability does not seem to be an indispensable requirement, so that the range of species acceptable to the P.M.G. should not be limited to the comparatively small number at present listed.

It was evident to the inspecting officer that there was need amongst inspecting officers of the P.M.G. for very much more education in timber use, identification and appreciation of the requirements of timber for specific purposes. Also, a short course in Wood Technology, suitable for P.M.G. engineers and executive officers, would be invaluable in bringing them up-to-date with current trends in preservation and utilization.

The latest development in U.S.A. includes the use of natural round crossarms. These can be treated easily by an open tank method, and may be worthy of investigation under Australian conditions.

Mr. Clarke drew attention to the fact that the survey was only on such crossarms as have been removed from service.

Mr. Gay asked if there was a figure for termite attack on karri cross-arms inspected in New South Wales.

Mr. Beesley replied that it was 29 per cent. in New South Wales, compared with 11 per cent. maximum (Albury) in Victoria.

Mr. Gay asked if Mr. Beesley knew what species of termites were responsible for crossarm failures in Western Australia.

Mr. Beesley replied that no figures were available because crossarms were removed from service as much as three years before inspection and secondary breakdown had occurred.

Mr. Gregson asked how the economic loss was estimated, as it appeared very high for Western Australia.

He suggested that considerable care would be necessary in interpretation of results and fixing figures.

Mr. Beesley again drew attention to the fact that the survey was made only on crossarms removed from service. He said the P.M.G. do not know the number in service, the proportion of each timber species, or the expected length of life. The economic loss was calculated on the replacement cost of crossarms removed during a certain period of time (about 1 year). The figure was estimated as £11,000 for Western Australia and £2,000,000 for the whole of Australia.

Mr. Gregson advised caution on this estimate, because large numbers of the arms removed are still fit for service.

Mr. Beesley stated that 25 per cent. are still fit for service but had been removed because when an old pole is removed the old arms are not replaced on the new pole. Another reason for removal of good arms is the placing of main lines underground.

Mr. Cokley stated that Queensland would like a survey there as soon as possible. He asked if it were possible to distinguish primary breakdown in stored recovered arms.

Mr. Beesley replied that it is very difficult, especially with termite attack, but an attempt is made.

Mr. Tack said that as crossarms usually outlive the pole by many years in termite country, but are rarely re-used when a pole is replaced, it is important to preserve the pole.

C. FENCE POSTS

Note: A technical paper on this subject - titled "Preservation of Fence Posts" and numbered 6D - has been printed in Vol.1. The discussion follows -

Mr. Beesley referred to the preprinted paper and stressed the need for propaganda to tell the public the value of treatment of fence posts. He suggested co-operation between the State forestry commissions, State farms etc.

Mr. Payne asked if Division of Forest Products could indicate the life of an *E. obliqua* post after treating.

Mr. Clarke suggested 30 years as a conservative estimate.

Mr. Payne agreed to publicise preservative treatment of posts, as the position is economically urgent in various parts of Tasmania.

Mr. Thomas said that the cost of creosote made treated round posts more expensive than split posts in South Australia. Treated *P. radiata* posts compared with concrete posts in price.

Mr. Huddleston said that D.W.T. had published a Bulletin on fence posts, which resulted in many enquiries from farmers. The staff situation has prevented enquiries being followed up. Insufficient labour makes Mr. Beesley's proposal impracticable. However New South Wales are prepared to make a 16 mm. film on the subject for showing in rural districts and would make copies available to other States. They would co-operate also with the Departments of Agriculture and Soil Conservation, but could do no more.

Mr. Clarke pointed out a weakness in the Division of Forest Products' pamphlet, which was written for the farmer when labour was abundant, but money scarce. He felt that the pamphlet should be directed to commercial firms as the farmer was probably short of labour, but prepared to pay for a good service.

Mr. Huddleston said that D.W.T. would be prepared to treat posts at the Putney plant, but questioned whether farmers would pay for transport.

Mr. Clarke agreed and suggested that a number of portable treating plants be set up.

Mr. Huddleston stated that the New South Wales Electricity authority has recently set up a treating plant capable of treating electrical poles. They would probably welcome the extra work.

D. SMALL SPECIMEN FIELD TESTS

Mr. Tack reported the position in regard to the proposed field tests in New Guinea. He said Mr. Tamblyn suggested to Mr. McAdam that 100 specimens (possibly of taun) be set up at each of 2 or 3 different sites. At each site minimum sets of 10 specimens would be treated, each with one of 10 preservatives and then installed. The sites suggested were - (a) Lae - warm and very wet,

(b) Port Moresby - long dry period,

(c) Mountain site - for comparison with central highland plateau - wet and somewhat cooler.

It was later suggested to Mr. Womersley that two loadings of each preservative - normal, and 50 per cent. higher - should be used with 100-150 specimens at each site. A minimum of 10 specimens should be used for each treatment. Tests were intended to give preliminary information on the comparative behaviour of various types of preservatives which are available in Australia. (D.F.P. preferred 2 in. x 2 in. specimens.).

A second proposal was that 3 or 4 representative species be used. These would be sawn 2 ft. x 2 in. x 2 in. and round billets to a maximum of 5 in. diameter. The sites would be similar to those for taun, and the treatments as under - (a) open tank creosote oil

(b) open tank CZC

(c) cold soak pentachlorphenol - 4 to 24 hours

(d) " " copper naphthenate

(e) untreated controls.

This test should give some idea of the effectiveness of the most immediately practicable treatments. Mr. Tamblyn did not consider surface treatments worth trying.

On a subsequent visit to the Territory, Mr. Tack discussed field tests of small specimens with Mr. J. Womersley and inspected the proposed site for a graveyard test (near Botanical Gardens). Subsequently, small specimens (6 in.x $1\frac{1}{2}$ in.x $1\frac{1}{2}$ in.) of 10 species were received by the Division of Forest Products. These were given a soak treatment in pentachlorphenol solution to investigate their relative absorptions. The order of absorption was klinki pine, kwila, New Guinea rosewood, taun, busu plum, erima, and New Guinea walnut.

In addition, a set of small stakes were sent to Lae for decay hazard testing to obtain information for comparison with matched specimens at Belgrave, Ballarat, Toolangi, and Highett in Victoria.

Mr. McAdam said that it was hoped soon to install graveyard tests. Already the material has been selected, but staff shortage is causing a delay.

Mr. Cokley asked on what basis should the susceptibility to decay and termite attack be assessed. Queensland Forestry Service propose to install a test in Brisbane suburbs and would appreciate a matched set from Division of Forest Products.

Mr. Tack replied that the method of appraisement of specimens, standardized in Division of Forest Products tests, is by visual examination. A copy of our appraisal methods can be supplied.

Mr. Da Costa stated that another series of matched sets could be prepared and one set sent to Mr. Cokley.

Mr. Cokley said that Queensland Forestry Service would not require them until December.

E. PHYSIOLOGICAL EFFECT OF PRESERVATIVES

Note: A technical paper on this subject - titled "Timber Preservatives - Physiological Effects" and numbered 6E - has been printed in Vol.1. The discussion follows -

Mr. West asked if the printed summary contained all information required by the Conference. He added that pentachlorphenol appeared to be the only preservative whose effects were under suspicion. However its vapour pressure is low and it is only at high temperatures that there is any hazard. Precautions might be necessary during mixing and making up solution.

Mr. Tack said that the statement covers what we require to know of the preservatives dealt with but it will be of value if D.R.L. can assist again by determining the physiological effects of the main toxic constituents of other preservatives, both proprietary and non-proprietary.

Mr. West suggested that D.R.L. would be glad to co-operate.

Mr. Cokley stated that in Queensland it has been found that sodium pentachlorphenate and the oil solution of the phenol may be controlled by suitable barrier creams. For fluorides Dr. Gordon's work indicates that protective clothing may be necessary, particularly during mixing.

Mr. Beesley said the increase in use of some preservatives, particularly those with high arsenical contents, suggests the need for warning labels, particularly when the preservatives are used on wood in cots, high chairs, etc. which might be chewed by babies.

Mr. Huddleston stated that D.W.T.'s policy is to leave the study of the physiological effects of preservatives to the various Departments concerned.

Mr. Clarke suggested that this sort of effect is more a possibility than a probability.

F. LABORATORY EVALUATION OF PRESERVATIVES

Note: A technical paper on this subject - titled "The Laboratory Evaluation of Preservatives" and numbered 6F - has been printed in Vol.1. The discussion follows -

Mr. Da Costa said that field tests are generally too slow, and it is desirable to have laboratory tests from which quick, reliable results may be obtained. It is hoped that the American Wood Preserver's Association who have sponsored laboratory tests, will have a standard specification available soon. The importance of correlating laboratory and field results was emphasized, and a request made to Conference that whenever field tests were being installed by the forest services, matched samples of timber and the preservative used should be sent to the Division of Forest Products for laboratory tests to be correlated with the field test. Division of Forest Products should be able to obtain sufficient material for testing each preservative from a piece of timber about 4 in.x 4 in.x 3 ft. long.

Resolution: It was resolved that any field test initiated by the forest services throughout the Commonwealth be paralleled with laboratory tests at the Division of Forest Products on matched specimens sent in by the particular State service.

G. LABORATORY TESTS ON DECAY RESISTANCE

Mr. Da Costa reported that a satisfactory technique has been evolved, but the start of work was awaiting completion of new incubation rooms and the arrival of test material. Arrangements for an International co-operative test on laboratory decay techniques have been made. Dr. Findlay, Princes Risborough, is to be co-ordinator, and it is hoped to collect material and start tests as soon as Mr. Tamblyn returns from overseas.

In addition to laboratory estimation of differences in decay resistance between species, the effect of silvicultural treatment would be investigated. The Queensland Forest Service promised to supply fast and slowly grown ironbarks for this investigation. Other States have been asked if they are interested in the testing of any particular species.

Mr. Clarke suggested that Western Australia might be interested in testing jarrah.

Mr. Brockway affirmed that jarrah re-growth which has a wide sapwood might be worth testing.

H. TREATMENT OF LYCTUS SUSCEPTIBLE TIMBER IN QUEENSLAND

Note: A technical paper on this subject - titled "The Present Position of Preservative Treatment of Lyctus Susceptible Timber in Queensland" and numbered 6H - has been printed in Vol.1. The discussion follows -

Mr. Cokley dealt with some of the points of the pre-printed paper in more detail.

Chemical Supply - The adequacy of supplies has often been questioned, but never satisfactorily answered. Most Queensland applications for supply which have been made since June have been cut by at least 50 per cent. This has the effect that companies are required to work on a 3 months' supply and new Companies, proposing to establish treatment plants are discouraged. Three alternative assessments of requirements have been made - one based on chemical analysis of the treated timber; a second based on estimated requirements of treatment plants' consumption and a third based on theoretical dosage requirements.

From these estimates, it is considered that 332 short tons are needed in Queensland this year. Of this 55 tons are required for veneer and the remainder for sawn timber treatment.

Import duty on Borax is £2/10/- per ton, whereas boric acid for timber treatment is duty free. It is considered that the duty on Borax constitutes unfair discrimination against timber treatments using this chemical. Conference was asked to approach the Commonwealth Authorities to remedy this situation.

Mr. Fogl was surprised to hear of the shortage in Queensland as the supply in New South Wales is adequate.

Mr. Beesley added that boric acid was not short in Melbourne.

Mr. Tack asked whether boric and borax comes from dollar sources.

Mr. Cokley replied that most of it did.

Mr. Clarke asked whether any Queensland firm was held up by a shortage.

Mr. Cokley replied that some were - two firms had to borrow from others and repay when supplies arrived. Some firms are overstocking while a few are over-ordering.

Mr. Fogl stated that three New South Wales firms over-bought and then decided to sell their excess supplies.

Mr. Clarke recommended that the matter be referred to the Commonwealth Forestry and Timber Bureau.

Mr. Hauser suggested that if a survey is made of the position in other States, the licencing authorities might be able to plan on a nation-wide basis.

Mr. Huddleston warned the Conference that boric acid might be used by firms for other than timber preservation.

Mr. Cokley outlined channels through which licences are supplied, and agreed that it was a matter for the C.F.T.B.

Treatment Schedules - Mr. Cokley stated that originally Queensland Forestry Service aimed at developing schedules for each susceptible species. After trials it was found that a group system was possible. Groups are based on density, porosity, ray structure, and soft tissue. Mr. Cokley explained that he did not aim at minimum schedules since the more refractory species in a charge might not be adequately treated. He proposed that since 60 per cent. of the timbers listed fall easily into groups, such a grouping system replace species schedules and be defined as follows -

(1) Easily treated timbers, maximum density 30 lb./cu.ft., (type species-white cheesewood).

(2a) Moderately easily treated timber, (type species - silky oak).

(2b) Refractory timbers, (type species-tulip oak).

(3) Refractory timbers to the equivalent of spotted gum.

(4) Remaining timbers, (eucalypts).

No work has been done on timber exceeding 3 in. in thickness.

Mr. Fogl agreed that it is impossible to arrive at individual schedules. He approved of the grouping system, but questioned the relative group positions of tulip oak and spotted gum.

Mr. Clarke remarked that spotted gum is notoriously variable. This would account for the difference of opinion.

Surface Treatments - Mr. Cokley said it was proposed to discuss this because of Mr. Tamblyn's visit overseas and the publicity given by the Timber Users' Protection Acts and Division of Forest Products Publications. Surface treatment is understood to apply to the finished product. The timber may or may not be sterilized but if it is not sterilized treatment is necessary immediately after cutting. Queensland Forestry Service has done work on surface coating with sulphur and K.55 creosote. He considered that firms having kilns could modify their treatment slightly by heat sterilizing after surface coating. Army Specifications 89 and 91, and South African Specification for surface treatment were discussed. After quoting figures he stressed the importance of considering commercial and legal requirements.

It was suggested that for thick dimension timber, treatments should be permitted other than those giving 0.2 per cent. concentration at the centre, as follows -

Timber less than 1 in. thick	- total penetration	treatment after 3 months seasoning
1 in. "	- minimum 1/3 in. penetration	
$1\frac{1}{2}$ in. "	- minimum 1/2 in. penetration	treatment after 6 months seasoning
2 in. "	- minimum 2/3 in. penetration	
Over $2\frac{1}{2}$ in. "	- minimum 1 in. penetration	

He asked Mr. Gay's opinion as to whether the suggested depths of penetration would be satisfactory.

Mr. Gay replied that the proposed depths seemed adequate. On end faces, he found the maximum depth of oviposition was 7 mm. On other faces it was less, possibly as little as 3 mm., and therefore 5 mm. penetration would be sufficient.

Mr. Fogl thought that the views expressed by Queensland were reasonable, but suggested that non-susceptible species be used for large-dimension members.

Mr. Cokley replied that this was difficult as the supply is restricted in regard to choice of timber.

Mr. Clarke remarked that Queensland relies on the fact that tulip oak is susceptible to get its supplies. He doubted whether in certain cases Queensland was justified in allowing incomplete treatment.

Mr. Tack suggested that a specification permitting 25 per cent. penetration of the cross-section could not be applied to irregularly shaped articles. It would be better to decide depths of penetration based on Mr. Gay's work.

Mr. Huddleston stated that two matters were of concern both to Queensland and New South Wales - to uphold the principle that timber must remain immune despite working subsequent to treatment, and the difficulty of tracing timber after it has been worked and brands removed, to allow checking against the type of approval originally given.

Mr. Cokley considered that there is little risk of attack due to working, abrasion, or the insertion of screws. He referred to South African figures.

Mr. Clarke suggested that it was not advisable to draw on overseas experience in this matter. It is the duty of the Queensland Forestry Service to police the Act and desirable for them to set out the problems and ask and heed the opinions of this Conference. With regard to the degree of protection of timber, it is well to err on the safe side, as otherwise manufacturers would soon be looking for cheaper treatments.

Mr. McAdam asked how the depth of penetration in an article is proved.

Mr. Clarke replied that it was necessary either to destroy some of the articles or depend upon schedules.

Mr. Tack suggested that pressure treatment may be necessary.

Mr. Cokley disagreed. He considered hot and cold dip would be satisfactory. Although, with a mild schedule there would be low penetrations only, it was hoped to get adequate sterilization by maintaining temperatures between 140 and 160°F. for 2 hours; i.e. it was proposed to rely on chemical and heat sterilization.

Mr. Gay considered that 1/2 hour should be an adequate treatment time.

Mr. Clarke cautioned against incomplete treatment.

J. PROTECTION OF TIMBER AGAINST MARINE BORER ATTACK IN QUEENSLAND

Note: A technical paper on this subject - titled "Protection of Timber Against Marine Borer Attack in Queensland" and numbered 6J - has been printed in Vol.1. The discussion follows -

Mr. Watson stated that a bulletin on this subject was published 14 years ago, but it was not sufficiently known. He suggested that Division of Forest Products should publish a Trade Circular covering marine borers in Australian waters and including subject matter from its own papers, those of the Maritime Services and Queensland Forestry Service.

Mr. Amos replied that early next year a Bulletin on siliceous timbers would be published. Research would be conducted in future along three main lines -

(a) Impregnation of susceptible timbers with silica and testing against borer attack.

(b) Investigation of the digestive mechanism of the teredimidae. This project will be undertaken in co-operation with the Zoology School, University of Melbourne.

(c) The uptake of silica by various species. This project will be undertaken in co-operation with the Botany School, University of Melbourne.

In most timbers there is a close parallel between silica content and resistance to attack. Forest red gum (E. tereticornis) is exceptional, the reason for its resistance being at present unknown.

Mr. Cokley asked how many samples had been examined for each species.

Mr. Amos replied that this depended upon the stock at the Division of Forest Products. Sometimes only one or two specimens were available, but usually several. Initially a microscopic examination is made and where silica is present this is followed by chemical estimations. Silica accumulation is constant for a species. Susceptible timber may be impregnated with silica quite simply. This has been done, but so far specimens have not been subjected to immersion tests. It should be realized that the silica content may be only an indicator of some other metabolic process which produces substances toxic to teredines.

Mr. Bryant, in referring to resistance of Callitris, said that callitrol is not a phenol but is chemically laevocitronellic acid.

Mr. Cooper suggested the possibilities of explosives or ultrasonic vibration for the destruction of marine borers.

Mr. Watson admitted the method could be temporarily effective but considered its value limited because the water contained millions of larvae which moved in swift currents and were constant source of re-infestation.

7. TERMITE INVESTIGATIONS

Note: A technical paper on this subject - titled "Termite Investigations" and numbered 7 - has been printed in Vol.1. The discussion follows -

Mr. Gay elaborated a few points mentioned in the printed paper, including various testing techniques, collections and the need to identify termites accurately. He then appealed to the various States to help build his collection for both record and material purposes. He described two testing techniques.

Rapid Laboratory Technique - This method is unique and gives highly satisfactory results. It is used for testing wood, plastics and other materials. The weighed test material is placed in a glass jar with moist termite mound material and a definite number of termites, and kept under suitable conditions of temperature and humidity for several months. The resistance of the material is then rated on the weight eaten by the termites and on the percentage survival of the colony.

At present the largest project is the testing, in co-operation with the various States, of the natural resistance of various hardwoods. It is considered that 50 trees of each species should give a representative picture covering the variability due to size, soil type, and general locality of the various trees. Matched material is being used by The Division of Forest Products for accelerated fungal tests and it should be possible to determine whether there is any correlation between decay and termite resistance.

Field Testing Technique - Mr. Gay described the history of the development of the method now used for testing treated or resistant timber and treated soil. A modification has been used to test "Wall" boards and other materials which, without protection from moisture absorption, may suffer severely from decay or physical softening.

Mr. Bryant asked if he could send samples of D.W.T. board for termite testing.

Mr. Gay agreed to test the samples.

Mr. Cokley congratulated Mr. Gay on the results.

Mr. West asked if the laboratory method could be used for testing wall-boards.

Mr. Gay replied that the method is satisfactory and rigorous - the termites have no option, they must either eat or starve.

Mr. Cooper suggested that soil tests also give the termites the no option.

Mr. Gay disproved Mr. Cooper's objection by describing an example where the termites had discovered a thin film of untreated surface soil and managed to avoid the treated earth. This could not always be guarded against. Termites would not build directly on treated soil.

Mr. Cokley asked Mr. Gay if preservative loadings used for borer control in Australia were effective against termites.

Mr. Gay replied that they were inadequate as at least 0.5 per cent. concentration would be needed.

Mr. Holmes referred to the surprising amount of damage caused by Mastotermes in the tropics and asked whether plastic piping, which was light and therefore cheap to transport, would fail against termites in Darwin.

Mr. Gay replied that Polyvinyl chloride was the most resistant of the plastics tried. It appeared that smoothness of the surface was important as extruded material was more resistant than moulded..

Mr. Holmes asked whether the pentachlorphenol tests were designed to control Mastotermes.

Mr. Gay replied that they were not. They were planned for local species.

Mr. Holmes suggested that, due to probable cracking of the concrete slab, there were very real difficulties in excluding Mastotermes by slab construction.

Mr. Gay agreed.

Mr. Clarke suggested that the problem of Mastotermes might be over emphasized as it has limited habitat.

Mr. Holmes asked for information on the relative resistance of Callitris glauca and C. calcarata.

Dr. Dadswell said that C. intratropica had a higher resistance than C. glauca.

Mr. Tack added that C. intratropica is the best and C. calcarata is far behind in resistance to Mastotermes.

Mr. Chaudhuri asked whether Mr. Gay had any results for teak or other hardwoods grown in Pakistan.

Mr. Gay replied that teak is at least as good as Cypress pine.

Mr. Watson remarked that Mastotermes was prevalent in Townsville.

Mr. Tack stated that the resistance of timber to attack varies with the different species of termites.

Mr. Gay added that only the relative resistance of Australian timber species against Australian termites is determined here.

8. BORER INVESTIGATIONS

A. STATISTICAL SURVEY OF DAMAGE BY BORERS, TERMITES AND DECAY IN AUSTRALIAN BUILDINGS

New South Wales Investigation

Note: A technical paper on this subject - titled "Statistical Survey of Pest Damage in Housing" and numbered 8A - has been printed in Vol.1. The discussion follows -

Mr. Huddleston stressed the desirability of a house damage survey in all States and drew the attention of the Conference to the questionnaire prepared by Messrs. Hartigan and Tack for use in the survey.

Mr. Tack said it was suggested at last Conference that the Division of Forest Products should extend the survey to all States and analyse the results. After discussion with the D.W.T., it was decided to modify the existing questionnaire. The present simplified form was evolved after a large number of interviews. The main difficulty has been to compromise between the information wanted and the technical limitations of the inspectors. The Department of Works and Housing have a well informed technical staff and should be able to return the most valuable data. Queensland and New Guinea Forest Services and other interested bodies have agreed to co-operate. The first of the revised forms have gone out and interim results should be available early in the new year.

Mr. Gay advised changing "white ants" to "termites" on the form.

Mr. Clarke in referring to preprinted paper said that it is interesting to note the incidence of termite attack is independent of age of the house.

Mr. Gregson asked if the forms had been sent to the State Housing Authorities.

Mr. Tack replied that they were distributed through the Works and Housing Departments in the various States. He added that forms had not been directed to Housing Commissions as these examine only new houses.

Mr. Gregson remarked that 3,000 houses had been erected in Western Australia over the last 4 years and some of these had been attacked by termites.

Mr. Clarke suggested that as termite attack occurs in new houses, these should be included in the survey.

Queensland Investigation

Note: A technical paper on this subject - titled "Borer Attack in Timber Buildings" and numbered 8A(ii) - has been printed in Vol.1. The discussion follows -

Mr. Huddleston, in referring to Mr. Watson's criticism of borer exterminators, said that this was also an important problem in New South Wales. He thought that the problem indicated a need for early legislation. One firm he cited actually planted evidence. He suggested inspectors should be licenced.

Mr. Tack agreed, but said the problem was not so serious in Victoria. He drew attention to the fact that large chemical firms supplied chemicals without considering the effectiveness of their method of application.

Mr. Watson and Mr. Cokley agreed that licencing of inspectors was advisable.

Mr. Clarke stated that it was a matter for State legislation. The conference could only advise on the position.

Mr. Huddleston agreed and explained that the object of raising the matter was to obtain any other ideas which might assist.

Mr. Tack felt that the publication of the results of the pest survey would meet the situation to some extent.

Mr. Huddleston said that this was doubted, because unscrupulous company's inspectors are very thorough.

Mr. Clarke remarked that propaganda had been fairly effective in Victoria.

Mr. Cokley asked that Mr. Huddleston make a resolution that action be taken.

Mr. Clarke agreed, but cautioned that as a borer and termite problem does exist care is required in wording a resolution.

Mr. Huddleston did not consider a resolution necessary.

B. LYCTUS SUSCEPTIBILITY GRADINGS FOR COMMERCIAL TIMBERS

Note: A technical paper on this subject - titled "Lyctus Susceptibility List" and numbered 8B - has been printed in Vol.1. The discussion follows -

Mr. Huddleston suggested that for publication only three gradings should be used, viz. - resistant, rarely susceptible and susceptible.

OTHER STATES AGREED TO THIS PROPOSAL

Mr. Clarke suggested that a Committee be formed to decide ratings of doubtful species and report to the Conference on Friday morning.

Messrs. Cokley, Fogl and Beesley were appointed to the Committee.

Mr. Tack suggested that the New Guinea Lyctus Susceptibility list be revised and a new report issued.

Mr. McAdam said he would like to see this done, and suggested that an officer of the Division of Forest Products should visit New Guinea.

Mr. Clarke replied that such a visit would depend on other Division of Forest Products commitments.

Report of Committee

Mr. Beesley reported that the Committee had met and examined the Lyctus list. Disagreements on species were noted and these are to be re-examined and re-assessed by the State Forests Departments. D.W.T. is to send samples to augment Division of Forest Products collection and also information on the number of infestations. This will provide more evidence on which to base timber susceptibility ratings. The new Trade Circular will mention three ratings only instead of the four, viz. - resistant, slightly susceptible and susceptible. The Laboratories will still use the four ratings.

Mr. Clarke thanked the Committee.

C. LYCTUS NUTRITIONAL STUDIES

Note: A technical paper on this subject - titled "Nutritional Requirements of Lyctus Larvae" and numbered 8C - has been printed in Vol.1. The discussion follows -

Mr. Gay said that of the five techniques listed in the printed paper on Lyctus nutritional studies, additional work had been done on methods 3 and 4. These methods required removal of substances from the wood by extractive methods and addition of certain substances to the wood by impregnation techniques. This was not a completely satisfactory method as one could never be sure that all the appropriate substances were removed from the wood, or that the substances returned were being put back in the correct form.

Method 5 - the use of artificial diets - had been successful. This method was first put forward by Parkin and is now used with certain modifications. The Division of Entomology had evolved a basic diet which included soluble starch, casein, sucrose, yeast, salt solution and a sterol. The diet proved adequate for larvae and adult borers were produced faster than in susceptible timbers. Materials were omitted from the basic diet and the effect on larvae determined. It is possible by this method to accurately determine Lyctus nutritional requirements.

Mr. Tack stated that the iodine test was not always a satisfactory test of Lyctus susceptibility and asked whether it were possible to determine any other substances in the wood which were important to Lyctus.

Mr. Cokley said Queensland would co-operate in such an investigation.

Mr. Bryant proposed consultation between Messrs. Gay and Tack, and Dr. Price.

Mr. Fogl suggested that if Mr. Gay did find that some minor chemical was necessary to Lyctus, it might radically change present immunization methods.

Mr. Clarke said that Lyctus requirements seem very exact and asked whether requirements of Anobium were as elaborate as those of Lyctus.

Mr. Gay said he thought it likely.

Mr. Clarke asked if there were sterols or yeasts in the heartwood.

Mr. Gay replied that yeasts were present but probably sterols were not.

D. ANOBIUM INVESTIGATIONS

Mr. Tack stated that late last year a number of P. radiata panels prepared from 9 trees collected from three States were forwarded to Mr. Spiller, Entomologist of the D.S.I.R. New Zealand, for inoculation with Anobium borer. It was intended that these panels should subsequently be distributed in twelve different Australian localities and observed for relative rate of attack. Unfortunately, although the panels reached New Zealand in ample time for inoculation in December, results were very poor and very few or no eggs were laid in the timber. Therefore, it has been suggested that these panels be re-inoculated in the coming season in the rather doubtful hope, according to Mr. Spiller, that results will be better. He considers that the whole problem of variation in egg laying in different timbers and in the same timber requires more careful investigation before embarking on a large scale test, and in the case of P. radiata, he intends to explore the variation in egg-laying from bark to core on a series of trees milled at the same and at different times. Mr. Spiller also considers that locality may be important.

That, at present, is the position of these tests, and we are unable to give further results until emergences occur about the end of the year.

Mr. Huddleston stated that this problem is important in Sydney.

Mr. Clarke said that there is evidence that Anobium attack occurs in the outer but not the inner part

P. radiata.

Mr. Beesley added that there is variation in susceptibility within the one species and the co-operation of the State services in mapping geographical variations within a species would be appreciated. This might show correlation between climatic factors and susceptibility.

Mr. Huddleston asked whether work had been done to evolve a spot test as for Lyctus.

Mr. Clarke replied that it had not.

Mr. Huddleston said that such a test would be very desirable and he suggested that nutrition studies should be undertaken as for Lyctus.

Mr. Tack stated that Mr. Spiller had made some studies.

Mr. Clarke asked if there be any advantage in using Mr. Gay's small tube technique.

Mr. Gay considered it a possibility.

Mr. Clarke said that we should elucidate the problem of P. radiata variability before continuing co-operative work with New Zealand. Mr. Tack and Mr. Gay should discuss the problem. Perhaps there are genetic reasons for the variability. If so, it is a problem for the foresters.

Mr. Watson stated that the Queensland Forestry Service would consult Mr. Brimblecombe for a list of towns where Calymmaderus sp. has been reported.

E. METHODS OF ANALYSIS OF BORIC ACID

Note: Two technical papers on this subject - one titled "The Development of a Simple Method of Estimating Boric Acid in Treated Timber" and numbered 8E(i); the other titled "The Determination of Boron by Calorimetric Methods" and numbered 8E(ii) - have been printed in Vol.1. The discussion follows -

Mr. Clarke suggested that a Committee be set up to discuss this item, the results of the discussion to be reported to the Conference on Friday morning.

The committee appointed consisted of Messrs. Cokley, Fogl and Christensen (Convenor).

Mr. Cokley suggested that the agenda item should include specification for boric acid analysis.

Report of Committee

Mr. Christensen thanked New South Wales for its co-operation and said the following were the main points to emerge from the discussions of the Committee at a meeting held on 12/10/'50.

(a) No agreement has yet been reached between Division of Wood Technology and Queensland Forestry Service on the acceptance of a mutually satisfactory method of analysis of boric acid in wood for treatment plant control.

(b) Considerable advancement has been made in both laboratories in obtaining improved methods of boric acid analysis in wood.

(c) Current work at the Division of Forest Products suggests that it will eventually be possible to present an accurate method of analysis where comparatively high precision is required.

A review of the position at the last Forest Products Conference showed that there was considerable dissatisfaction with each of the existing methods of plant control analysis of boric acid. It was considered highly desirable that a reference method of analysis of boric acid in wood should be developed for use in special cases, e.g. in research work, legal cases, etc. The Division of Forest Products undertook to investigate this. Division of Wood Technology and Queensland Forestry Service on the other hand, proposed to investigate alternative methods for use in plant control.

Development of accurate method at Division of Forest Products

Unfortunately the Division has been hampered by staff difficulties, but it is probable that a method of analysis will be developed having an accuracy of 1 per cent. at all concentrations of boric acid above the legal limit (0.2 per cent.), i.e. ± 0.002 per cent. boric acid. The Committee has agreed that further work in this direction should continue and it is hoped that a method will be available in detail before the next Conference. The Division has undertaken to notify the Queensland Forestry Service and Division of Wood Technology by letter of the method as it stands at present if they so desire.

Development of plant control methods

The Committee agrees that a uniform method adopted by all States is desirable, particularly in view of the proposed specification for treated timber. It has also agreed that before any method can be regarded as acceptable it should be capable of giving in the hands of those who are to use it an accuracy of 0.02 per cent. boric acid, i.e. an accuracy of 10 per cent. at the legal limit. This refers to both reproducibility as well as recovery of boric acid. In the case of Queensland Forestry Service it is proposed that the method will be used by trained chemists or Queensland Forestry Service personnel only. Division of Wood Technology proposes that the method of analysis should be operable by chemically untrained personnel.

As a contribution to the solution of the problem, the Queensland Forestry Service has submitted, as an alternative to the Double Indicator method, a colorimetric method. This is seen at present to have the following advantages -

(a) Reduction of personal factor.

(b) Speed of operation (60 analyses per day).

(c) Possible attainment of the desired order of accuracy, and disadvantages -

(a) Use of a comparatively expensive instrument.

(b) So far, accuracy is lower than required.

The Division of Wood Technology, persevering with the Bromthymol Blue method of analysis, have attempted several refinements, some results of which have been included in the preprinted paper. Further refinements have been made, however, particularly in the leaching process and it now appears that the required accuracy is attainable under certain circumstances. Following are some advantages -

(a) Moderately simple laboratory method requiring little specialized equipment.

(b) Appears to have the required accuracy, but this is not yet confirmed, and disadvantages -

(a) As a micro method it is more susceptible to error than a corresponding macro method, particularly in the hands of unskilled operators.

(b) Possesses a considerable personal factor.

It will be seen from the foregoing that neither method is yet completely satisfactory to the point at which further investigation is not needed, and Queensland Forestry Service and Division of Wood Technology have agreed to seek further improvement. The Division of Forest Products is prepared to examine <u>if possible</u> any method which, meeting the above requirements, is suggested as suitable for adoption universally.

<u>Mr. Fogl</u> said that a specification for immunized timber had been prepared in draft form. This is given below. After criticism it is proposed to submit the draft to the Standards Association.

AUSTRALIAN STANDARD SPECIFICATION FOR LYCTUS IMMUNIZED TIMBER

This standard has been prepared for use in relation to the utilization of Lyctus susceptible sapwood, satisfactory utilization of such timbers only being possible after they have been immunized by means of approved Lycticides. Boric Acid, Borax, Sodium Fluoride and Seekay Wax A123, are such chemicals.

Introduction

This specification applies to the immunization of Lyctus susceptible timbers and is divided into three sections:

a. Section 1, applies to the requirements for the immunization of rough sawn timber.

b. Section 2 applies to the requirements for the immunization of veneers.

c. Section 3 applies to the methods of test.

Section 1. Rough Sawn Timber

Concentration of Preservative

Timber described as immunized against Lyctus brunneus (Steph) (The Powder Post Beetle) shall contain throughout a minimum preservative concentration as prescribed in Appendix A.

For the purpose of this specification test samples shall be taken from the core of the timber only and the core shall be defined as a piece cut from the core of the board, such that it is not wider than one fifth of the width of the board and not more than one fifth of the thickness of the board or one quarter of an inch (1/4 in.), whichever is the less in thickness.

The core sample taken for test shall be cut from the centre of the board, at least eighteen inches (18 in.) from either end.

Selection of Test Samples

a. Number of Samples. At least one sample shall be taken for testing for each thousand superficial feet of timber in any charge or consignment. If the charge or consignment contains less than two thousand (2,000) superficial feet of timber, at least two samples shall be tested. Where a charge or consignment consists of more than one species of timber, at least one sample shall be taken from each species contained in the stack.

b. Location of Samples. If the test samples are taken from a freshly treated stack, at least fifty (50) per cent. of the samples shall be selected from the two uppermost layers in the stack. If the stack has been broken down for delivery, all samples shall be selected at random throughout the consignment.

c. Size of Samples. All samples shall be obtained from boards at least four inches (4 in.) wide. Where a charge or consignment is composed of timber less than four inches (4 in.) wide the widest material available shall be tested.

d. Sample Boards. All samples shall be cut from sound boards and consist of starch-containing sapwood. The method of testing for sapwood shall comply with Section 3 of this Specification.

e. Test Results. The average of the analytical results obtained from the individual samples from any one charge or consignment shall be taken as the preservative concentration in the whole charge or consignment. The preservative concentration in any charge or consignment shall equal or exceed the concentration shown in Appendix A, and no individual sample shall show a concentration less than 20 per cent. below the concentration specified in Appendix A. Any charge failing to meet the above test requirements shall be rejected.

In cases where the concentration of the preservative in the core is likely to increase for a period after treatment, the charge may be allowed to stand and shall be subjected to further tests before acceptance. In these subsequent tests, test samples shall be taken and the charge shall comply with the requirements of Clause (e), Section 1.

Branding. Every board in a charge submitted for test as preservative treated and accepted shall be branded with a distinctive brand.

Section 2. Veneers

Concentration of Preservative

Veneer described as immunized against *Lyctus brunneus* (Steph.) (The Powder Post Beetle) shall contain in the core a minimum preservative concentration as prescribed in Appendix A.

For the purpose of this specification the core shall be defined as that portion of the veneer remaining after it has been sanded evenly on both faces, and the core shall not exceed one sixteenth of an inch (1/16 in.) or one half (1/2) of the thickness of the veneer whichever is the less. A core sample taken for test must be cut at least one (1) foot from either end of the sheet of veneer.

Selection of Test Samples

a. Number of Samples. One sheet of veneer shall be taken for testing from each thousand sheets treated with the proviso that additional samples shall be tested if the treatment is varied either by a change in the treatment solution or in the thickness or species of the veneer being treated.

b. Location of Samples. All samples shall be selected at random throughout the charge or consignment.

c. Sample Sheets. All samples shall be cut from sound veneers and consist of starch-containing sapwood. The method of testing for sapwood shall comply with Section 3 of this specification.

d. Test Results. The average of the analytical results obtained from the individual samples of any one charge or consignment shall be taken as the preservative concentration in the whole charge or consignment. The preservative concentration in any charge or consignment shall equal or exceed the concentration shown in Appendix A and no individual sample shall show a concentration less than 20 per cent. below the concentration shown in Appendix A. Any charge or consignment failing to meet the above test requirements shall be rejected.

Branding. Where sheets of veneer are consigned singly or in loose parcels from the factory, each sheet shall be stamped with a distinctive brand. Where the sheets are sold in bundles or crates, the application of the distinctive brand to the outside of each bundle or crate shall be deemed sufficient for the purpose of this specification.

Section 3. Methods of Testing

a. Test for Sapwood. In the case of boards the ends shall be docked and the whole cross section of the board painted with a 0.05N solution of iodine in potassium iodide. In the case of veneers, the solution shall be painted across the whole width of the sheet. Except where the boards or veneers have been freshly sawn, the surface to be tested shall be freshened up by planning. Any trace of grey or black colouration on the timber after painting with the iodine solution indicates the presence of starch.

Dissolve half an ounce of potassium iodide crystals in about one-fifth of a tea-cupful of water; add a quarter of an ounce of iodine crystals with constant stirring until all are dissolved, then make up the solution to one quart with clean water.

b. <u>Test for determining the Boric Acid and Borax content of Treated Timber</u>. The core shall be cut from the sample board as specified in Sections 1 and 2 respectively and rasped or ground to sawdust sufficiently small to pass a 1/4 in. mesh. A representation sample shall be placed in a weighing bottle and the moisture determined as follows:

The sample, immediately after grinding, shall be weighed on a balance which shall be accurate to the second decimal place. The sample shall then be dried in an oven at a temperature of 212° to 221°F. (100-105°C.) until the weight is constant, allowed to cool in a dessicator and then weighed.

The percentage moisture content shall be determined using the formula:

$$M.C. = \frac{W - Wo}{Wo} \times 100$$

Where M.C. = percentage moisture content
W = initial weight of specimen
Wo = oven dry weight of specimen.

The boric acid analysis shall be made in duplicate as follows:

Mix a 5 gm. sample of ground up wood with 2.5 g. of lime eschka (consisting of a mixture of three parts of calcium oxide and one part of anhydrous sodium carbonate ground finely) and place in a platinum dish. Cover the sample evenly with a further 3 gm. of lime eschka mixture and ignite gently over a medium burner flame until the sample ceases to flame spontaneously. Continue the ignition over a Meker burner until most of the carbon has been removed and the mixture is a light grey colour, care being taken to prevent fusion. The ignition should not take longer than 20 to 25 minutes.

Grind the mixture to a fine powder in the dish, using a small pestle and transfer the powder to a 400 ml. beaker. (If the ignition has been carried out correctly the mixture will come away cleanly from the platinum dish and no lumps of carbon or fused mixture will remain). Wash out the dish with a few ml. of dilute hydrochloric acid and add the washings to the beaker, followed by about 10 ml. of the water and then concentrated hydrochloric acid slightly in excess of the amount required to dissolve the mixture (from 15 to 20 ml. should be sufficient). The beaker should be covered with a watch-glass during this operation to avoid loss by spattering.

When all the mixture has dissolved the contents of the beaker are washed into a 200 ml. standard flask and 1 ml. of brom-thymol blue added. Sufficient 15 per cent. caustic soda is added to make the solution just alkaline. 10 per cent. hydrochloric acid is then added drop by drop until the precipitate disappears. The solution is then made up to volume.

Take a 10 ml. aliquot and pipette into a 250 ml. conical flask. The aliquot is made up to approximately 25 cc. with distilled water and 10 drops of brom-thymol blue are added. The flask is then simmered under an air condenser for 10 minutes, quickly cooled in cold water then titrated.

The titration is carried out in three steps and a micro-burette is used.

(i) Standard caustic soda is run in until the solution is just alkaline, the colour changing from yellow to blue. This is the first end point.

(ii) 0.5 g. of mannitol is added, if boric acid is present the colour change is from blue to yellow.

(iii) A reading of the burette is taken and the solution is titrated to the second end point.

The colour of the second end point should coincide as near as possible with the first end point.

Alternative Method of Analysis. An alternative method of analysis may be used if desired. In this case the ash is brought into solution in a 400 ml. beaker as in the above-mentioned method. Then to the solution in the beaker add a few drops of phenolphthalein, followed by sufficient 15 per cent. caustic soda solution, added dropwise, to make the solution just alkaline. Make up to 100 ml. with water and filter the solution through a dry paper into a dry beaker.

Take a 25 ml. portion contained in a 250 ml. conical flask for each titration and using phenolphthalein as an indicator add 1 per cent. hydrochloric acid solution dropwise until the colour is discharged. Then add a few drops of methyl red and continue the addition of acid until the solution is just acid to this indicator. Boil the solution gently under a reflux condenser for about 10 minutes to remove the carbon dioxide from the solution, but taking care that no large amount of steam issues from the top of the condenser. When the solution is cool adjust it to the methyl red end point by means of 0.05N caustic soda solution, add 1.5 gm. mannitol and 1 ml. of phenolphthalein and titrate to the phenolphthalein end point with standard 0.05N carbonate-free caustic soda solution. The end point is different from the usual phenolphthalein end point in that it occurs only as a faint orange colour, which is easily missed if care is not taken. At the end point the solution changes in colour from the yellow of the alkaline methyl red to a colour closely resembling the neutral red colour of this indicator. The addition of a further drop of caustic soda solution produces a very faint pink colour. The occurrence of the red colour indicates the true end point of the reaction and its detection may give difficulty, but reliable verification may be obtained by reading the burette at the supposed end point and then adding one drop more of the caustic soda solution, when the further colour change mentioned above should take place.

The amount of boric acid present in the aliquot is calculated from the caustic soda used.

1 ml. of 0.1N NaOH = 0.00618 gm. H_3BO_3

The boric acid content of the timber shall be the average of the duplicate determinations and shall be expressed as a percentage of the oven dry weight.

The duplicate determinations shall agree to within 20 per cent. of each other, otherwise they shall be disregarded and fresh determinations made. Where the samples contain boric acid in excess of 0.8 per cent. as calculated on the oven dry weight of the timber, the duplicate determinations may differ by more than 20 per cent. if the lower result obtained is greater than 0.3 per cent. boric acid.

c. Test for determining the Fluorine Content of Treated Timber. The preparation of the sample and the determination of its moisture content shall be as laid down for boric acid in Section 3b.

Place 5 gm. of the finely ground wood sample in a 250 ml. conical flask and 40 ml. of distilled water and reflux on a sand bath for five minutes. Cool and filter into a 100 ml. volumetric flask. Wash down the conical flask and filter paper with several small successive portions of distilled water to ensure the transfer of all the original solution into the 100 ml. volumetric flask. Then make up to volume. If the solution is coloured, add 5 mg. of lead nitrate and then filter.

Prepare a set of colour standards as follows:

Dissolve 100 mg. of iron as ferric chloride in one litre of distilled water containing 30 ml. of N HCl.

Place 10 ml. of the ferric chloride solution in each of 12 Nessler tubes with 3 ml. of 8.24 per cent. sodium chloride aqueous solution. Then add to each, 10 ml. of 2.4 per cent. ammonium thiocyanate aqueous solution. To ten of the tubes in succession add respectively 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10 ml. of a standard fluoride solution containing 0.5 mg. NaF per ml.

To each of the remaining two tubes add 5 ml. of the test solution. Then dilute the contents of all the tubes to 50 ml. and adjust the pH to 3.2 with HCl.

The concentration of the fluorine is determined by comparing the colour of the solution in the tubes containing the test solution with those of the standards, in a Lovibond Tintometer or a suitable colorimeter.

The fluorine content of the timber shall be the average of the duplicate determinations, which latter shall agree to within 20 per cent. of each other otherwise they shall be disregarded and fresh determinations made.

d. <u>Test for Determining the Seekay Wax A123 content of Treated Timber</u>. Since the above preservative contains 59 per cent. chlorine, its estimation can be carried out by determining the chlorine content of treated timbers using the well known Volhard's method. The chlorine content of a comparable sample of untreated timber must be deducted from the result.

The preparation of the ground wood sample and the determination of its moisture content shall be as laid down in Section 3b. for the Boric Acid Test.

Place 5 gm. of the ground sample in a 100 ml. silica basin, mix well with one quarter of its weight of finely divided calcium oxide (chlorine free) and sufficient water to give a thin paste. Take the dryness of the mixture on a water bath and ash slowly in a muffle furnace, commencing at a low temperature, just sufficient to char the mass. Gradually raise the temperature until a very dull red heat (about 550°C.) is reached but do not exceed this temperature.

After allowing to cool, moisten the ash with 25-30 ml. of hot dilute nitric acid (1:4) taking care to avoid loss by effervescence. After a few minutes filter the solution into a 250 ml. volumetric flask (a 9 cm. Whatman No.44 filter paper will be found suitable). Wash the basin and filter paper with warm water.

When the filtrate is cool add an excess of 0.1N Silver Nitrate (A.R.) measuring the volume accurately. Shake the solution until the precipitate of Silver Chloride clots, then dilute to volume and thoroughly mix the contents of the flask. Filter through a dry 11 cm. Whatman No. 44 filter paper, rejecting the first runnings and collecting the rest of the filtrate in a dry flask. To a suitable aliquot, usually 100 ml. add 2-3 ml. of Ferric alum solution (prepared by adding 5 ml. of 6N Nitric Acid (A.R.) to 100 ml. of a saturated solution of Ferric Ammonium Sulphate (A.R.)), and then titrate it at less than 25°C. with 0.1N Ammonium thiocyanate, against a white background, until the first signs of the reddish brown colour of ferric thiocyanate persist. The amount of standard thiocyanate used corresponds to the excess of Silver Nitrate added calculate the amount of Chlorine present in the original sample. The chlorine content of the timber shall be the average of duplicate determinations which latter shall agree to within 5 per cent. of each other, otherwise they shall be disregarded and fresh determinations made. 1 ml. 0.1N Silver Nitrate corresponds to 0.00355 g. of chlorine.

Note 1: In the above procedure, the precipitation of the chloride and its subsequent removal by filtration may be avoided by the addition of a little pure (A.R.) Nitrobenzene (1 ml. for each 0.05 g. of chloride present).

Note 2: The nitric acid used in the extraction of the ash and in the ferric alum solution must be free from nitrous acid. It is prepared by diluting A.R. nitric acid with about one fourth of its volume of water and boiling until perfectly colourless.

Appendix A

Concentration of Preservative

a. Boric Acid and Borax. Timber immunized with boric acid or borax shall contain in the core a minimum concentration of boron equivalent to 0.2 per cent. boric acid calculated on the oven dry weight of the wood.

b. Sodium Fluoride. Timber immunized with sodium fluoride shall contain in the core a minimum concentration of fluorine equivalent to 0.1 per cent. sodium fluoride calculated on the oven dry weight of the wood.

c. Seekay Wax A123. Timber immunized with Seekay Wax shall contain in the core a minimum concentration of chlorine equivalent to 2.0 per cent. Seekay Wax A123 calculated on the oven dry weight of the wood.

Mr. Huddleston considered that separate specifications should be prepared for decay, Anobium, fire-proofing, etc. He suggested a Committee be formed to examine the draft specification for immunized timber.

Mr. Cokley agreed with Mr. Huddleston.

Mr. Tack drew attention to anomalies in chemical nomenclature.

Mr. Clarke advised that "Methods of Testing" be separated from the specification, as these may be required for other purposes.

Mr. Huddleston suggested that the details be left to a small committee.

Mr. Cokley supported Mr. Huddleston. He said he was interested in the legal view (in connection with the State Acts) should the proposed specification become an Australian Standard.

Mr. Turnbull considered that such a proposed standard would have a very low priority with the Standards Association.

Mr. Clarke suggested that it might be possible to have the proposed specification made a standard more speedily if the methods of analysis were eliminated.

Mr. Huddleston replied that it was impossible to eliminate the methods of analysis until there was some replacement, possibly in the form of an Appendix.

Mr. Clarke asked for suggestions for committee members, the committee to operate by correspondence.

Mr. Huddleston suggested Messrs. Tack (Convenor), Turnbull, Fogl and Cokley.

F. TOXICITY OF WOLMAN SALTS

Mr. Tack: A working Plan has been prepared for this investigation. Constant liaison between the Division of Forest Products, Division of Wood Technology and Queensland Forest Service should result in the test commencing this summer. Borax and boric acid are to be included, together with a number of other water soluble preservatives, and a re-determination of toxicity levels made.

Division of Forest Product's Lyctus breeding room has been renovated. The walls have been cement rendered and finished with a rubberized paint. Because of mite infestation, all shelving has been re-dressed and crevices and cracks treated with a pentachlorphenol solution before painting with enamel.

A satisfactory breeding rate has now been achieved, and over a period of several weeks, we have consistently collected from 400 to 500 beetles each week. The number of live beetles produced per female has been increased by 75 per cent. These beetles have been used for the propagation of two separate strains which will be used in the forthcoming experiments to determine the minimum lethal concentration of a number of chemicals including Wolman tanalith, boric acid, and borax.

Mr. Gay was thanked for his very generous contributions of beetles over the past two years and for his advice.

G. GLUE LINE TESTS

Mr. Gordon: In the extensions to the Veneer and Gluing Laboratory, it is proposed to have one room of experimental plywood containing two concentrations of "Gammexane" and one room with control plywood. The plywood is being prepared in Queensland. The initial difficulty in converting I.C.I. "Gammexane" into powder to use in glue has been overcome. Queensland Forest Service is to retain surplus plywood made from the gammexane glue to carry out parallel observations under different climatic conditions. Correspondence with I.C.I. following the publishing of an article by Messrs. Gordon and Tamblyn in the Newsletter, suggested that "Gammexane" readily breaks down under alkaline conditions. This information is doubted because in tests controls were attacked while treated specimens remained sound.

Mr. Clarke asked whether the action was heavily buffered.

Mr. Gordon said that it was.

Mr. Cokley assured Mr. Gordon that extensive work has been started and stated that Mr. Gordon's results did not agree with those of Cooke (South Africa) who stated that D.D.T. lasts only three months.

Mr. Gay said the effective life would depend upon the circumstances in which D.D.T. is used. He had found 100 per cent. protection in a 12 months' soil test.

Mr. Tack asked did the pH influence the matter.

Mr. Gordon replied that although I.C.I. suggested that glues with a high pH would negate the effectiveness of admixed Gammexane, the test panels had been glued with urea glues having a pH of 13.5 and after 2½ years exposure were apparently still proof against borer attack.

H. PINHOLE BORER CONTROL

Mr. Huddleston: We have found that creosote spraying as soon as possible after felling is a satisfactory control, but the Malayan Forestry Authorities disagree - they say that the "gammexane" type of poison is needed. Species in Malaya and Australia differ and it is proposed to leave Malayan species to Malayan authorities. Creosote sprays are being checked and "gammexane" is being included in tests to determine the necessary concentration for protection.

Mr. Tack said that creosote had been quite effective at Casino, N.S.W. It has been included in the Trade Circular, with "gammexane" as an alternative.

Mr. Clarke asked what were the quarantine requirements for pinhole borer control.

Mr. Huddleston said it was required to spray with creosote, or the timber must remain in quarantine until sawn, when it must be kiln dried.

It was suggested that "Gammexane" plus oil may be cheaper than creosote.

J. LYCTUS PUBLICATIONS

Mr. Beesley explained the lack of action on these publications since last Conference. He said the new Trade Circular was to be issued shortly.

Mr. Tack suggested that early publication would be assisted by quick revision by Queensland Forest Service, Division of Wood Technology and Mr. Gay.

Mr. Fogl drew attention to the Treatment Manual being prepared by New South Wales.

9. PAINTS AND LACQUERS

A. GENERAL PAINTING TECHNIQUE PUBLICATION OF THE DEFENCE RESEARCH LABORATORIES

Mr. Bussell reported that work was progressing steadily after some delay through lack of staff.

B. STENCIL PAINTS FOR GREEN AND STORED TIMBER

Mr. Bussell stated that an Aluminium or Black pigmented spar varnish had proved satisfactory, also a Standards Association of Australia case marking paint. The latter was made by several Sydney paint firms whose names he could supply.

C. GENERAL

Mr. Bussell reviewed the paint-holding properties of Australian timbers. He reported 2 year's exposure of painted panels at Villawood, N.S.W. and Maribyrnong, Vic. Australian timbers - hoop pine, jarrah, blackbutt, spotted gum, mountain ash, cypress pine and radiata pine were compared with the American timbers - Western red cedar (good paint holding qualities), northern white pine (fair paint holding qualities) and southern yellow pine (poor paint holding qualities). Four primers were compared.

After 12 months jarrah, hoop pine, radiata and western red cedar showed good paint holding. After 2 years the paints in the New South Wales test had deteriorated much faster than in the Victorian test. Paints on jarrah, hoop pine, cypress and radiata were satisfactory and better than those on western red cedar. No primer differences were noted.

The results of the inspection at the end of three years are difficult to evaluate. Separate values were allotted for direct paint failure and paint failure resulting from timber failure. This analysis is still in progress.

The recent very wet winter in New South Wales had caused increased failure of paint films and failures because of timber failure. Gum exudation on blackbutt had restarted after 18 month's inaction and caused considerable staining of panels. Some panels, notably pines, had split and warped severely. Paints on hoop pine and jarrah panels are in the best condition in New South Wales, although on other panels, particularly radiata and cypress pine, failures of paint occured only on small knots.

The New South Wales panels will have to be withdrawn in 12 months, but the Victorian test should last 2 years more. The number of panels of each timber, free from paint failure caused by timber failure is similar at each station.

The rate of paint breakdown in Victoria over the last 12 months was slow because of mild conditions, but generally the differences observed in New South Wales were repeated.

Red lead primer may yet prove better than the U.S. tests indicate.

A report of this 3 year inspection will be prepared and published in full in Paint Notes.

Messrs. Bryant and Huddleston both stated that there had been considerable paint failure in Sydney as a result of the very wet winter.

Mr. Bussell added that March and April were the best months to paint to prevent ultra-violet breakdown of new paint. Painting in this period could greatly prolong paint life. It was also advisable to keep to one manufacturers paints for all three coats as their formulations were complementary.

Mr. Turnbull asked if the Defence Research Laboratories were extending the tests to other timbers.

Mr. Bussell replied that they would be testing Queensland timbers at 3 stations in Queensland.

Mr. McAdam asked if they would extend to New Guinea where his Department could assist.

Mr. Bussell replied that extension of the work would take time. He thought that there were some wartime test sites for aircraft fabric and dope in New Guinea and these might be used.

Mr. Dale raised the possibility of high moisture content of the timber contributing to the Sydney paint failures and asked if Defence Research Laboratories had checked moisture content as the tests progressed.

Mr. Bussell replied that no check had been made. He also said that in considering results it should be kept in mind that the paints in the test were not designed for maximum life, but to fail by different means such as chalking and flaking.

Mr. Turnbull asked whether different timbers needed different primer spreads.

Mr. Bussell replied that no real differences were found in the tests, but that there was probably some difference between porous and greasy timbers.

Mr. Huddleston said that they were very interested in the whole question, as the cost of painting was increasing and forcing people to use substitutes such as aluminium window frames which, although they cost 3 times as much as wood cut out painting and only needed cleaning with steel wool.

10. MOISTURE CONTENT OF TIMBER

A. THE EFFECT OF CHEMICALS ON THE DETERMINATION OF MOISTURE CONTENT

Mr. Kingston stated that the last annual Forest Products Research Conference carried a resolution that Division of Forest Products examine the capacity method for determination of moisture content of timbers, particularly with respect to salt impregnated and preservative treated wood. Unfortunately the Division has been unable to proceed with this work in the past twelve months, but it is hoped that it will be commenced in the near future.

B. EQUILIBRIUM MOISTURE CONTENT OF TIMBER - REPORT OF COMMITTEE

Mr. Ellwood gave the following brief report on the activities of this committee. He stated that answers to a questionnaire on an Australia wide E.M.C. survey which was submitted to the State Forest Services were received from the majority of States. It has not been possible to take the matter much further, but with a view to determining the minimum number of samples to be included in the survey, preliminary experiments have been initiated to determine the E.M.C. variation between trees and within trees.

11. VAPOUR DRYING

A. EXPERIMENTAL WORK

Note: A technical paper on this subject - titled "Vapour Drying of Australian Timbers" and numbered 11 - has been printed in Vol.1. The discussion follows -

Mr. Ellwood stated that recent experiments on the preservation of *Pinus radiata* sleepers by the Reuping process have given promising results with regard to penetration and absorption. The following schedule was used: 50 lb./sq.in. initial pressure with final pressures of 200 lb./sq.in. for 3/4 hr., 150 lb./sq.in. for 1 hr., and 100 lb./sq.in. for 2 hr. followed by a vacuum of 28 in. of Hg. for 1/2 hr. Samples of treated sleepers were shown to the conference.

Present investigations are concerned with the moisture content of the sleeper prior to treatment, final treatment pressures and duration of the various phases of the Reuping process. Preliminary results are encouraging and show that timber with a high moisture content may be treated.

The most outstanding result obtained with hardwoods has been in the drying of Tasmanian Alpine Ash. It has been shown that this is technically possible, but it cannot be decided at present whether commercial application is feasible.

It is intended also to investigate the vapour drying of collapse-prone hardwoods from an air-dried condition. With most hardwoods, very careful control of drying conditions is necessary and good results have been obtained only when treating under high vacuum and keeping the wood-temperature low.

Twenty species have been tested. Technically it appears that most species can be dried, but it is questionable whether it can be done economically. Technically the drying of Pinus radiata joinery stock does not seem to offer any major problems.

Samples of vapour-dried joinery stock of Pinus radiata, Tasmanian alpine ash and Tasmanian myrtle beech were shown to the conference.

Mr. Cokley asked for a comparison of the costs of vapour-drying and kiln-drying.

Mr. Ellwood replied that from the performance of the Division's experimental plant it was difficult to judge the economics of a commerical installation. It appears that the economics may be satisfactory for permeable timbers.

Mr. Wright added that it is difficult to estimate the cost of the process because there are many unknown factors. For a plant drying 2,000,000 s.ft. p.a., the cost of the installation might range from £8,000 to £18,000, depending on the availability of equipment. Taylor-Colquitt quoted 80,000 Dollars, including the boiler (about A£35,000). The probable cost in Australia is £12,000 to £15,000. Mr. Crowe paid £8,000 for his first plant, but much second-hand equipment was used. Availability of personnel, species and sizes to be dried, etc. must also be taken into consideration. As an illustration, the cost for ordinary kiln-drying may vary from 4/6 to 9/- per 100 s.ft. depending on number of kilns.

Mr. Bryant asked if any measurements had been made of the amount of recoverable resin extracted from the timber.

Mr. Ellwood replied that no tests have been made at the Division, but American tests on slash pine have shown that measurable amounts could be recovered.

Mr. McAdam asked if the collapse exhibited in one of the samples shown to the conference could be removed by reconditioning.

Mr. Ellwood replied that the samples had not been reconditioned, but good recoveries had been obtained with reconditioning of other samples. He added that vapour-dried boards have very big moisture gradients at the end of the drying treatment, e.g., 2 per cent. in the case and 17 per cent. in the core for a board with an average moisture content of 12 per cent. This condition also calls for a steaming treatment.

Mr. Payne asked if the more refractory timbers were the more costly to dry.

Mr. Ellwood replied that was so, e.g. with ash eucalypts, a continuous high vacuum is required and this necessitates special equipment and maintenance. A continuous vacuum also makes the recovery of the drying agent more difficult.

Mr. Turnbull asked for information on the substances used, their prices and the losses of chemicals during the process.

Mr. Ellwood replied that there was a great range of prices and the most expensive item was perchlorethylene at 16/- per gallon. This solvent has the advantage of being non-inflammable. Many other solvents range about 4/- per gallon.

The losses are fairly big on the Division's plant, but in America where most work is done on large dimension stock, solvent losses are reported to form a very small percentage of the total cost.

Mr. Clarke asked if the cost of treatment was influenced by absorption of the drying agent.

Mr. Ellwood replied that some solvent was absorbed during the process, but a final vacuum was used to remove it.

Mr. Clarke asked why the losses are higher when drying under a vacuum if a final vacuum removes the absorbed drying agent.

Mr. Ellwood replied that the condensor of the experimental plant was not efficient and solvent vapours escape through the vacuum pump to the atmosphere.

Mr. Gottstein added that a large quantity of solvent is retained in the sapwood.

Mr. Clarke remarked that there should be no sapwood in Tasmanian alpine ash, though there could be some in myrtle beech.

Mr. Wright replied that the remarks regarding retention of solvent did not refer to Tasmanian alpine ash, but to sapwood generally.

Regarding the cost of treatment, the cost is higher for the more refractory species and relatively lower for *Pinus radiata* and the like. The process should therefore be first applied to pines,etc. It must be noted that the Americans remove only the free water as a preparation for preservation.

Mr. Turnbull asked if the process could be controlled by instruments, or must a skilled operator be present.

Mr. Wright replied that in America, the process is controlled by instruments. A skilled chemist is present during the daytime, but negro labour only during the night. On the straight process, where no high vacuum is required, automatic control is possible.

Mr. Ellwood added that for the more refractory species, the control becomes difficult.

Mr. Wright said that it should not be more difficult than control of distillation processes, and these are controlled by instruments in many cases.

Dr. Dadswell asked if the effect of the high temperatures on the properties of the timber had been investigated.

Mr. Ellwood replied that no work has been done at the Division. American reports, which may be coloured to some extent, suggest that large size vapour dried stock is stronger than steamed material. There are no data comparing vapour dried stock with kiln dried stock.

Mr. Wright added that some remarks on the history of the process might be helpful in this connection. Taylor Colquitt at first air dried their poles, sleepers, etc. Later on, the timber was steamed for a certain time and the residual heat after removal from the chamber dried out a proportion of the moisture. This steaming treatment caused up to 25 per cent. loss in strength. The company then turned to vapour drying in the hope that rapid drying might be achieved without loss in strength.

Tests carried out by the Bell Telephone Co. suggest that vapour-dried poles are stronger than steamed poles, but weaker than air-dried ones.

Dr. Dadswell suggested that it would be worth while conducting a test to investigate the effect of the heat of drying on timber strength.

B. APPLICATION OF VAPOUR DRYING AND PRESERVATIVE TREATMENT IN AUSTRALIA

Mr. Clarke stated that during a visit to the Division this week, Mr. Crowe suggested vapour drying attachments be fitted to the high pressure cylinder. I refused as it would delay installation and our cylinder will be fully occupied for some time with pressure treatments. Also all our immediate experimental vapour drying work can be satisfactorily accomplished with the existing equipment. Mr. Crowe had in mind a project for the formation of a public company with the following objectives:

a. Vapour drying plus creosote treatment of P. radiata in South Australia.

b. Pressure immunization with borax, boric acid, etc. of scrubwoods at Newcastle, Coffs Harbour, Casino, etc., such plant to be also suitable for the creosoting of poles, posts, etc.

c. Establishment of pole shaving plants to bark or desap 200 poles per 8-hour day, using a crew of 8 (Taylor Colquitt manufacture this plant).

d. The establishment of small size pressure treating plants (capacity 1500 to 2500 s.ft. per charge) of about 3 ft. diameter and 35 to 50 ft. in length. These plants are to be erected in selected areas, staffed initially by Boracure men and operated under licence. These plants are to treat with borax or creosote, etc. and will cost in the vicinity of £2,500 (N.Z.) each. Finally these installations will be used in conjunction with vapour drying treatments. Crowe considers that all timbers amenable to Lyctus immunisation treatment should be amenable to vapour drying. He also considers there are no indications that poles and other round timbers cannot be vapour dried successfully, at least in the sapwood zone.

Mr. Huddleston stated that he had read Mr. Crow's proposals. He was not concerned with the details of drying methods, but felt that in New South Wales there is definite need for preservative treatment of poles, posts, etc. He said that the Division of Wood Technology would help and encourage Mr. Crowe in establishing preservative treatment.

Mr. Irvine asked if Mr. Crowe held patent rights of Taylor Colquitt for all vapour drying.

Mr. Clarke replied that he had, but it may be necessary to test their validity in the court as other drying agents might be used.

Mr. Wright remarked that in New Zealand, the Division of Forest Products were using a vapour drying plant.

Mr. Huddleston questioned whether the government was exempt from patent law?

Mr. Wright said that a government could make and use patent products provided it was not for gain.

Mr. Huddleston said this is doubtful. The Division of Wood Technology was advised that they were liable if they copied a patent by measuring scale.

Mr. Fogl suggested that Mr. Crowe's optimism seemed to have some grounds. D.W.T. had found Lyctus susceptible timbers easily impregnated. The proposal may be economic if boric acid treatment and vapour drying are combined.

Mr. Thomas said that South Australia is very interested in the vapour drying of Pinus radiata, especially scantling timbers. "Boracure" are negotiating for a pilot plant, but availability of suitable material (sleepers, scantlings, etc.) was still a few years off. He suggested that it may be uneconomic to start for about 5 years in South Australia.

Mr. Tack stated that the company formed in South Australia did not now include Mr. Crowe on the Board of Management. He added that for a pressure plant to be run economically it must work full time, so that if timber supplies are inadequate a pressure plant becomes uneconomic.

The present day hot and cold bath boric acid plants in Australia run one charge per day, which does not interfere with normal mill running.

Mr. Gokley in support of Mr. Tack's remarks about pressure plants running full time said there are four mills at Tully, each cutting about 3000 s.ft. per day. Queensland Forest Service tried to persuade the millers to put in a central treating plant to operate full time, but they prefer individual plants. It is claimed that the labour and cartage costs would be too great.

Mr. Huddleston suggested that under Australian conditions, any treating company would have to be a trading company, i.e. they would buy timber, treat and sell. This should not be difficult, as there is an agent company at Coff's Harbour, N.S.W., who deliver fence posts, sleepers, etc. from the mills to the wharves for export, or forward direct to the various Government Departments. A treating company could buy from such agents and re-sell, or buyers could require treatment before delivery from the treating company.

Mr. Fogl stated that, at present, pressure treatments with borax seem to be uneconomic if operated by a single mill to treat only its own output. Division of Wood Technology have no cost figures.

12. PREDRIERS

Mr. Gottstein: In the Division of Forest Products statement on the predrier at last year's conference, it was pointed out that because of the rather difficult nature of the drying requirements, considerable modification and development was necessary.

After careful consideration of the merits of progressive stack movement, progressive adjustment to air circulation and species requirements, it was decided to investigate the possibilities of a multiple stack drying unit which could provide substantially the same drying conditions throughout the compartment.

The slow drying rate associated with the Tasmanian hardwood species suggested that a design incorporating reheat between stacks should be practical. Under such conditions, air at a velocity of 200 f.p.m. can pass through at least six stacks before significant changes occur in wet bulb temperature. Substantially uniform conditions can thus be applied to six stacks side by side in one large compartment and such an arrangement avoids all stack and baffle movement problems. The design is being developed, and it is anticipated that construction will commence, at at least one plant, in the very near future.

The proposed unit will provide constant schedule predrying conditions in which any stacking line may be reloaded as required and mixed thicknesses may be loaded on separate lines without serious upset. Alternatively, with suitable control equipment the arrangement will permit changes in the steady drying conditions throughout the unit so that operating as a large compartment, schedule conditions in accordance with species requirements can be applied. There are indications that a true progressive unit cannot provide ideal drying conditions for "ash" type eucalypts. The efficiency, from a thermodynamic aspect, will not be quite equal to that of a progressive type, but as surplus fuel is generally available this may not be serious.

Initial schedule trials of the more flexible conditions available in the multiple stack compartment have shown, that with Tasmanian brown top (E. obliqua), results are most promising. This has been confirmed by trial in a commercial compartment unit in Tasmania. Laboratory work on schedule development is being continued.

The predrier unit at Stanley, Tasmania, which was referred to at the last Conference, was originally built approximately according to our design, following proposals made by Mr. Hugh Fenton (at that time Director of Circular Head and Amalgamated Timbers, Tas.). This unit had 7 stacking lines and a total charge capacity of about 100,000 s.ft. In order to increase capacity Fenton introduced a portable air circulating unit using high pressure axial flow fans. The stack lines were then increased to 15, giving a charge capacity of more than 200,000 s.ft.

Serious operational difficulties were encountered and our assistance was requested in April of this year. Tests carried out on the unit showed that the portable air circulator and axial fans were remarkably effective. They provided adequate air circulation through 14 stacks with a loss of about 1/2 in. of static head at an air flow of 200 f.p.m. through the stacks. However, heat distribution was most unsatisfactory, causing dry bulb temperature differences of as much as 15 degrees between top and bottom of the same stack. Faulty heat distribution was primarily due to air losses from the main heating duct into the drying chamber and conduction and radiation losses. Air distribution from the heaters and ventilation was also unsatisfactory.

Modifications effected major improvement in performance and ultimately good drying quality control was obtained. However, it was questionable whether the large charge capacity and attendant lack of flexibility were satisfactory. With each stack change the necessary movement of the air circulating units was cumbersome. It is possible too, that an inherent weakness of the design would have caused excessively high wet bulb temperatures under warm and humid summer conditions, as adequate ventilation was not attainable.

Unfortunately a fire occurred in the plant recently and the predrier was completely destroyed. The cause of the fire is not known; it may have been due to an electrical fault in the portable air circulating unit or to a belt or bearing failure. Fire control facilities were not good and the construction was not of a very high standard.

Mr. Fogl asked what routing was followed in moving stacks and air circulator units.

Mr. Gottstein explained that the sequence used to obtain satisfactory drying conditions was similar to that used in an orthodox progressive drier with moving timber stacks.

13. ADHESIVES

A. STANDARDS FOR ADHESIVES

Mr. Gordon reported that the Standards Association of Australia had set up an adhesives committee, of which he was chairman. It was proposed that the revision of the Australian Standard Specification for Plywood No. 0.6 - 1938 should refer to standards drawn up by this committee. Draft standards for synthetic resins and for protein adhesives have been prepared. It is proposed to draw up a standard for adhesives for assembly gluing.

B. TANNIN FORMALDEHYDE ADHESIVES

Mr. Gordon reported on work done in testing the tannin-formaldehyde resins developed by the Division of Industrial Chemistry. Though the cost of production was low a major problem resulted from the working life being too short for commercial application.

Dr. Fitzgerald and Mr. Dalton referred to experiments being carried out to modify the resin chemically. Treatment with sulphite was being investigated.

Mr. Bryant said that Pinus radiata bark might be worth investigating as a source of tannin.

It was agreed that the Division of Forest Products could supply bark for extraction in the Division of Industrial Chemistry.

C. SETTING OF RESIN GLUES IN COLD WEATHER

Mr. Higgins drew attention to trouble which had been experienced by plywood and furniture manufacturers using urea-formaldehyde resin glues in cold weather. Most Australian factories are not centrally heated and low night and early morning temperatures, which occur even in Queensland in winter, may not allow the setting of the glue in the period normally available for this process. Some resin glues have a threshold temperature, below which the setting rate is very slow. High relative humidity may be a factor in slowing down the setting time. The rate of setting of resin glues is not taken into sufficient consideration in comparing their relative merits with other types, such as protein glues, under Australian conditions.

Mr. Huddleston suggested that the behaviour of urea resin glues in the presence of boric acid-treated veneer should be included in any investigations which were to be carried out on these problems.

Mr. Gordon pointed out that in the United States, resin glue manufacturers usually specified 70°F. as the minimum temperature for use: a point which often seems to have been overlooked in Australia.

Mr. Oakley referred to proposals to establish plywood plants in North Queensland and a discussion took place on the most suitable types of adhesives for these projects.

D. BLOOD PROTEINS FOR ADHESIVES

Note: A technical paper on this subject - titled "Blood Proteins for Adhesives" and numbered 13D - has been printed in Vol.1. The discussion follows -

Mr. Plomley added that fertilizer grade blood glues can be set only in the hot press. They are not well suited to timbers of low density, owing to their tendency to penetrate the wood and starve the glue-line. Improvements have been observed in allowing the glue to dry out before pressing and by incorporating 20 per cent. of casein. The possibility is not good of obtaining a satisfactory cold-setting glue from fertilizer blood and the main success with this material has been confined to building boards, as reported previously by Mr. Hebblethwaite.

In the subsequent discussion it was pointed out by State delegates that there was no very strong interest in the proposal by the abbatoirs.

E. PROTEIN INVESTIGATIONS

Note: A technical paper on this subject - titled "Protein Investigations" and numbered 13E has been printed in Vol.1. The discussion follows -

Mr. Higgins stated that his paper on protein investigations included no technical or scientific detail, but outlined merely the scope of the work and the way in which it impinged on other fields. Since the paper was prepared a considerable amount of work had been carried out on the action of rennet on casein.

Mr. Lawrence said that the problem of the formation of casein gels was of vital importance to the field of dairy research, and cited several examples.

14. COMPOSITE WOOD CORRESPONDING COMMITTEE

Mr. Gordon: The summary of Collation No.2 of the

Composite Wood Corresponding Committee and a copy of my contribution for Collation No.3 have been forwarded (on the 10th August) to State Forest Services, New Guinea Forests Department and the Forestry and Timber Bureau.

The following is a summary of points in Collation No.3 which should be of interest to those attending this conference.

A. EXCHANGE OF RESEARCH PROGRAMME

a. India

The following items are of interest. At Dehra Dun the following equipment has been installed:

Merritt veneer lathe.

Covell Hanchett knife grinder.

Merritt Dryad.

Diehl jointer.

Diehl splicer.

Francis glue mixer.

Francis glue spreader.

Adhesive Investigations

Tests are being carried out on proteins from seeds of *Terminalia belerica* and *Lathyrus sativus*.

Drying of Veneer

A small veneer drier using infra-red lamps has been constructed and a few experiments have been carried out.

b. U.S.A.

Items of interest in the programme for the current year include studies of durability of glued joints, gluing properties of different species of untreated wood and of treated and modified wood, records on service of glued joints including laminated timbers, study of methods to reduce checking of veneer blocks and peeling blocks during heating. The evaluation of overlays for plywood, veneer and low quality lumber is continuing with emphasis on the development of tests for specification purposes. The preparation of dry-formed boards and pressing at high temperatures are being investigated in studies to evaluate various types of composition boards as corestock materials.

c. Canada

Laminated constructions including rifle furniture and railway ties (sleepers) are being developed.

d. England

Investigation into causes of distortion of plywood are proceeding. An infra-red oven for very rapid determination of moisture content in veneer is under construction.

B. ADHESIVES

Information exchanged concerning requirement of adhesives for plywood shows a general agreement that adhesives might well be classified into four groups, viz. a. waterproof (Princes Risborough-weatherproof), i.e. will withstand indefinitely, exposure to alternate wet and dry conditions or high humidity; b. highly water- or moisture- resistant (Princes Risborough weather-resistant), i.e. will withstand soaking in warm or cold water but, if subjected to continued wetting and drying, will ultimately break down; c. moderately moisture-resistant, i.e. will regain strength after soaking in cold water for a limited time; d. non-moisture resistant - for use in dry conditions only. However, it is considered in England, Canada and U.S.A. that for all practical purposes only three types of glue are required:

a. Waterproof.

b. Moisture resistant.

c. Dry-bond - for use where moisture resistance is not required.

Proposed Interchange of Weathering Test Material

The interest in the proposed exchange of plywood samples for weathering test observations has been considerably diminished. Madison considers that any additional information obtained would not warrant the work and expense involved in preparing test samples. However, discussion on this point is not yet finalized. We are still very interested in carrying out tests which would help us determine to what extent characteristics of veneer used in outer plies affect serviceability of plywood the glue-lines of which remain intact.

Gluing of Preservatized Wood

There was an exchange of information on the gluing of preservative treated wood. Naturally, if preservative treatment is necessary to protect laminated timber against decay, a waterproof type of glue must be used. Consequently most references suggest the use of resorcinol and phenol glues.

The Princes Risborough laboratory provided an interesting table showing that the wet and dry shear strengths of a phenolic film glue was practically unaffected by impregnating veneer with "Tanalith" 4 per cent., "Chromel" 2 per cent., "Faspos" 2 per cent. or borax 2 per cent. The plywood made from the first two is reported to be in excellent condition after nearly seven years exposure to the weather.

Classification of Adhesives

The Madison Laboratory proposes that four sub-divisions be employed:

Low-temperature or cold-setting	5° to 20°C.
Room-temperature setting	20° to 30°C.
Intermediate-temperature or warm setting	30° to 95°C.
High-temperature or hot-setting	above 95°C.

Madison also drew attention to certain trends in the use of glues in U.S....

a. The use of straight resorcinol glues seems to be decreasing presumably on account of cost but phenol-resorcinol blends, which sell at moderate cost and set at temperatures below 100°C. seem to be increasing in popularity.

b. Very little melamine adhesives is sold to the woodworking industry but melamine modified urea adhesives are in only moderate demand for plywood production.

c. Although separate application urea resin and acid catalyzed phenol-resin glues have been actively promoted they have not gained any wide use in the production of wood items.

d. Polyvinyl emulsions have not persisted in use, except for special purposes where resistance to sustained load is not required. They have been found suitable for dowelled or tenoned joints.

e. Wheat flour and walnut shell flour continue to be the chief extenders and fillers for resin glues. The use of corn gluten as an extender for phenol and resorcinol glues has been demonstrated and one plywood manufacturer is using a component of Douglas fir bark. An investigation is being made on the use of spent crank case oil for the same purpose.

f. Industrial use of high frequency electrical heating methods seems to be in an uncertain state. Certain manufacturers are using the process successfully and claim saving in cost (chiefly for edge gluing of corestock). Others have been dissatisfied, claiming prohibitive percentages of rejects, or failures to realize savings. Technical difficulties seem to result from lack of proper control over items such as moisture content, segregation of species and surfacing. Experiments are being conducted to determine the durability of joints cured by high frequency electricity.

A recent British development is the manufacture of a phenolic glue retaining the desirable characteristics of a plywood glue but which sets at temperatures as low as 100-105°C. Pot life up to two days, recommended spread 2-4 lb. per 100 sq. ft. The opinion is expressed that such "easy to use" phenolic glues will do much to speed the introduction of the one class exterior plywood specification.

C. PLYWOOD MANUFACTURE

Mechanics of Peeling

Information concerning peeler setup and nomenclature of essential parts is being exchanged.

Assessment of Veneer Quality

All laboratories are agreed that some good method of comparison is desirable, but so far visual methods and personal judgment are used for evaluation.

Evaluation of Species for Peeling

Necessity for log grades is acknowledged everywhere and Madison is giving attention to correlating external appearance of logs with quality of veneer obtained. Madison has initiated studies on hickory to determine if popping can be reduced by variations in felling and cross-cutting technique.

At the Princes Risborough Laboratory an attempt is being made to formulate a scheme for assessment of veneer both as regards quality and quantity. However a major difficulty arises when comparing veneer from Douglas fir logs above 4 ft. diameter with veneer from birch , say 10 in. diameter.

Surface Coating of Plywood

Madison reports industrial use of three main types:

a. dense high resin paper - abrasion and water-resistant,

b. lower resin content paper - concrete forms,

c. low resin paper - masking defects, reducing face checking, as a base for painting.

Standards are being considered.

Corestock - Substitutes for timber.

In U.S.A. there is definite interest in composition boards made from sawdust and other wood waste. Investigations have been made of the effect of particle size, resin content and pressure in the properties of dry formed boards. The problem is to produce a board with shrinkage similar to wood. India is also working on projects in this field.

Madison reports being at a loss to judge relative importance of factors such as cross-grain, density and shrinkage on the warping of plywood. Even greater difficulties have arisen in determining causes of warping in hollow core constructions.

Mr. Clarke asked that delegates give special consideration to the activities of the Composite Wood Corresponding Committee and asked for special comments concerning the value of the work.

Mr. Gordon indicated that certain items under review by the Committee had been very helpful in providing guidance which was used in drafting Australian Standards for waterproof plywood and for classifying adhesives into different grades of moisture resistance. Referring to the increasing use of phenol-resorcinol blends in U.S.A., he indicated that there is at present on the market in Australia a so-called resorcinol glue setting at temperatures of 70°F., and upwards, which gives a completely waterproof bond and is therefore suitable for many purposes for which urea glues are unsatisfactory.

15. PLYWOOD

A. STANDARDS FOR PLYWOOD

Mr. Cokley said that the method of determining the strength of the glueline, as outlined in the Australian Standards Draft Specifications for Waterproof Plywood, was rather ambiguous. He asked whether it would be possible to standardize a definite shear or wood failure figure.

Mr. Gordon explained that the standards covered a large number of species and several adhesives, and that wood failure and shear values would differ from species to species, depending on the relationship between the strength of the wood and the strength of the bond.

Mr. Clarke asked whether Borneo cedar would be used as Marine or Standard Grade waterproof plywood.

Mr. Gordon replied that Borneo cedar varied greatly in density from tree to tree and he had received information of several unfortunate experiences using Borneo plywood in a stressed skin construction. He stated that the strength and quality of plywood should be judged in the light of its suitability for the particular use to which it would be put.

B. DRYING AND RECONDITIONING OF VENEER FROM ASH EUCALYPTS

Mr. Ellwood said that experimental work on the drying of ash eucalypts was now being applied to industrial practice. An officer of the Division visited one plant in Tasmania and installed a pilot reconditioning unit. Subsequently it was reported by the manager of this plant that daily recovery of the ash veneers had increased by approximately 8,000 sq. ft. a day (2,000,000 sq. ft. a year).

Also it was stated that buckling was removed, fine checks closed up, handling produced less degrade and in general the quality of the veneer was improved.

The success obtained in drying the ash eucalypts directs attention to other species which are difficult to dry, e.g. satinay and brush box and it is hoped later to investigate the drying of veneer from these species.

Mr. Cokley asked what was the position in regard to the Gurevicz process for gluing green veneers.

Mr. Gordon replied that no action had been taken on this matter. He also said that Gurevicz had reported that tests he had carried out at two plywood mills in New South Wales were not completely successful. Gurevicz blamed this in part on the facilities placed at his disposal. Mr. Gordon pointed out that checking of the face and back veneers must be expected if they were glued in this green condition. The quality of such plywood, although poorer than top grades of plywood manufactured from dried veneers could compete with lower grades especially since the cost of manufacture would be less. Mr. Gordon also stated that there was a large tendency for the sheets of plywood to warp when glued according to the Gurevicz process. He stated that the idea was not new and that large quantities of Russian plywood had been made in the past by a similar process.

Mr. Huddleston supported Mr. Gordon's remark and stated that the plywood mill at Armidale was not satisfied with the Gurevicz process.

Mr. Gordon in reply to a question from Mr. Cokley stated that the preservative treatment in the Gurevicz process was a simple borax cold dip of the veneers before assembly and that if conditions were controlled during drying of the plywood after assembly the resultant bond was quite good.

C. SILVICULTURE AND VENEER QUALITY

Note: A technical paper on this subject - titled "Silviculture and Veneer Quality" and numbered 15C - has been printed in Vol.1. The discussion follows -

Mr. Gordon said he wished to stimulate discussion of the desirable relationship between silvicultural treatment and veneer log quality. Although pruning is the aspect dealt with in the pre-printed paper, it is probable that other factors, such as rate of growth, might become important as further investigations are made in forest management and utilization.

Mr. Huddleston considered that the work carried out suggests that pruning practice is bad where the knotty core is about 8 in. diameter. It appeared desirable to prune to a 4 or 5 in. diameter core, but care must be taken in pruning to ensure that a 3 in. branch stub be left. To improve silvicultural practices it might be necessary to use different tools, techniques or schedules from those currently employed. The New South Wales Forestry Commission was very interested and would be glad to provide materials for further investigations.

Mr. Watson advised that Queensland was very interested in the project and would provide additional logs for study. He stated that the present tendency is to prune trees whilst still of relatively small diameter. Referring to problems of gapping of the veneer knife he stated that the Queensland plywood producers found that there was a definite relation between the quality of the steel in the knife and their susceptibility to damage in peeling knotty logs.

Mr. Thomas said that in South Australia logs of *Pinus radiata* had been peeled for a number of years. No difficulty has been experienced in peeling through knots and in fact plywood manufacturers preferred to have large logs irrespective of their external appearance and quality. South Australia is interested in improving silvicultural practice, but it should be realized that pruning too early reduces the rate of growth.

Mr. Payne stated that the oldest pine plantations in Tasmania were approximately 12 years old and for the last three years these had been pruned with a view to producing producing plywood and joinery stock. Although the cost of pruning was considerable, it was expected that a higher return for the clear timber would compensate. His department considered that insufficient was known on this problem and the matter was urgent. Tasmanian plantations were at a stage where they could benefit from a well considered policy based on correlations between pruning and quality. He suggested that Mr. Gordon visit Tasmania to discuss these points with the silvicultural experts.

Mr. Irvine commented that his observations on the veneer obtained from logs from Ovens Valley suggested that a higher recovery was obtained from unpruned than from pruned logs.

Mr. Gordon pointed out that the investigation of trees from Ovens Valley had been on a limited number of long logs and that the unpruned material was the top section of the pruned trees. However, Mr. Irvine did make an important point about the Ovens Valley logs - they were pruned too late to obtain maximum benefit and possibly it would have been better if they had not been pruned.

Mr. Clarke suggested that the effect of pruning a tree must be considered in relation to the full growth cycle of perhaps 40 years. Consideration should be given to the effect of having dead branches on the lower parts of the trunk which would give rise to encased or loose knots which would fall out on processing.

Mr. Brockway pointed out that there is a strong relationship between spacing in plantations and vigour of growth. Trees should not be pruned unless an economic improvement in quality can be assured. Because of labour shortages, the pruning programme in Western Australia has fallen well behind, but they were trying to catch up.

Mr. Chinner said that casual observations of the photographs circulated suggested that about 65 per cent. of the diameter of the hoop pine logs investigated had been laid down in the first 7 years, after which time growth had slowed down considerably. He felt that pruning practices must be allied with thinning studies and that the increment rate should be considered in relation to pruning. If only the final crop trees were pruned there would be some probability of loss of vigour due to the reduction of their crowns, and the dominance of final crop trees would be reduced.

Mr. Brockway sought information on whether there was any relation between the rate of occlusion and the size of the knots.

Mr. Gordon advised that insufficient material had been investigated to make a statement of this, but it was one of the points intended to be covered in future studies. He referred also to the fact that there was some relationship between the quality of steel in a peeling knife and its susceptibility to damage on cutting through hard knots. It was felt that knife damage might be reduced by some modification in grinding technique. Attention would be given to this point in the course of further work.

He stated also that he was glad to have the offers of co-operation from all Forestry Departments in supplying material for this investigation and he felt that as additional information was obtained the scope of the work might greatly expand. It would be of benefit to silviculturalists, to veneer and forest products researchers and in industrial applications of veneer and plywood manufacture.

D. RESISTANCE HEATING

Note: A technical paper on this subject - titled "An Electrical Method for Accelerating Gluing" and numbered 15D - has been printed in Vol.1. There was no discussion.

16. GROWTH STUDIES

A. GROWTH STRESSES

Note: A technical paper on this subject - titled "Tree Growth Stresses" and numbered 16A - has been presented in Vol.1. The discussion follows -

Mr. Boyd, in commenting on his paper, mentioned that many people had considerable difficulty in appreciating the system by means of which stresses accumulated in a tree. He went on to describe briefly how these stresses probably originate and how they build up in both the longitudinal and transverse direction. In explaining how the longitudinal stress relief at a cross-cut resulted in "dome-ing" of the cross-cut end of the log, Mr. Boyd said that it can be shown that the stresses set up are sufficiently high to cause such degrade as heart shakes in the log and spring in sawn boards. Brittle heart may also be a result of the theoretically very large longitudinal compressive stresses which develop towards the centre of a tree (these may be of the order of 18,000 lb./sq.in. at the centre of a tree 24 in. in diameter). He went on to say that these stresses are probably related to such factors as rate of growth and age.

and that possibly a suitable silvicultural treatment may be devised to control stresses and so reduce the amount of degrade in timber converted from the logs.

Mr. Huddleston said that he had read the paper, but found it difficult reading. However the work was of interest and very useful, as at present degrade was causing heavy economic loss. Sawmilling and veneering practice was based purely on previous experience. He would like to see Mr. Boyd's work extended to a consideration of how these practices might be improved in the light of the knowledge of the existence of these stresses in the living tree.

Mr. Payne stated that these stress factors need more attention than had been given them in the past. At present it is assumed that trees should be grown as fast as possible. He quoted a case of a Tasmanian sawmiller who was allowed to give up the milling of an excellent stand because of difficulties arising from popping of the logs. His department has decided to examine silvicultural treatments to see if this tendency to degrade could be overcome.

B. THE EFFECT OF SILVICULTURE ON CELL WALL STRUCTURE AND THE PROPERTIES OF WOOD

Note A technical paper on this subject - titled "Cell Wall Structure and the Properties of Wood" and numbered 16B - has been printed in Vol.1. The discussion follows -

Dr. Wardrop stated that results to be discussed were obtained by Wardrop, Dadswell and Bisset in collaboration.

Mr. McAdam said there appeared to be two ways of altering silvicultural practices to produce timber containing desired properties. Plant breeders should produce trees which had long tracheids right from the beginning (or facetiously) that trees should be planted on their 10th birthday when tracheids had increased in length.

Mr. Irvine asked if short tracheids would be produced by trees grown quickly at the start.

Dr. Wardrop replied that it is rapid radial growth which produces shorter tracheids. Priestley has shown that during rapid radial growth more anti-clinal divisions occur in the cambium and this results in short tracheids.

Mr. Amos added that in E. gigantea, latewood fibres may be 60 per cent. longer than early wood fibres and that the magnitude of fibre extension was the feature which controlled fibre length.

Dr. Wardrop stated that all his work had been done on gymnosperms, but he was aware that transverse anti-clinal divisions did not occur in angiosperms.

Mr. Wright asked whether short fibre length and large spiral angle, with consequent large longitudinal shrinkage, would be significant in sizes of timber cut commercially.

Dr. Dadswell replied that boards cut radially from the pith would have greater longitudinal shrinkage on one edge than the other and this would cause bowing.

Mr. Gordon suggested that Mr. Boyd and Dr. Wardrop collaborate with tree breeders to produce trees in which the effects of bowing due to growth stresses in trees cancelled bowing in the opposite direction due to longitudinal shrinkage.

Mr. Cooper asked whether the tensile strength of local wide-ringed, quickly-grown pines would be less than that of overseas narrow-ringed, slowly-grown pines.

Dr. Wardrop replied that it would.

Mr. Turnbull asked whether any work had been done on the properties and strength of the intercellular material.

Dr. Wardrop replied that the project had been commenced by Dr. Dadswell several years ago. In experiments to date on thin sections, and using the micro-tester developed in the Timber Mechanics Laboratory, all tensile failures had occurred in the tracheid wall and not in the cementing material between tracheids.

C. SILVICULTURE AND STRENGTH PROPERTIES

Mr. Kloot reported that progress towards the preparation of a working plan for the project on the relationship between silvicultural treatments and strength properties of timber had not been as rapid as was expected. This was partly due to technical difficulties and also to the large volume of testing required. Approximately 1,000 micro-specimens per month had been tested over the last six months, but this in the aggregate represented only a small amount of test material.

At present two investigations are in progress, one of these is the examination of the correlation between the micro-tensile test and other properties such as bending compression and toughness. Some 2,500 tests had been done on radiata pine and the results appear to be promising. The other investigation is a study of the variation of strength between and within growth rings laid down during a known period. The object of this study is to determine whether there is any similarity in the pattern of variation amongst trees grown under similar silvicultural conditions. Although he considered that the technique being used would eventually form the basis of a new working plan, it was felt that the preparation of such a plan at this stage would be premature.

D. SAPWOOD - HEARTWOOD INVESTIGATIONS

Note: A technical paper on this subject - titled " "Sapwood - Heartwood Relation" and numbered 16E - has been printed in Vol.1. The discussion follows -

Dr. Chattaway said that although it was not proved beyond all doubt, she was of the opinion that heartwood was the direct result of fungal attack on the sapwood. Fungal hyphae had been found up to the boundary of the heartwood in all cases examined. She had found eight species of timber containing no heartwood. They also had no tannins or extractives in the ray cells. In tannin containing woods fungi caused formation of certain types of crystals in the heartwood. Injury to the outside of the tree could cause phenomena similar to heartwood.

Fistulina hepatica and other unknown fungi are associated with heartwood formation. A sample of diospyros contained apparent heartwood which was later found to be all sapwood and coloration was due to accumulation of tannin in heartwood zone. Cells had been found alive and associated with starch right to the centre of the tree. In some species isolated spots of pathological heartwood occur. Griffoen likened the black heart of ebony species to fossilized wood and suggested bacterial action as the cause. With this she agreed. Oxidation of kinos may be responsible for development of colour in heartwood. The appearance of heartwood and sapwood under ultra-violet light was demonstrated. Brown and black heartwood regions fluoresced bright yellow and white sapwood was neutral (pale mauve).

Mr. Payne wanted to know what facilities Division of Forest Products had for fungal studies.

Mr. Da Costa replied that D.F.P.'s main interest is in fungi causing decay of wood. We experienced considerable difficulty in forming cultures of fungi from heartwood specimens supplied by Dr. Chattaway.

Mr. Clarke suggested these types of fungi might be anaerobic.

Mr. Da Costa replied that this was very doubtful.

Mr. Payne asked in what way States could assist in overcoming some of the difficulties associated with the work on heartwood.

Dr. Chattaway stated she would welcome freshly felled material, properly grease-coated and packaged and dispatched air freight. She wanted a wide range of sapwood species rather than large quantities of one species.

Mr. Huddleston said that Dr. Chattaway's personal contact with forest officers had aroused their interest in her work and these officers now regularly forwarded satisfactory timber samples to her.

Dr. Dadswell suggested that association of fungi and heartwood was more than a coincidence and felt that fungal attack on sapwood was a direct cause of the formation of heartwood. He considered that a new project was needed to study and make cultures of these heartwood-forming fungi.

Dr. Chattaway stated that there often appeared to be a shake associated with heartwood development and this might provide entrance for fungi.

Mr. Gordon asked how fungi get into trees.

Dr. Chattaway suggested that possibly it entered via broken branches and roots.

Mr. Da Costa asked which levels in the tree had been studied for heartwood.

Dr. Chattaway replied that most investigations were on material from near the butt, but higher levels in some trees had been investigated.

Mr. Da Costa said if a new fungi project was commenced two aspects would have to be studied - methods of culturing and identifying fungi, and distribution patterns of fungi in trees. The former would entail completely new work, as Australian Basidiomycetes have not been studied to any extent. It was asked what percentage of sassafras trees contained black heart.

Mr. Cokley stated that black heart was becoming important in Queensland and that Queensland would be willing to assist in the proposed projects. He wanted to know if there was any correlation between starch distribution and reaction under ultra-violet light.

Dr. Chattaway replied that there was not.

17. SAWMILLING

A. SAWMILL ENGINEERING - LABORATORY AND FIELD

Sawmilling in Scandinavia

Mr. Wright gave an outline of his study of this subject during his visit overseas in 1949. He said a close study of Scandinavian sawmilling methods was made during the three weeks his itinerary allowed in Sweden and Finland. Time was given to this study because relatively few Australian forest product workers have so far had an opportunity of studying in detail the milling and conversion methods used: methods known to be well suited to the conversion and utilization of the very considerable quantities of timber which will increasingly become available from the softwood plantations being established in Australia. Also, it was felt that economy of timber seasoning, like that of milling, is very closely associated with the handling and sorting methods used. Frequently these methods are common to both operations and require careful integration to ensure satisfactory flow of timber.

In this summary it is not proposed to discuss the procedure followed, nor the techniques and equipment used in Scandinavian sawmilling practice. A reasonably comprehensive report on this subject has been presented elsewhere*, and this is available for any sufficiently interested to pursue it further.

Scandinavia and Finland together produce about four times as much timber as Australia, i.e. some 4,000 million s.ft. per annum.

Approximately half of this is available for export. The milling problems involved are much less diverse than those found in Australia, principally for the following reasons - (a) only two species are generally milled, and both of these have very similar characteristics, (b) the countries have a vast waterway system and the sawmill logs are generally "floaters", so that log transport is relatively cheap, (c) the logs are relatively small and light, so that problems of equipment design are simplified, (d) the timbers are extremely tolerant to conversion and processing methods, and do not introduce difficulties from the presence of gum and the development of spring or collapse, as do many Australian species.

The Scandinavian sawmilling industry has adopted the frame or gang saw as the sawing unit around which the sawmill is developed. Two frame saws are invariably used in tandem to complete the conversion of a log. These two frames, together with a board edger and jack ladder from the log pond comprise the sawmill unit. A sawmill may comprise one or more of such units, up to as many as 6 or 8, in parallel and at from 10 to 15 ft. centres.

Production per sawmill unit of two frame saws, approximates some 32,000 s.ft. per 8 hour shift. Production rate per man shift of mill and log pond crew, approximates

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* "Swedish Sawmilling Practice". The Australian Timber Journal, July, 1950.

some 3,250 s.ft. - some 6 to 8 times the average rate obtained in Australian sawmills.

Average recovery from the mill log is approximately 78 per cent. on Hoppus basis. By comparison, mill recovery in Australia ranges from about 45 to 70 per cent., depending on a number of factors including species, log quality, log size and sizes sawn.

It is believed the major lessons demonstrated by the Scandinavian approach to sawmilling are, (a) the importance of designing sawmills on a truly functional basis. Among other factors this involves the accumulation of sufficient data to ensure that performance characteristics of various pieces of equipment are properly integrated and are suited to the particular conversion problem involved. The most satisfactory method of determining these data is by time and production studies, or mill studies as they are known in the field. (b) That sawmills are designed as an engineering unit with equipment to give precision cutting without the need for repeated face cutting through the mill, and that the auxiliary equipment and services provided are adequate for the duties required of them. (c) That the mechanizing of handling and transport systems leads to many economies. It results in less fatigue to workers, reduces the number of employees needed, and usually results in higher overall rates of production with consequent reduction in production costs. (d) That the time and money spent on plant maintenance is well spent. In many Australian mills too much production time is lost through the failure or inefficiency of sawing, power transmission or conveying equipment.

In comparing the cost of a well engineered mill and one indifferently built, it is of interest to note that the capital outlay of Swedish sawmills is of the order of

£14,000 per 1000 s. ft. of production per 8 hour day, whereas that of the average Australian mill approximates £1,000 per 1000 s. ft. per 8 hour day. However, the labour and other operating costs of the Swedish mills are considerably less than those of the Australian mills.

The mills and equipment seen abroad have emphasized the importance of the work now being done by forest products research groups in Australia, in seeking the engineering and production data which is so vital to the economic establishment of our timber industry.

Field Work in Australia

Mr. Turnbull: The Division of Forest Products has continued its service to the sawmilling industry on questions of engineering. The descriptions of equipment released in the News Letter continue to influence sawmillers, and an increasing number are approaching us for advice on layout of mills and choice of equipment. During the year assistance has been given in the preparation of sawmill designs to the State Electricity Commission, Victoria, the City Electric Light Company, Brisbane, to a number of private sawmillers in Victoria, South Australia, Queensland, New South Wales and Western Australia, and to a company proposing to operate in Pakistan. Some of these contacts are prepared to assign engineers to implement our suggestions and from this we hope that improvement in mechanical standards will result in some of the mills.

During the year we contacted all firms known to be manufacturing sawmill equipment in Australia, asking for information on their range of items and for descriptive matter. The response, although incomplete, has given us a considerable knowledge of the equipment manufactured in Australia and we are now arranging and indexing it for ready reference.

We propose to continue activities on the above lines in the coming year.

Laboratory Investigations

Experimental equipment has been brought into operation in the Division of Forest Products and studies on the fundamentals of circular sawing are proceeding. The equipment provides a means for driving a saw and a fly wheel of considerable mass at high rim speed, for disengaging the drive, and for feeding a piece of timber against the saw until the saw rim drops to a pre-selected speed and automatically disengages the feed. The rim speeds at the commencement and end of the feed and thus the energy for each cut is standardized, and by measuring the amount of wood cut by the saw during this interval it is possible to determine the effect of changing various features in the preparation of that saw. We propose to work with saws sharpened in various ways and to follow with work with different timbers.

Laboratory work is also proceeding with chain saws. We have been associated with the development of apparatus that will allow chains to be sharpened by a grinding wheel. This will eliminate slow and costly hand methods of sharpening. We have obtained a range of types of chain. We have also obtained an electrically driven unit, but are awaiting the receipt of a cutter bar of desired length before we can launch systematic cutting investigations.

Mr. Huddleston stated that at present it is not possible to correctly design sawmills and mill machinery, because of lack of information as to power requirements and no definite information as to correct saw speeds or feeds. The price of hardwood has risen from 33/- in 1939 to 87/9 in 1950 with a further 5/- to come and with the increase in basic wage yet to be felt. He felt the only way to offset this great increase in cost was to increase sawmill efficiency.

He suggested that Victoria gets more sawmill service from Division of Forest Products than other States, and that this should be corrected. At the same time, State bodies should build up staff in order to relieve D.F.P. of some of this work. He considered that a manual or handbook on sawmill engineering should be prepared to aid field officers.

Mr. Cokley remarked that a mill installed in Queensland and based on Victorian practice was not operating satisfactorily.

Mr. Clarke stated that the staff position at D.F.P. for this type of work is difficult, and at present no greater assistance could be given.

Mr. Wright remarked that an explanation of the non-uniformity of D.F.P's assistance on sawmilling would be found in the fact that New South Wales and Queensland have staff available for this work, but the other States do not.

B. MILL STUDIES

Mr. Turnbull stated that recently a mill study had been completed in the Heyfield area. Here, under conditions of licence, sawmillers are required to accept head logs, i.e. logs of small diameter from the branched length of the tree.

This study was made at the request of the Victorian Sawmillers' Association to investigate the yield obtainable from head logs and their influence on sawmill performance. It is expected that a report covering the study will be ready for issue in the near future.

Mr. Littler stated that recently Queensland completed a six weeks study on a mill cutting thinnings of several species. The study report will be published.

Mr. Walduck said that he would be taking part in mill studies in the future and asked if there was any certainty that mill crew worked normally over the period of the study.

Mr. Wright replied that the usual practice of Division of Forest Products was to explain the purpose of the study to the mill hands, then after a short period they apparently take little notice of the study crew. However, the first day of the study, though recorded, is not generally regarded as satisfactory.

18. BUILDING RESEARCH

A. BUILDING RESEARCH LIAISON SERVICE - REPORT ON ACTIVITIES

Mr. Brown: At last year's Conference Mr. Banks gave delegates a review of the functions of the Building Research and Development Advisory Committee and the Building Research Committee, and explained how these Committees formed part of the machinery which had been set up to co-ordinate the work of the various research bodies to ensure that the maximum benefits might accrue to the building industry from their activities. He also outlined the functions and programme of work proposed for the Building Research Liaison Service, which at that time had only recently been set up for the purpose of helping to implement the decisions of the two Committees mentioned.

I will endeavour to give you some idea of what has been done since that time. We were at the outset - and still are - severely handicapped by a shortage of suitable technical staff, and while this is a common complaint today, the inevitable result is that we have not accomplished all that we would have liked. The present technical staff at Head Office consists of Mr. Banks and myself and we have a Field Officer working practically full-time on our work in Sydney. In all other States we are dependent on the part-time assistance of officers who are so busy carrying out their normal duties that they are unable to give us more than nominal assistance. However, we are hopeful that this situation may be rectified.

Last year Mr. Banks mentioned his efforts to establish links between the industry through its professional and trade organizations and the research bodies through the Liaison Service. I am happy to say that we have been successful in establishing research Committees of Master Builders and Architects in Brisbane, Sydney, Adelaide and Perth. These Committees are extremely co-operative and anxious to help us in our work.

An important function of the work of the Liaison Service is the organizing of lectures on suitable research subjects to various groups within the building industry. A start has been made in this direction and lectures have been delivered to audiences of Master Builders and tradesmen in Adelaide, Melbourne and Sydney on the use of mechanical equipment in house building work. In Sydney a course of 12 lectures organized by the Liaison Service, under the general title of "Building Research Review", has been delivered at the New South Wales School of Architecture and Building by officers of various State and Commonwealth research bodies, the Standards Association and the Liaison Service. On the timber side, extremely valuable contributions were those of the Division of Forest Products and the New South Wales Department of Wood Technology. In addition to organizing lectures such as these, officers of the research bodies and the Liaison Service take every opportunity of speaking to builders and architects during interstate visits.

Another important feature of Liaison Service work is the distribution of the publications of the Commonwealth

Experimental Building Station. We have sold 1,500 copies of the C.E.B.S. booklet 'BUILDING TECHNIQUE AND BUILDING RESEARCH' and 900 complimentary copies have been sent to public and private authorities concerned with building and civil engineering. The mailing list for 'NOTES ON THE SCIENCE OF BUILDING' is now more than 9,500 and as these Notes are sent mainly to people who take the trouble to fill in an Order Form requesting them, the figures can, I think, be regarded as satisfactory. One of the most popular of these Notes is SB.11 dealing with Termites.

Exhibitions

A display of Exhibits on building research prepared by the various research organizations was held in the Sydney Technical College last month and arrangements have been made for it to visit Melbourne, Adelaide, Perth and Brisbane in the near future. As this was our first attempt at running an Exhibition, we were naturally concerned as to how it would be received. I am glad to say that reports from Sydney seem to indicate considerable success. Something like 3,500 people attended the Display during its week's run in Sydney.

Field Projects

Another important part of the work of the Liaison Service is in organizing field trials in order to prove under actual building site conditions, the efficiency or otherwise of materials and methods of construction already proven under experimental conditions by the various research organizations.

One such project with which the Division of Forest Products has been closely associated concerns the use of 9/16 in. hardwood flooring. As a result of investigations carried out in collaboration with the Commonwealth Experimental Building Station, the Division is satisfied that a hardwood floor 9/16 in. thick supported on joists at 18 in. centres will sustain satisfactorily all loadings likely to be imposed on it in a normal dwelling. Demonstration floors which have been laid for inspection by interested persons have supported this conclusion. However, Sawmillers and Building Contractors have expressed doubts as to whether a satisfactory floor could in fact be laid with the normal run of mill flooring under site conditions and also whether anything is likely to be gained on the score of economics.

It is clear that the real merits of the proposal can be determined only by a properly conducted field investigation in which sawmillers and builders participate, in consultation with the research bodies.

The Queensland Housing Commission has agreed to adopt 9/16 in. hardwood flooring in a group of 25 or 30 houses and the Queensland Sub-Department of Forestry is endeavouring to arrange for a sawmiller to produce the required amount of flooring. I understand that there is at present some difficulty with the Housing Commission as regards method of payment for the flooring and perhaps Mr. Watson can say a little more on this matter.

A similar project on the use of the C.E.B.S. light timber roof truss, which has been designed for domestic construction, is at present in hand and we are hopeful of obtaining worthwhile results from both of these projects.

The Liaison Service is also organizing field surveys in the various States with the object of obtaining factual information on certain specified subjects for the research bodies. Two such surveys at present being conducted concern flat roof construction and staining troubles with decorated fibrous plaster.

<u>Mr. Cooper</u> pointed out that the Division of Forest

Products had never recommended 9/16 in. flooring for softwoods. However, imported houses used 5/8 in. softwood flooring, so if that proved satisfactory there would be no doubt that 9/16 in. hardwood would be adequate.

Mr. Huddleston suggested that, as local building surveyors were often the main obstacle to the adoption of innovations, the Liaison Service should approach the municipalities and attempt to persuade them to adopt a more open attitude.

Mr. Wright stated that Stawell Timber Industries Ltd., are using 9/16 in. hardwood flooring in their prefabricated houses and find it satisfactory. Appreciable sawing and drying savings are made by using 3/4 in. green boards.

Mr. Boyd drew attention to a defect in the C.E.B.S. plans for nailed roof trusses. The nailing details are not sufficiently clear and detailed and in some cases appear impracticable.

Mr. Clarke in closing the discussion, informed Mr. Brown that the Conference members appreciated the efforts of the Liaison Service and the work it was doing in informing industry of modern methods and ideas.

B. TIMBER SIZES IN DOMESTIC BUILDINGS

Mr. Cooper stated that Pamphlet 112 was almost out of print and so a decision had to be made as to whether a new edition was warranted. As methods of construction were bound up with sizes of structural members, he had undertaken an Australian-wide survey to see whether the pamphlet was widely used, and whether building methods had changed since it was issued. He had found that the pamphlet, on the whole, was widely used and that there had been no changes in construction methods. However prefabricating plants were in an entirely different category and the pamphlet could not be expected to apply to them.

On these grounds, and also because Pamphlet 112 is listed in the Victorian Uniform Building Regulations and contains information in addition to that relating to the construction for domestic dwellings, it has been decided to re-issue the pamphlet.

Mr. Turnbull said that some imported houses have 3 in.x 2 in. softwood studs at 3 ft. centres, and these were heavily notched for bracing and nogging. If these are satisfactory, Pamphlet 112 is very conservative.

Mr. Gordon replied that the original basis of the sizes was the minimum specified in the existing municipal codes. The results were checked to ensure that they were adequate.

Mr. Cooper said that the Pamphlet was intended as a first step only, and recommendations were limited so as not to conflict too much with existing practice. There is some difficulty in making a further step, but tables for floor loadings of 30 lb./sq.ft. may be added and the builder could adopt these sizes if he wished. A new Australian code for design loadings is being prepared and he believed that 30 lb./sq.ft. may be specified for domestic buildings. Until this code appears, which may not be for several years, it may be better to issue the Pamphlet in its present form.

Several members agreed that lack of grading is an obstacle to using smaller sizes. Builders claim that timber is of poor quality and hence large sizes are needed.

19. GENERAL ITEMS

A. BATTERY SEPARATORS - REPORT ON SPECIES TESTED

Mr. Kingston reported that electrical resistance, flexibility angle and breaking radius tests had been carried out on separators of vanikoro kauri (from the Pacific islands), jelutong (from Malaya) and Victorian grown radiata pine. The electrical and mechanical properties of vanikoro kauri are poor and probably it is unsuitable for battery separators. The electrical and mechanical properties of jelutong and radiata pine, however, are satisfactory and it is considered that these species warrant further testing. Batteries have now been assembled containing separators of jelutong, radiata pine and klinki pine (as control) and life tests are in progress.

To further test the suitability of yellow carabeen separators in comparison with klinki pine, life tests were made in five six volt accumulators. Failure in all cases was thought to be due to loss of the active material from the positive plates. Arrangements have been made for a supply of very heavy duty plates in an attempt to obtain failure of the separators.

There was no significant difference in the number of cycles completed by the cells with klinki pine or yellow carabeen separators, but the negative plates in the cells with yellow carabeen showed relatively more sulphation. This might eventually lead to failure of the cells. Some manganese was present in the yellow carabeen untreated separators, but it was considered this would be negligible after treatment with sulphuric acid.

Mr. Gray stated that the supply of proved suitable material for battery separators is seriously inadequate. He suggested that work on Australian timbers be continued, and asked over what period did a laboratory "life" test extend.

Mr. Kingston replied that a life test extended over two months. He added that potentially satisfactory timbers must be in good supply. Suitability for battery separators imposes stringent requirements and of all species tested, only klinki pine has been found entirely satisfactory.

Generally, softwoods appear potentially most suitable, but most Australian softwoods have been tested already with little success.

Mr. McAdam said that klinki pine is available in New Guinea and exportation is likely, however demands on this material are so great that it is unlikely that much would be available for separators. He was particularly interested in the investigation of radiata pine and would like the project continued.

Mr. Kingston stated that because of shortages, already manufacturers are using timbers which have not been fully tested. For example yellow carabeen and Douglas fir are being used and trouble with both have been reported.

Mr. McAdam asked if milky pine had been tried.

Mr. Kingston replied that it had not.

Dr. Dadswell suggested the testing of conifers from New Guinea.

Mr. McAdam said it was difficult to get them, though celery top pine may be obtained.

Mr. Kingston stated that Tasmanian celery top pine was knotty and asked if the New Guinea material was similar.

Mr. McAdam replied that clear celery top should be available, but it was not as accessible as klinki pine.

Dr. Dadswell asked if Borneo kauri had been tested.

Mr. Kingston replied that he had arranged for supplies for testing.

Mr. Cokley said that he had received a complaint on the failure of kauri in batteries in Queensland. He enquired the position in regard to substitutes for wood as separators.

Mr. Kingston replied that substitutes for wood were very expensive. He stated that the New South Wales

Railways Department had used microporous rubber separators but discarded them because of early battery failures.

Mr. L. N. Clarke stated that there had been complaints from Queensland also.

Mr. Cokley suggested that inadequate washing had caused the separators to fail.

Mr. Chinner asked the effect of pin knots.

Mr. Kingston replied that they may fall out and give rise to short circuiting.

Mr. Watson stated that the kauri coming into Queensland was being absorbed in other uses. He suggested that investigations be made on two other Daphnandras and two Sloaneas. He asked also if tests had been made on parana pine.

Mr. Kingston said no - the material was too flecked with pin knots.

Mr. Cooper suggested that the price of substitute separators might drop, to make them more competitive with wooden ones.

Mr. Cokley asked what was likely to happen when supplies became available from overseas.

Mr. L. N. Clarke replied that American supplies were doubtful because of the dollar shortage. English microporous rubber separators are not yet satisfactory. It is doubtful if substitutes will ever be as completely satisfactory as wood.

B. UTILIZATION OF QUEENSLAND BUILDING AND COOPERAGE TIMBERS

Note: A technical paper on this subject - titled "Utilization of Queensland Building and Cooperage Timbers" and numbered 19B - has been printed in Vol.1. There was no discussion.

C. BOX TESTING

Note: A technical paper on this subject - titled "Box Testing" and numbered 19C - has been printed in Vol.1. The discussion follows -

Mr. Fogl stated that although little box testing had been done by the Division of Wood Technology, the demand for this work seems to be increasing. Investigations by D.W.T. had been directed to the design of stapled boxes and the effect of moisture content on nail-holding power. More recently the problem of field lug-boxes had been tackled, as this was an important subject in the irrigation areas. His Division proposes to seek the co-operation of the other States in obtaining information on the use of this type of box.

Mr. Cokley promised Queensland's co-operation in providing such information.

D. SURVEY OF TANNING MATERIALS

Note: A technical paper on this subject - titled "Survey of Tanning Materials" and numbered 19D - has been printed in Vol.1. The discussion follows -

Mr. Bryant said that present work on P. radiata bark which was not discussed in the paper as presented, had shown tannin contents of over 20 per cent. This bark appeared to be a promising material and he expected to examine more samples in the coming year.

Dr. Cohen stated that the Division of Forest Products has had samples of P. radiata bark forwarded from both South Australia and Western Australia. These are being milled and forwarded to the Division of Wood Technology and Dr. Anderson for examination.

Mr. Brockway said that tannin analysis made on the bark of a West Australian eucalypt (E. brockwayi) had shown a tannin content of over 40 per cent. The tannins were not of a high quality. The chief difficulty, especially in internal areas, was in obtaining labour to strip the bark.

Mr. Clarke suggested that inland species might assume much greater importance in any scheme for the development of Central Australia.

Dr. Cohen suggested that these bark analyses may be overloading the Division of Wood Technology. Some spreading of the work might be desirable but care should be taken to avoid overlapping.

Mr. Bryant replied that D.W.T. was interested mainly in the pinus species. The staff position limited the amount of work that could be done, but if two assistants could be obtained and trained they would be able to handle the work requested of them by Division of Forest Products.

Mr. Huddleston stated that D.W.T. had discovered a relationship between the hot water solubles and the tannin content of a bark. This might reduce the amount of work required for any tannin survey.

Mr. Bryant added that this relationship had been established for only two types of bark and it could not be applied with safety to any general tannin survey.

Mr. McAdam said that considerable interest was being taken in the mangrove areas of New Guinea and that a survey was contemplated.

E. CORK FROM THE BARK OF THE PAPER BARKED TEA-TREE

Note: A technical paper on this subject - titled "Cork from the Bark of the Paper Barked Tea-Tree" and numbered 19E - has been printed in Vol.1. The discussion follows -

Mr. Bryant distributed various articles which incorporated the bark in their manufacture.

Mr. Clarke asked if it were proposed to strip the bark without destroying the tree.

Mr. Bryant replied yes, but the staff position has made it difficult to obtain data on such factors as yield and rate of growth.

Mr. Huddleston stated that small scale manufacture of the ground bark was being made in the north coast area. This material was being used by manufacturers for experimental purposes.

Mr. Watson said that a considerable amount of this timber is cut in Queensland and the bark could be utilized.. The tree increases in size as one goes further north. Samples of the bark could be forwarded to the D.W.T. for examination.

Mr. Huddleston said the Division would be pleased to receive these samples. He stated that some of the bark had been made into small gaskets and had been quite satisfactory in a motor car engine.

F. VOLATILE OIL INDUSTRY

Note: A technical paper on this subject - titled "Some Problems of the Essential Oil Industry in New South Wales" and numbered 19F - appears in Vol.1. The discussion follows -

Mr. Bryant said that the industry was being hampered by labour shortages. He asked the conference to consider the practicability of silvicultural research on a Federal basis.

Mr. Hauser asked if the best methods of harvesting were known. He added that it might be possible to investigate this aspect in the Canberra area.

Mr. Bryant replied that there was practically no data on the influence of the method, frequency of cutting, and other factors on oil yield.

Mr. Huddleston stated that work related to tea-tree oils was, of necessity, confined to northern New South Wales and southern Queensland.

Mr. Irvine said that Victoria has no accurate data on these matters and opinions of eucalyptus oil distillers varied widely. In Victoria there would be little possibility of carrying out any detailed investigations in the near future.

Mr. Cokley stated that interest in the silvicultural aspects of oil distillation was very limited. The universities might be able to assist in this matter.

Miss Wilson said that the investigation being made at the University of Queensland was only into the chemical nature of essential oils.

Mr. Watson stated that some work was being done at the Technological Museum of New South Wales.

Mr. Bryant added that this work was of value, but it was limited in so far as the Museum have no control over silvicultural aspects of oil production.

Mr. Huddleston stated that D.W.T. were concerned that the essential oil industry might be lost to Australia. If the industry were run and managed efficiently it could compete economically with overseas sources of supply. Most of the investigations into essential oils relate purely to chemical aspects.

Mr. Irvine said that fluctuations in the values for oil make it difficult to integrate the industry.

Resolution: "That representation be made to the Forestry Conference to be held in November to request the Commonwealth Forestry and Timber Bureau to investigate the production of essential oils in Australia."

G. UTILIZATION OF SAWDUST

Mr. Bryant said that hardwood sawdust mixed with fowl manure had been used in New South Wales as a fertilizer, and for lightening soil. In his view, there was no proof that tannins were likely to harm the soil.

Mr. Da Costa pointed out that spent tan bark and softwood sawdust were used as a mulch for pineapples.

Mr. Chinner said that significant results had been obtained in England using sawdust as a mulch.

Mr. Turnbull said that Division of Forest Products had been approached by a man from South Australia for information on this subject and he asked Mr. Thomas if he had any knowledge of this man's experiments.

Mr. Thomas replied that he had none.

Mr. Gordon said that though sawdust, when composted, was not as good as some other organic fertilizers, its availability made it a matter of considerable interest. He suggested seeking the Agricultural Departments' assistance on these investigations, if required.

Mr. Pearson referred to a publication called "Your Garden" which contained information on the use of sawdust.

Mr. Cokley said that sawdust was being used in Queensland to mulch ginger crops and that 100 cubic feet per day was being obtained from Beerwah for this purpose. In this district, cost of transport from mills to farms was the factor limiting use.

Mr. Gay enquired if there was any record of termites working in sawdust, as indications were that it might be a barrier if placed under a house.

Mr. Huddleston said that he had seen termite attack in timber stacked on a sawdust heap

Mr. McAdam said that he had noted that sawdust caused the death of a large snail which attacked coconuts in Rabaul   it might possibly be a control if placed round the palms.

H. PHYTO-CHEMICAL REGISTER

Mr. Bland said that the list of genera which he had mentioned at the last conference had now been drawn up by Mr. Morris of the National Herbarium. It had met with criticism from botanists, but it was maintained that such a list was necessary and that this one was suitable for its purpose. Log sheets had been printed and issued to searchers in order to ensure that their reports came to the register in a standard form. Australian journals were being searched first, each in the State in which they were published. Many of the journals were now out of print, but it was thought that some may contain valuable information.

Mr. Bryant said that locally published journals were being searched in New South Wales, but that little information was coming from them. He mentioned that Mr. Hughes of Sydney University had now isolated an alkaloid from Flindersia australis.

Mr. Cokley said that the search was going on in the Queensland journals with similar results - not much definite data so far.

J. COLLECTION OF MATERIAL

Mr. Turnbull: All members of Conference will acknowledge that research work on timber cannot proceed unless a range of timbers is available for investigation purposes. We look to the State forest services to assist us with collecting, and we appreciate the assistance they have given us over many years. As mentioned at previous conferences, the Division has endeavoured to establish a bank of timber including many of the most important Australian species. Orders for material have been distributed to various States, and we now have on hand a valuable quantity of several timbers. Deliveries, however, are in arrears, and the whole question of procurement is giving us concern, particularly as the Preservation Section has extensive and urgent requirements for its projects on durability. During the past year forest services have been approached with regard to collecting the first group of timbers required for preservation work, and as it is necessary for all timbers in the group to be on hand before the investigational work can proceed, we are anxious for the collecting to proceed immediately, and for a quick delivery to be effected. Several trees of more than 70 species are required. Samples are coming forward slowly and we would like an indication from the States as to what action is practicable to expedite collecting.

Mr. Huddleston said that D.W.T. needed material also and its collection was an increasing problem, as the forest officers were always too busy to go through the routine necessary for collecting authentic material. The Division was considering the appointment of a collector to its staff. However they are reluctant to do so because qualified men were needed elsewhere in the service and few are available. It was suggested that New South Wales co-operate with Division of Forest Products on collection on the basis that D.F.P. provide the collector and New South Wales the transport etc.

Mr. Clarke said that some such scheme may be necessary as all others had failed. He said the situation was getting serious.

Mr. Turnbull suggested that as in Dr. Chattaway's case, personal contact by a collector might stimulate interest and response in field officers.

Mr. Huddleston said that the cases were different - that much larger sizes and quantities of material were involved and these could be coped with only by someone whose special job was to do it.

Mr. Watson supported the idea of co-operation and regarded a collector as essential.

Mr. Thomas expressed the wish to see a list of the requirements from South Australia.

Mr. Payne expressed a wish to see a list of the requirements from Tasmania.

Mr. Brockway also disclosed difficulties in collection of material.

Mr. Clarke said the Division's financial allocation was a limiting factor in any arrangement such as proposed for collection, but something must be done. He delegated Mr. Turnbull to go into the matter with New South Wales and Queensland.

Mr. Huddleston said that as in New South Wales, possibly the other States would find the burden of collection less severe if they could have material collected for their own work at the same time.

Mr. Bryant added that New South Wales had collected material for the Division of Industrial Chemistry.

K. USE OF STATE FACILITIES FOR MECHANICAL TESTING

Mr. Cooper informed Conference that the universities of Tasmania, Queensland, Victoria and Western Australia had been asked if they would undertake the standard testing of their local species. Some of the professors are interested, but are concerned about finance. Further progress is awaiting a detailed working plan now being prepared.

Mr. Payne emphasized that Tasmania is very restricted financially and that such a programme of testing would be difficult to justify from the State's point of view, when there is a Commonwealth organization capable of doing the work. Professor Burns estimated he would need £600 p.a. for a graduate, plus £300 for auxiliary equipment.

Mr. Clarke pointed out that the Executive of C.S.I.R.O. does not regard species testing as research and hence it is not D.F.P's province. Further, it would take the Division many years to complete the standard testing of all our species.

Mr. Huddleston said that the University in Sydney has no staff for testing and does not like work which interferes with the students' use of the machines. Division of Wood Technology will put its machines on the projects as soon as staff is available.

Mr. Littler said that standard testing could be done as part of the work for fourth year students at Queensland. According to Mr. Payne, Professor Burns thought students were not sufficiently reliable, but Mr. Cooper considered this was because Professor Burns has no staff to supervise them properly, a position which does not apply in Queensland. If it isn't worthwhile for the States testing their own timbers, it isn't worthwhile for the Commonwealth to do it.

L. EDUCATION IN WOOD TECHNOLOGY

Mr. Clarke said he had raised this matter because, although there are facilities in Australia for training in forestry, only limited facilities exist for training in forest products. The position has been relieved somewhat in New South Wales, but there is still no provision for training in forest products to the same standard as in forestry. In America, training is given in pure forestry and forest utilization and students can take a Degree, specializing either in forestry or wood utilization.

This matter concerns us all directly. Reference has been made to the backward state of the industry in many respects - a condition which may be traced to inadequate training of senior personnel in the industry. I have kept the matter a live issue with the Melbourne University.

Mr. Chinner: This Division provides special courses for students of the School of Forestry, Canberra and of the School of Forestry, Melbourne University; these are very much appreciated. When Mr. Clarke raised the matter of the absence of any provision for training in the field of forest products in Australia, I queried the demand for such people with specialized training. Mr. Clarke said the demand for such people would increase greatly if they were available. I would like to see provision made for training in wood technology at Melbourne University. Mr. Clarke asked me whether I would be prepared to recommend the appointment of a lecturer in wood technology. I discussed it at length and for the moment we have agreed to defer the matter because our staff is inadequate.

A course in wood technology would require laboratory facilities which are not at present available. Following Mr. Clarke's representations I submitted the matter to the Faculty. I recommended, that at the earliest opportunity and when laboratory facilities were available, this matter receive consideration. I recommended that as a first step a lecturer be appointed and an alternative course to forestry be set up. The recommendation was accepted in principle, but the Faculty felt that there should be the one basic training, with specialization at a later stage. It will probably be three years before extra laboratory facilities are available and all we can do at the moment is to develop the idea soundly.

Mr. Huddleston said their trouble in New South Wales was caused by losing highly trained men to industry. Some years ago a tentative 5-year Diploma course was considered, with the first two years concentrating on basic science, the latter three years specializing in either forestry or wood technology. I offered our laboratories for teaching purposes and a lecturer, Mr. Cromer, was to be appointed. However, he accepted a position with the Forestry and Timber Bureau and the matter rested there. The position today is more urgent than it was four years ago and we should make a strong recommendation that all States institute such courses. Any such recommendation should be accompanied by an offer to supply an officer to organize the course in the early stages.

Mr. Turnbull asked whether the Board of Higher Forestry Education had considered this matter. He thought a satisfactory course would be two years basic science, third year forestry and 4th year either higher forestry or forest products.

Mr. Walduck said the Board of Education last year recommended that such a course be instituted in one or more States of the Commonwealth, but very little seems to have been done.

Mr. Chinner said the institution of such a course is not as simple as has been stated at this Conference. There are only 26 weeks in an academic year and it is doubtful if specialized training could be completed in this time. The feasibility of such a course will ultimately lie in adequate finance. Given adequate finance we could find the staff. Wood using industries and Associations might be willing to back such a course.

Mr. Cooper said two courses should be considered, one at the professional level in Canberra and one at the sub-professional level at Technical Schools and Institutes of Technology. But for either course to eventuate they must be pushed. If we feel they are necessary, we ought to take some positive step.

Mr. Clarke said he would contact the Secretary of the Board of Education and draw attention to our common problem - the loss of trained foresters to the forest products field and the industries lack of trained forest products personnel.

Mr. Huddleston pointed out that any course of study cannot hope to make specialists in a particular subject at graduation. Specialization must come after graduation with post graduate training in industry.

Mr. Chinner suggested and Mr. Clarke agreed to write to the University as well as to the Board of Education.

Mr. Huddleston suggested that Mr. Clarke should interview University authorities personally re the possibility of such a course.

Mr. Clarke said the Board of Higher Forestry Education should be approached first - all Universities are represented on the Board.

M. TRANSLATIONS

Mr. Clarke said this matter was raised in writing by Mr. Ellis of Queensland. He had asked for an arrangement whereby Australia and other countries paid for a translator or translators to translate all articles which may be of interest to forest products workers. Mr. Clarke had notified Mr. Ellis that C.S.I.R.O. is spending a lot of money on translations at present and he would not be prepared to recommend any such proposal. Further, he thought such a method of translating would be unsatisfactory. However, Mr. Ellis asked that the matter be brought up again at this Conference and at the next Empire Forestry Conference.

Mr. Huddleston said his Division would not be prepared to put money into such a scheme, as the value of a translation could not be assessed until completed and many would be valueless.

Mr. Chinner said that the Commonwealth Forestry Bureau at Oxford undertakes to perform translations at cost. With airmails, this is a very satisfactory service.

N. PUBLICATIONS

Dr. Dadswell gave the following report of publications of the Division of Forest Products:

Pamphlet 112. This will be in the printer's hands by Christmas.

Lyctus Publication. This will be in the printer's hands by Christmas.

Trade Circulars. Many Trade Circulars are out of print; no new trade circulars are being prepared.

News Letter. From time to time we are short of suitable articles and would be prepared to print research articles supplied by Forest Services.

Scientific Publications. C.S.I.R.O. Head Office is doing a lot of work to expedite publication of the Australian Journal of Scientific Research.

Bulletins. Printing of Bulletins is nearly up to date and any new Bulletins prepared would be printed quickly by Head Office. However, a number of Bulletins are out of print and we have to consider whether they are worth re-printing and whether we will include results of work done since they were first printed.

O. ARRANGEMENT OF FUTURE CONFERENCES

Mr. Gordon said Section Heads of Division of Forest Products had discussed this matter and there was some feeling that a conference of this nature does seriously interfere with the work of the Division. It was suggested that if the Conference were held every second year there would be more to report and each Conference would prove more valuable. He asked for comments from other organizations.

Dr. Cohen said the Wood Chemistry Section had not taken a very active part in this Conference because they are committed very heavily for the annual Pulp and Paper Conference. He would like to see both Conferences held every second year, so that his Section could participate more fully.

Mr. Huddleston preferred the annual conferences but thought they could be of shorter duration - perhaps 2 or 3 days.

Mr. Cokley preferred every second year.

Mr. McAdam thought it would be a retrograde step if results of research work were published every second year instead of every year.

A vote was then taken of visiting delegates. Messrs. Thomas, Brockway, Bryant and Cokley favoured a conference every two years, and Messrs. Walduck, Watson, Payne, Huddleston, Fogl, Gay and Littler favoured shorter annual conferences.

Mr. Clarke said the views of the delegates would be considered in planning future conferences. He suggested that the matter be left in his hands.

RESOLUTIONS AND DECISIONS OF THE

FIFTH ANNUAL

FOREST PRODUCTS RESEARCH CONFERENCE

MELBOURNE, OCTOBER, 1950

1. Nomenclature of Australian Species. Mr. Turnbull of D.F.P. was asked to continue the revision of Australian Standard Specification O.2 with a view to giving each genus a distinctive trade name. Generally established names were not to be discarded.

2. Nomenclature of Timbers Imported into Australia. Action on the nomenclature of timbers imported into Australia, and reference of the tentative list of names to the Standards Association is to be based on discussion between Mr. Gray of the Commonwealth Forestry and Timber Bureau and Mr. Huddleston of the New South Wales Division of Wood Technology. Matters arising from Mr. C. S. Elliot's representations at the Bangkok conference are to be taken into account.

3. Building Boards. The market survey carried out by the Commonwealth Forestry and Timber Bureau was considered to be of appreciable value. It was decided that research on the manufacture of boards from waste should be so planned that there was no over-lapping of work within D.F.P., at D.W.T. and elsewhere. It was considered there would be advantages in proceeding as quickly as possible to reach finality on the respective products now under examination by the different interests.

4. Railway Sleeper Grading Studies. The working plan prepared by D.F.P. for grading studies to be undertaken on permanent way railway sleepers was approved.

5. Railway Sleeper Preservation Treatment. The specification prepared by D.F.P. for sleepers to be used in

the high pressure preservation treatment investigation was considered satisfactory. The detail of preparation for treatment was left to D.F.P. with the suggestion that some sleepers should not be end coated prior to impregnation.

6. Mechanical Tests on Sleepers. It was resolved that mechanical tests on sleepers initiated by D.F.P. should now be continued in the States and under the immediate supervision of the respective State Forestry Services.

7. Preservation of Fence Posts. The desirability of preservation treatment of fence posts was acknowledged. It was decided that the States co-operate with the respective Departments of Agriculture and Soil Conservation and give wide publicity to the value of treatment. The D.F.P. pamphlet on this subject should be re-written.

8. Physiological Effect of Preservatives. The Conference expressed appreciation of the work of the Defence Research Laboratories in investigating this matter and suggested that the work might, with advantage, be extended to determining the physiological effects of the main toxic constituents of other preservatives, both proprietary and non proprietary.

9. Laboratory Evaluation of Preservatives. It was resolved that any field tests initiated by the State forest services should be paralleled with tests at the D.F.P., on matched specimens sent in by the respective State services.

10. Supply of Boric Acid and Borax. Difficulties in the availability of borax and boric acid in Queensland and the import duty of £2/10/- per ton for borax, whereas boric acid is duty free, have caused considerable difficulty in the treatment of Lyctus susceptible timbers. The Commonwealth Forestry and Timber Bureau were asked to investigate the matter with a view to having the duty lifted and supplies improved.

11. Statistical Survey of Damage by Borers, Termites and Decay in Australian Buildings. The proposed form of questionnaire and record sheet was approved by the Conference. It was considered that new homes should be included in the survey as these may be subject to termite attack.

12. Lyctus Susceptibility Gradings for Commercial Timbers. It was decided that for publications, only three grades be used, viz., resistant, rarely susceptible and susceptible.

13. Lyctus Nutritional Studies. These investigations by the Division of Entomology were considered of great importance. The Queensland Forest Service offered to co-operate in this work.

14. Anobium Investigations. The problem of P. radiata variability should be investigated before continuing the co-operative work with New Zealand on the material prepared from timber from the various States. Conference proposed that Mr. Gay of the Division of Entomology and Mr. Tack of D.F.P. consult on the problem generally and the possibility of there being generic reasons for the variability. The States should co-operate on the mapping of geographical variations of susceptibility of species.

15. Methods of Analysis for Boric Acid in Timber. Queensland and New South Wales are to continue their attempts to develop a satisfactory treatment plant control method of analyses for boric acid in wood. D.F.P. is to continue its efforts to obtain an accurate method of analysis for use where high precision is desired. The D.F.P. will, if possible, examine any method of plant control analysis which is proposed by a State as being of sufficient merit for universal adoption.

16. Australian Standard Specification for Lyctus Immunized Timber. A corresponding committee consisting of

Mr. Tack, D.F.P. (convenor), Mr. Turnbull, D.F.P., Mr. Fogl, New South Wales and Mr. Cokley, Queensland was appointed to examine and report on the draft specification submitted by New South Wales.

17. Tannin Formaldehyde Adhesives. To assist the Division of Industrial Chemistry in the development of these adhesives, D.F.P. are to supply bark for tannin extraction.

18. Silviculture and Veneer Quality. Considerable interest was shown by the State authorities and several offers for the supply of suitable test material were made.

19. Growth Stresses in Trees. It was considered that this work had great economic importance. It was requested that the study be broadened to investigate possible improvements in sawmill and veneer production practice.

20. Building Research Liaison Service. The Conference members expressed appreciation of the efforts of the Liaison Service in informing industry of modern methods and ideas.

21. Battery Separators. As the supply of proved, suitable material for battery separators is inadequate, it was suggested that work on Australian timbers be continued.

22. Volatile Oil Industry. It was resolved that representations be made to the Forestry Conference to be held in November, to request the Commonwealth Forestry and Timber Bureau to investigate the production of essential oils in Australia.

23. Collection of Material. The difficulty of the States in collecting test material for D.F.P. was very real. Mr. Turnbull of D.F.P. was to co-operate with New South Wales and Queensland in an endeavour to find a solution of the problem.

24. Education in Wood Technology. Mr. Clarke was asked

to point out to the Board of Higher Forestry Education, the lack of personnel trained in forest products technology, and the consequent loss of trained foresters to these fields and to industry. The Board and the Universities should be asked to institute a course of training in the forest products field.

25. Arrangement of Future Conferences. The Conference recognized the large amount of work required of the staff of D.F.P. in preparation for annual conferences in their present form, but was divided on the alternative proposals of holding conferences every two years, and holding a shorter annual conference. The matter was left to Mr. Clarke to decide in the planning of future conferences.