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PROCEEDINGS

THIRTEENTH

FOREST PRODUCTS RESEARCH CONFERENCE

HELD AT

THE DIVISION OF FOREST PRODUCTS,

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION,

MELBOURNE

AUGUST 7-11, 1967

REPRESENTATION

Division of Forest Products	–	R. W. R. Muncey, W. G. Kauman, J. D. Boyd, J. W. Gottstein, W. E. Hillis, H. G. Higgins, R. S. T. Kingston, N. Tamblyn, A. P. Wymond (Secretary).
New South Wales Forestry Commission	–	E. B. Huddleston, L. H. Bryant, D. W. Edwards, P. Marshall, A. Anton.
Dept. of National Development Forestry & Timber Bureau	–	M. R. Jacobs, A. G. Brown, N. Hall, J. Redmond.
Queensland Department of Forestry	–	T. F. Ryley, C. J. J. Watson, K. Cokley, J. Hornibrook.
Western Australia Forests Department	–	H. C. Wickett.
South Australia Woods & Forests Department	–	V. M. Healy, J. H. Harding, R. M. Cowan.
Papua-New Guinea Department of Forests	–	G. Vickers.
Victoria Forests Commission	–	A. J. Threader, J. D. Gillespie, plus observers.
University of Melbourne	–	J. Chinner.
Australian National University	–	P. Rudman, K. Groves.
New Zealand Forest Research Institute	–	R. Orman.
Commonwealth Experimental Building Station	–	J. Keough.

CONTENTS

ITEM 1. WOOD STRUCTURE

Item 1(a). Review of Research Activities

I. DIVISION OF FOREST PRODUCTS*

The work done in the Physiology and Microstructure Section since the 12th Forest Products Research Conference has been concerned with 3 main topics.

Improvement of yield of wood from the forest

Quality of wood

Aspects of wood properties

IMPROVEMENT OF YIELD OF WOOD FROM THE FOREST

Mycorrhiza. - In association with the Victorian Forests Commission we have examined the mycorrhizas of healthy green and yellow stunted seedlings of radiata pine and Douglas fir. An examination of the healthy plants, which frequently have a white type mycorrhiza, showed that there was an extensive polyphenol layer produced in the epidermal cells of the host. However, a fungal mantle formed and hyphae penetrated the epidermis to form a Hartig net in the root cortex. There was morphological and cytological evidence that the hyphae were adversely affected by the materials in the polyphenol layer. In these healthy seedlings there was an absence of starch in the host root cells but abundant glycogen in the inner cells of the fungal mantle and in addition abundant bacteria were observed in the outer layers of the mantle. These bacteria may fix atmospheric nitrogen. On the other hand, in stunted seedlings there was a more extensive polyphenol barrier, the fungal hyphae did not penetrate the cortex to form a Hartig net and glycogen and bacteria were absent from the mantle. Chemical examination has indicated a mechanism whereby the symbiotic mycorrhizal association of root and fungi is controlled.

Sirex. - The mechanism of Sirex resistance has been examined from the point of view of the polyphenols formed in the tree in response to the symbiotic fungus associated with the insect. Samples of Sirex-affected wood taken from Pinus radiata trees which have overcome attack have shown that the polyphenols are very largely composed of two stilbenes known to have high fungistatic and fungitoxic activity. The amount present is sufficient to stop growth and the fungal hyphae do not penetrate the polyphenols formed at the periphery of the affected wood region. The two non-toxic flavonoids which accompany these two stilbenes in heartwood are absent completely from the Sirex-affected wood.

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* Prepared by Dr. W. E. Hillis

Provenances. - In collaboration with the Forest Research Institute in Canberra an examination has been made of the polyphenols in the leaves from different provenances of Eucalyptus camaldulensis. The data shows that the provenances may be divided into 3 main groups and possibly into subdivisions. The conclusions are in close agreement with those drawn from morphological characters, and it appears that the advantages of this new technique will assist the characterisation of specimens from different areas.

WOOD QUALITY

The collection of basic data to assist the establishment of plantations of trees with improved wood properties has continued.

Heritability. - Heritability estimates for ring width, percentage late wood, average tracheid length, basic density and incidence of grain inclination were obtained for selected growth rings from pith to bark from specimens of P. radiata. Systematic change with age was observed in the estimates of some of these parameters. Genetic control of spiral grain appears to be at a maximum in the early life of the tree and therefore maximum gains from selection can be expected from the examination of the first-formed wood.

Site Factors. - A number of parameters were determined for specimens of the Leiria provenance of Pinus pinaster, grown from one seed source and taken from four sites. The availability of soil moisture to the trees was found to influence the percentage of late wood, and fluctuations in growth rate due to moisture stress in summer and autumn reduced average tracheid length. It was concluded that angles of grain inclination were not significantly different between poor, intermediate and good quality sites.

Assessment of wood qualities for tree breeding. A number of above average trees of the Leiria provenance of P. pinaster have been examined as part of a cooperative project with the Western Australian Forests Department. Results show that tracheid length increased throughout the age range under review viz. 135 years. Basic density did not show any systematic variation whereas the ring width and percentage late wood did.

WOOD PROPERTIES

Precise anatomical details of wood from Fiji, British Solomon Islands and New Guinea have been provided to enable the preparation of wood sorting keys.

We have continued our studies to define precisely the structure and composition of wood and fibres so that a better understanding of the way they react is obtained. On this basis we will gain a clearer view of the limitation of wood and fibres in certain applications and whether their behaviour can be improved and how this can be done.

The work can be subdivided as follows:-

Vessel Length. - Preliminary work has shown that the length of vessels in a specimen can be very variable. A method to find a frequency distribution for vessels of different length has been developed. In Eucalyptus obliqua some of the vessels were up to 4 to 5 metres long but most were shorter and about half were less than 35 cms long.

Density of pulped fibres. - This has been measured by mercury porosimetry and by microscopy of individual fibres. Preliminary results from dry fibres using mercury porosimetry gave high values (1.5 gms/cc) and there does not appear to be any difference between beaten and unbeaten pulps or between material used as a pulp and material made up into paper.

Penetration of liquids. - An examination of liquid penetration into the wood cell wall has been undertaken as a follow-up to earlier studies on the path of penetration into wood. A number of solutions containing heavy metals were allowed to saturate small wooden blocks and after drying, the blocks were sectioned and examined in the electron microscope. As the concentration of silver nitrate solutions was increased the number of spots visible in the cell wall increased greatly in number, but decreased markedly in size. It was concluded that the cell wall contained no fixed structural capillaries but that the microfibrils had spaces between them in the wet state and these disappeared on drying.

Fracture and Fibre Separation. - Further investigations into the inception of fracture in wood were undertaken. Earlier observations of sections broken in a micro-tensile testing machine verify the hypotheses of Wardrop and Addo-Ashong concerning the weakness between the S1 and S2 layers and also indicated that middle lamella cracking was common.

A series of partial NSSC cooks of Eucalyptus regnans and of chemical pulps of eucalypts were prepared and examined microscopically. Fibre separation in both the middle lamella and the S1 - S2 zones was observed. It was found that an appreciable proportion of the S1 layer comes off during sulphate pulping and the rest requires beating for removal. Much more beating is required for the removal of the S1 from NSSC and cold soda pulps. The fibre bonding was shown to be of a very intimate nature and it was possible for bonds to form between any combination of cell wall layers.

Recently P. radiata pulps prepared by the sulphite and sulphate processes have been examined in a similar fashion. The S1 comes off the sulphite pulps readily during beating, but this layer requires more beating for removal from sulphate pulps. There was marked collapse particularly with the sulphite pulp. The cold soda radiata pulp did not respond greatly to beating and collapse and conformability remained very poor although there was splitting between S1 and S2.

Lignin. - Our improvements in the vibratory ball milling technique of Bjorkman have enabled a considerably increased yield of unchanged lignin to be obtained from wood. There is a continuing demand for unchanged lignin to enable precise studies to be made on different problems of our own and of others. An examination of this lignin for example has given a greater understanding of the processes concerned with the alkali pretreatment of wood prior to grinding.

A critical examination has been made of the staining reactions for lignin which are commonly employed in anatomical work. The different lignins in different parts of Eucalyptus botryoides were isolated and the staining reactions found to be in agreement with the chemical composition.

The lignins from 4 Eucalyptus species belonging to the series Tereticornes collected from Papua, North Queensland, South Queensland, Victoria and Tasmania were examined. A correlation was found between certain properties of the lignin and the latitude of the origin of the specimen. Two types of lignin, tropical and temperate zone types, may be recognized even in closely related Eucalyptus species. The properties of lignin may be variable within a species but this variation appears to be related to climatic conditions.

In order to gain further precise knowledge of eucalypt lignins, the studies of their biosynthesis has been continued. A noteworthy observation is that of a complex of phenylalanine with an unknown substance and this complex is possibly an important intermediate in lignin formation.

Reaction wood. - The histochemistry of reaction wood differentiation of P. radiata has been investigated. When first formed, the primary wall and S1 layer gave strong positive tests for cellulose, contained reducing groups and some para-hydroxyphenol substituted units. Changes occur in the primary wall and the S1, as the S2 is laid down and as it lignifies. There is some evidence that lignification may go on after the cells have died.

The ulstrastructure of reaction wood differentiation in Eucalyptus species, Liquidamber and Tristania have been examined and a number of differences from normal wood fibres observed.

The effect of disease on wood structure. - Attack by Diplodea pinea on the leaders of P. radiata causes extensive collapse of the rays and the lysis of the middle lamella and wall substance of the tracheids. This collapse presumably causes the bending of the leader of the tree, and this and other aspects have been studied in collaboration with the Victorian Forests Commission.

Cankers on Exocarpus and Acacia species cause considerable anatomical abnormality, increase in pathological heartwood and extractives content.

The fungal attack on wood. - Cytological examination of Coriolus versicolor has been made with special reference to the secretion of materials through the plasmalemma. Lysis of the host walls appears to be localized at first and the relation of this to localized vesicular secretion is being examined.

The wall structure of fungal hyphae of Polyporus minor-myllitae and a number of other wood rotting fungi has been studied and chemical examination has revealed two fungal groups, those with chitin as an important constituent in their walls and those with cellulose.

The growth and aging of the wood cell. - We are determining the time taken by cambial cells of P. radiata to pass through the various phases of their development and are also studying the seasonal changes in the time taken for this development, especially those which might be associated with spring and summer wood formation.

The formation of polyphenols in P. radiata has been shown to take place in specialised areas of the cytoplasm. The different stages in the formation of polyphenols have been ascertained and the behaviour of different organelles in the cytoplasm have been examined.

Methods for determining the activity of certain enzymes have been modified by using eucalypt leaf as experimental material. These methods will be used to determine enzyme activities across sapwood and the sapwood-heartwood boundary. This examination will be done in conjunction with our other studies concerned with the biochemical basis of heartwood formation.

Research Review (New Zealand)

*Wood Structure. - Research on the wood anatomy of the indigenous trees and shrubs has continued. An identification key based on the anatomical features of twenty indigenous conifer species has been prepared. These species belong to five genera, namely, Dacrydium, Podocarpus, Phyllocladus, Libocedrus and Agathis. A large proportion of the wood and charcoal specimens sent to the Forest Research Institute for identification consists of the native softwoods, and therefore this identification guide should prove considerably useful.

Some observations on the microstructure of the native softwoods are:

Species with distinct growth rings have more numerous pits on the tangential walls of tracheids.

Species with large (window-like, taxodioid, cupressoid) crossfield pits lack axial parenchyma

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* Prepared by R. N. Patel.

Within a genus, the tracheids are longer and the rays taller in tree species than in shrubs

The number of cross-field pits is greater in the upper and lower margins of the xylem rays than elsewhere in the ray tissue

Rays frequently more than 30 cells high are present in some species. Rays up to 70 cells high have been recorded in Podocarpus dacrydioides.

*Survey of Wood Properties. - A country-wide survey of the wood density of Douglas fir has been completed. Major differences were found in average wood density between sites as well as between trees within each site. Of the growth factors studied (altitude, latitude, mean annual temperature and radial growth rate) only the last could be shown to be significantly related to wood density and this accounted for one third of the total variation. The relative importance of seed source and environment in producing these variations could not be assessed and other methods of doing this are being considered - e.g. assessment of provenance trials which may be old enough to yield useful results in 3 years time.

A similar survey of Pinus contorta has been started. A little more is known of seed sources in this species and efforts are being made to examine stands planted with similar seed on a variety of sites. At the same time material is being collected for parallel studies of wood and extractives chemistry, pulp and paper-making properties, mechanical properties and wood anatomy.

Provenance Research. - A preliminary examination of an 11 year old provenance trial of P. pinaster revealed relatively minor differences in wood density between the 44 provenances studied, though trees from sources as diverse as Portugal, Italy and Morocco showed great variation in form and growth rate.

Genetics. - Cooperative work has continued with the Tree Improvement and Silviculture sections as outlined at the last meeting. In addition techniques have been developed to assess wood density and tracheid length in young radiata pine (5 years old or more) with a view to testing selected trees for propagation by cuttings. In all 500 trees of superior morphology were examined and cuttings of 250 trees with better-than-average density have successfully been propagated vegetatively.

Wood density as a criterion for silvicultural selection. - If wood density of standing trees could be assessed in the field it would greatly facilitate "stand assessment", (i.e. for wood properties), "tree selection" for developing seed stands, and might even make the use of wood density as a criterion for selecting trees during thinning operations

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* Prepared by J. Maddern Harris.

a possibility. To investigate this last point wood density was measured for all the trees (400) in one acre 40 year old Douglas fir using increment cores from b.h. Forest rangers were then instructed to mark the stand for thinning using wood density as one of the criteria for tree selection. It proved possible to "mark out" all but two of the trees in the lower 20% of the wood density range and to include most of the trees in the upper 20%. This could be a potent method of ensuring that only those trees producing the strongest wood are carried to full rotation. In marking for second thinning, it is believed that even more emphasis might be placed on wood density since tree form would be less variable after the first thinning.

D.S.I.R. are cooperating in developing apparatus for assessing the wood density of standing trees. Torsional tools are being examined now.

Spiral grain. - The cause of spiral grain in the corewood of radiata pine is believed to be spiral flow of photosynthates induced by the spiral arrangement of the parastichies of the short shoots on the stem. Spiral girdling and other techniques used to make photosynthates flow around the stem have resulted in xylem tracheids aligning themselves with the direction of nutrient flow to the extent that grain angles have changed by up to 70° in one year's growth. Nails driven into trees to simulate persistent needle traces have also induced spiral grain of up to 10° in stems that were formerly straight grained. Other experiments have examined the role of auxins in this process.

Discussion

Bryant said that they had some evidence that trees attacked by Diplodia were deficient in boron, possibly also another element not yet determined.

General discussion took place on the role of micorrhizal fungi in fixation of atmospheric nitrogen. It was also mentioned that the work on characterization of specimens of E. camaldulensis can be extended to other species - queries regarding this work could go either to Mr. Banks of the F R I or Dr. Hillis.

Rudman gave brief details of the following projects being carried out at A.N.U.: Examination of effects of environment on clonal material of E. camaldulensis and a similar experiment planned for E. regnans; a study to determine the effects of silvicultural practices on wood quality in regrowth E. regnans (in association with the Victorian Forests Commission); a study to determine the effects of nutrient deficiency and nutrient excess in P. radiata - the part dealing with potassium deficiency has been completed; the effect of season of growth on the type of wood laid down by E. regnans and E. delegatensis.

Item 1(b)

Nicholls: In collaboration with the Western Australian Forests Department, we have been examining trials involving mature P. pinaster. We had 2 replications of 6 thinning treatments ranging from unthinned at 1000 stems/acre to thinned at 100 stems/acre. We examined 5 trees per plot, all plots being fertilized after thinning, so we had a measure of the effect of thinning alone and thinning/fertilizer interaction.

So far the results for spiral grain and tracheid length are to hand. There are no significant effects of thinning, thinning rate or fertilizer treatment on spiral grain. The effect of thinning on tracheid length (a decrease) is not apparent until about 1½ years after treatment, the effect of thinning rate is not significant and the effect of fertilizer is only apparent in thinned plots, persisting for only about 1 year.

Our new scanning type densitometer has only recently arrived and results from this have not yet been analysed.

Item 1(c) Effects of fertilizers on the wood properties of Pinus radiata (NSW)

Examinations of wood of P. radiata from two fertilizer trials have been made. The first experiment was concerned with a fertilizer trial laid down at Penrose in 1947 in which rock phosphate and super phosphate were applied. In this experiment the trees showed marked response to both treatments. Tracheid length, basic density and percent latewood were measured on alternate rings from ring 2 to ring 14. Comparison between the treatments and the controls showed no significant differences in the wood properties.

The second experiment was on five year old trees from a close-planted trial at Belanglo. The treatments consisted of P, N, S, and a mixture containing the other main plant nutrients. These fertilizers were applied separately and in all combinations. Basic density of a radial strip containing all rings and tracheid length of the whole of ring 4 were measured. The results confirmed the Penrose findings in which phosphorus was not found to lower either basic density and tracheid length. Nitrogen on its own however depressed both tracheid length and density.

It is hoped to continue these experiments on older trees and on other sites.

Discussion

Muncey asked whether fibre length was still considered to be a particularly important property, he felt that the pulp industry was not very interested in longer length fibre.

Bryant said it was convenient to use fibre length as a basis of comparison, but he considered evenness of growth was more important to the user of sawn timber. The pulp industry was demanding more eucalypt in spite of it having a much shorter fibre length than the softwoods.

Rudman said that cell dimensions were important in relation to their influence on density, and measurement of fibre length was useful because it could be carried out rapidly.

Bryant suggested that there should be greater interest in the way P. radiata lays down heartwood because of its industrial importance.

Hillis indicated that work on P. radiata heartwood was programmed and it was hoped to start it later in the year.

Item 1(d) Wood identification systems (NSW)

Compilation of the data for the development of a card sorting key for the identification of the commercial species marketed in New South Wales has been completed. About 160 species will be represented in the key. The list of species to be included was obtained by making enquiries with members of the industry.

The key will be based on macroscopic and lens characters and will be made as simple as possible. A trial key is being produced and will be ready for testing in the near future.

Item 1(e) Anatomical studies of Pinus radiata in relation to penetrability (NSW).

Investigations are being made into the relationship between cell wall characteristics and the penetrability of P. radiata. The ray parenchyma cells show little thickening and lignification in the sapwood. It is suggested that in drying, the walls of the ray parenchyma rupture or shrink away from the surrounding tracheids leaving radial cavities to serve as channels for inter-cellular movement of liquids. The possibility that pre-steaming may induce the ray parenchyma to shrink or rupture is being investigated.

The tori of the bordered pits of the axial tracheids are also being investigated. So far only dry wood has been examined and in this state the tori of the earlywood of both sapwood and heartwood are aspirated. In the latewood the position of the tori are variable and appear to be aspirated in only about 50% of pits. The shape of the tori in the latewood does not appear to lend itself to closure of the pits as do the tori of the earlywood.

Item 1(f) Anatomical studies of epicormic shoots of regenerating eucalypts (NSW)

The production of epicormic shoots is associated in many eucalypts with the production of gum veins which in turn causes a significant decrease in the value of the timber.

It is planned to examine the site of the epicormic growths so as to determine how the epicormics are integrated into the vascular tissue of the tree trunk. Before this work becomes too far advanced it is desirable to know whether any work on these lines is being conducted by other organisations.

ITEM 2. PHYSICS*

Item 2(a) Research review (DFP)

Microwave Moisture Meter. - Tests were carried out with a microwave moisture meter to investigate its potential as a means of determining the moisture content of chemically treated timber. Radiata pine specimens were pressure treated with two commercial CCA preservative salts at two retentions and compared with water treated specimens as controls.

Over a limited range of moisture contents, generally between 7 and 15%, the results from treated and untreated radiata pine at the same moisture content were not significantly different. However, the results from the untreated material showed that the microwave meter is less accurate than the resistance type in this part of the range, but it is more accurate on both treated and untreated material at high moisture contents, 30% and beyond, where the indications of the resistance type meter are often very misleading.

Work is continuing on this moisture meter and modifications to the instrument will be made in an effort to improve the accuracy.

Species correction data for resistance type moisture meters. - Tests were completed on 34 New Guinea, 29 Fijian and 6 miscellaneous species. Tests are in progress on 43 species, mostly from the Solomon Islands.

Electrical Conductivity. - Electrical conductivity measurements on specimens of spotted gum, messmate, and radiata pine have confirmed overseas results that preservative treatment with Celcure A (a CCA preservative of the salt type) increases the conductivity at a given moisture content markedly and treatment with Boliden K33 (a CCA preservative of the oxide type) may reduce or increase the conductivity slightly as compared to water treated material. In the case of Celcure A, the increase ranges from about 3 times to 8 times in the moisture content range of 15%-60% for sapwood and from no increase to perhaps 5 times for heartwood.

Sorption studies. - The main emphasis has been on the mechanism of water uptake by wood cell walls and the way this is affected by a number of experimental variables. It may be recalled from the last conference that the rate of swelling of wood cell walls after immersion in liquid had been found to be much faster than the rate at which they take up vapour from the vapour phase. At the same time, their rate of swelling in liquid, like the rate of sorption of vapour, was found to be very dependent on initial moisture content. When the uptake started from high equilibrium moisture contents, both sorption of vapour and uptake of liquid were very much slower than when starting from low equilibrium moisture contents. The effect of factors other than initial moisture content on swelling rate have also been studied. These include cell wall thickness, temperature, applied stress, delignification and the presence of tension wood. As a result of this work, it is now believed that the rate of uptake of both vapour and liquid by the cell wall is controlled by swelling stresses. A mechanism by which this is achieved has been suggested and seems able to account for most of the previously unreconciled experimental observations.

One of the questions arising from this work and one which has not yet been resolved concerns the nature and location of the solid surfaces from which the swelling starts. Do they consist of the surfaces of the cell lumen or do they consist of the surfaces of capillaries within the cell wall into which vapour or liquid penetrates before swelling commences?

In an attempt to throw light on this problem, measurements have been made of the density of dry wood in a range of non-polar organic liquids. A new technique was employed for these measurements which had a high sensitivity and allowed measurements to be repeated on any one specimen. Further, any changes in the apparent density with time could be followed easily and final measurements delayed until equilibrium was reached. The presence of traces of water in the liquids or even the exposure of the dry liquids to the ambient atmosphere during density determination were found to lead to a significant uptake of water by the wood specimen while it was immersed. This observation cast considerable doubt on any published values for the density of wood substance which were obtained under conditions where moisture was not totally excluded.

Two important facts were demonstrated from these measurements. It was shown first of all that, contrary to some published data, the swelling of dry wood (klinki pine) in dry non-polar liquids, such as benzene, carbon tetrachloride, heptane and decalin, is less than 0.01%, provided water is rigidly excluded throughout the experiment. It was found further that the apparent density of a sample of wood measured in each of these liquids was the same, namely 1.431 ± 0.001 g/cc. This suggests that within this accuracy, there were no discernible differences in accessibility of cell wall voids, if any, to these four different non-swelling liquids. It is planned to compare these density figures with those using mercury or helium as the displacement fluid.

Note: The swelling pressure work which was foreshadowed at the last conference was not commenced as we were unable to appoint a suitable Research Scientist. The appointment has now been filled however, (Lesse) but the nature of the work that he will be undertaking will not be decided until his arrival.

Rheology. - Work has continued in the fields of creep, deformation due to simultaneous loading and moisture changes, vibrational properties, and the physics of fracture.

Measurements of creep in compression at various stress levels have shown that, for stresses below about 70% of the ultimate stress, the time dependant deformations are proportional to stress, but above about 70%, the deformations rise much more than proportionally. This shows a basic difference between tensile and compressive creep and has helped to clarify the non-linear behaviour of creep in bending at high stresses.

Observations of beams that have been under load for about 10 years in conditions simulating practice have continued and monthly deflection readings are being taken and examined to assess the effect of seasonal humidity changes.

Stress relaxation in wood held at a constant strain perpendicular to the grain and subjected to moisture cycles has qualitatively followed the behaviour of relaxation parallel to the grain, i.e. there is a considerably greater reduction in stress in material with a fluctuating moisture content than in that with a constant moisture content.

Four beams of a eucalypt and four of a non-porous species subjected to moisture cycles between dryness and saturation at a small stress showed an increase in deflection after each moisture cycle with no apparent upper limit to the process even after 34 cycles.

Beams cut from particle board and cycled from the dry to the saturated state showed the usual increase in deflection after each cycle, the major increase in deflection occurring during each drying period. This latter observation agrees with our experience of solid wood but does not agree with the results published by an overseas laboratory.

The elastic modulus and internal damping of three species were measured at frequencies from 0.1 c/s downwards in the bending mode. The results obtained at 2 temperatures and 3 moisture contents did not show any abrupt change in elastic properties with frequency as has sometimes been postulated. Hopes that results from vibrational tests might lead to shorter testing times in creep studies have not been realized.

A start has been made on the measurement of fracture energy in shear and cleavage but at present the accuracy of the results is not good enough to compare the effects of various treatments on fracture energy. Moiré fringe techniques are being studied with a view to improving the experimental results.

An officer of the Section, who spent some months at the CSIRO Division of Textile Physics working with single fibres of wool, hopes to begin work on single fibres of wood to help clarify the mechanism of time dependent deformation in wood.

Item 2(a) Research Review (New Zealand)

*Microfibril angle and shrinkage. - Cooperative studies with DSIR are continuing in this field. Exceptionally high longitudinal shrinkage in corewood of P. jeffreyi (up to 6%) was found to be the result of microfibril angles in excess of 45°. These results demonstrated the "cross-over" between the curves relating longitudinal and tangential shrinkage to microfibril angle as postulated in the reinforced matrix theory proposed by Barber and Meylan.

Item 2(b) Shrinkage in compression wood of P. radiata (SA)

Harding queried whether any work had been done on shrinkage of compression wood in P. radiata. G. Christensen said that there was little systematic work on this. Early work by Greenhill on native softwoods indicated that transverse shrinkage in compression wood of these species was less than for normal wood, but that the longitudinal shrinkage was greater than normal, and causes most of the trouble. An isolated experiment on P. radiata indicated the same for this species.

ITEM 3. TIMBER ENGINEERING

Item 3(a) Research review (DFP)

Standard Tests. - Mechanical tests have been completed on 21 trees of Callitris intratropica from the Northern Territory. These tests conducted at the request of the Forestry and Timber Bureau indicated that this species is significantly denser and superior in strength properties to Callitris glauca.

In collaboration with the Utilization Section, the properties in the green condition of five trees of immature messmate stringybark from Tasmania have been determined, and similar work on eight trees of immature mountain ash grown in Victoria is in progress. The testing of the dry material from 48 trees representing eight North Queensland plywood species is nearing completion.

The properties of 81 New Guinea species have been published in the Division's Technological Paper No. 41. Species testing for the Fiji Department of Forestry and for the British Solomon Islands Protectorate has continued, some 60 individual Fijian species and 27 B.S.I. species having been sampled to date.

* Prepared by J. Maddern Harris.

A computer program has been prepared and used for both analysing the test data and presenting tables of properties of species in a form suitable for interim publication. Work has begun on a long range plan to transfer statistical data from all species testing to punched cards to facilitate analysis by computer.

Joints. - A basic load-deformation curve independent of species, nail diameter and other joint parameters has been described in an empirical form for joints under short-duration loading in tension or compression. The possibility that the characteristics of a nailed joint under cyclic loading and under long-duration loading can also be described empirically, is now being examined.

Investigations of the characteristics of metal toothed plate connectors in Australian timbers are continuing. It has been established that a similar empirical relationship between load and deformation as obtained for nailed joints can be used to describe the short-duration load-deformation curve for a plated joint.

Trusses. - In the current program, 18 commercial trusses have been erected for test under long-duration loading. Analyses of the results obtained so far appear to indicate that:

performance of a W-type truss under short-duration loading can be reasonably predicted by means of an analysis developed at the Purdue University;

the use of a test load in excess of the design dead load may be effective in determining whether certain truss designs or material are likely to be adequate;

better control of the properties, particularly the modulus of elasticity of individual members is desirable;

seasoned conditions at the time the trusses are erected affect the rate of deflection, the rate being relatively fast in hot, dry weather and slow in cool, wet weather;

in spite of seasonal differences in creep rate, the total fractional deflection after 12 months loading is relatively constant, and

the displacement/time relationship is basically the same for all points on the truss, i.e. not only at but also between panel points.

Detailed analysis of the data is continuing.

Scantlings. - An investigation of the effect of shrinkage and degrade on drying on scantlings of messmate stringybark and blackbutt has shown that for all grades of both species, the loss of section on drying resulted in an insignificant loss of stiffness of approximately 5 per cent. The load-carrying capacity, on the other hand, increased by between 20 and 25 per cent.

Parcels of dry and also green radiata pine, and green Victorian hardwood scantlings have been tested in tension to determine whether strength can be estimated with any degree of reliability from stiffness in bending as measured in a mechanical grader. Already the results indicate the soundness of the current North American design recommendation which requires the working stress in tension to be reduced to 80 per cent. of the working stress in bending, instead of 100 per cent. as formerly used.

Plywood. - From an investigation of the effect of defects of various types on the strength and stiffness of plywood, suggested working stresses have been supplied to the Australian Plywood Association for a proposed industry standard for structural plywood. A working plan has been prepared and specimens obtained for a study of the effect of peeling and assembly conditions on the strength and stiffness of structural plywood.

Pole Strength Investigations. - Reports on the properties of yellow stringybark and grey ironbark have been prepared for publication.

Timber Engineering Developmental Studies. - A computer program has been completed for the design of timber and plywood portal arches, and tabulated design information for a range of arch spans and loadings is being prepared. A design procedure has been developed for beams with discontinuous webs, and a paper dealing with the design of pole frame buildings has been revised and extended.

Code of Practice - Light Timber Framing. - Using the new strength grouping system and the related working stresses as a basis, computer programs were prepared for the calculation and tabulation of recommended spans and timber sizes for the proposed light timber framing code.

Other Activities. - Officers of the Section have been active on various committees of the Standards Association, at several seminars and symposia, and in lecturing at both the under-graduate and post-graduate levels.

Item 3(a) *Research Review (New Zealand)

Sawn Timbers. - A paper relating tests of 6, 8 and 10 x 2 in. beams of kiln dried NZ Douglas fir to grading rules and design stresses for a Standard Structural Grade is in preparation.

Poles. - No investigations have been made in the past two years. Further information is desirable on the effect of steam conditioning of Corsican and radiata pine, on the effect of machine shaving and on the properties of larger poles, say about 45 ft in length. Testing of small clears cut from natural rounds before and after steaming will be the initial approach, but where internal checking

develops, tests of full sized members may be needed. It is still possible that tests of shaved poles will be done jointly by N.Z.P.O. and Wood Preservers' Association, with our assistance.

A paper on "Some Practical Background to Considerations of the Economic Significance of Spiral Growth", relating mainly to poles, but also other produce, was accepted for a future symposium at the IUFRO Congress, Munich, 1967.

Mechanical Fasteners. -

(i) Punched Metal Plates. A proposition regarding "gang-nail" joists was examined but interest has evidently lapsed, in one instance on consideration of economics of length requirements for jointing at specified positions in relation to bearers. Advice regarding acceptance of "Twinaplate" trusses was given to State Advances Corporation.

It is evident that some tests of "gang-nail" and possibly "Twinaplate" joints in our chief timbers are desirable, but for the very basic studies in this field we will probably rely mainly on the DFP. On the other hand, it is thought that it will be rewarding to put the larger part of our effort in this field into short and long term tests of prototype assemblies etc., when we are adequately staffed and equipped in the new laboratories.

(ii) Grooved Nails. These are now made in New Zealand, and the makers complain of a poor market. It is considered that a lot of work would be required to clarify the extent of their rational use in New Zealand. However, there are several valuable applications evident for their large and reliable withdrawal resistance, as the best approach for the present would seem to be a series of relatively small comparative studies, each relating to a particular end use.

(iii) Coach Screws. There is a need of some tests for design data for these.

Scaffold Planks. - The following planks of nominal 9 x 2 in. section have been tested for stiffness and strength in bending flatwise on a 9 ft span.

13	solid N.Z. Douglas fir
14	solid imported Douglas fir
11	horizontally laminated N.Z. Douglas fir
8	vertically laminated N.Z. Douglas fir, 2 in. stock
8	" " " " 1 in. "
12	" " N.Z. Larix decidua, 2 in. "

Some were loaded centrally, others at points 1 ft either side of mid-span; some were put through the microstress grading machine and proof loaded on a 3 ft span to determine modulus of elasticity.

A report on strength properties and the question of laminating is being prepared. The regressions of breaking stress on modulus of elasticity for 3 ft or 9 ft span are being examined with a view to a further report on prospects for machine grading.

Although the basic difficulty in interpretation, "what is the minimum test strength of an acceptable plank?", has not been fully resolved, it is clear that some planks of both N.Z. timbers are strong enough. Larch is the better prospect, whether solid or laminated, but would have to be selected after very thorough seasoning to avoid trouble from excessive twisting. There are doubts about the feasibility of getting a reliable product (for the special class concerned) by laminating fir, and one is inclined to view solid planks of this species as presenting a selection problem that cannot be readily solved without machine grading.

It is of interest to record that discussions have been held with one firm on the concept of an ad hoc test on the machine grading principle - this raises questions of the most appropriate span and loading arrangement for a reliable and inexpensive grading device.

Panel Products (Radiata pine plywood)

(i) Basic Testing. The basic testing consists of an evaluation of the properties of "clear" material as a basis for later work; the first consignment, comprising veneer from the main source (Central North Island) is nearing completion. Material from another North Island region and two South Island sources is to follow, and manufacture will be by a different factory in each instance. This study is confined to 1/8 in. veneer in 3-, 5-, and 7- ply panels, with a planned total of 30 sheets of each construction.

(ii) Grade Effects. A draft specification defining several grades of veneer is now available but no tests have been possible to date. However, methods of testing large specimens in panel shear and rolling shear have been established through incorporation in the basic testing program. That work suggests reasonable agreement between "2-rail" and "4-rail" (Standard) panel shear tests, and very encouraging rolling shear strength compared with values reported for North American Douglas fir.

(iii) Structural Assemblies. F.R.I. work on this culminating aspect is obviously in the more distant future, but we anticipate collaborating with industry in the near future on their proposal to conduct a number of tests to support tentative design strength assignments. In this way it is hoped to "get off the ground" reasonably safely without detailed evaluation of panel grades. It should be possible to do some strength ratio tests on sheets from the batches of plywood for these assemblies.

Tests on Long Columns. - Tests have been completed on columns of radiata pine complying with the structural grading rules, and having slenderness ratios varying from 5 to 28.

In the shortest columns lateral deflection was very small and failure occurred by transverse compression; but in the largest columns flexture occurred with the initial application of load and failure was primarily by bending, although transverse failure still occurred in association with defects.

As the slenderness ratio increased the fibre stress at proportional limit and the maximum crushing stress progressively decreased. Provided that a strength ratio appropriate to the grade of material is applied (60% in this case) the maximum crushing stress of columns of R=18 or less can be calculated with adequate precision by the Madison fourth power formula; the Euler formula caters for more slender columns. The only data required for these calculations is a knowledge of the properties of small clear specimens.

Machine Stress Grading. - Work has been done on dry radiata pine (7 x 2, 9 x 2 and 8 x 3) and Douglas fir (7 x 2 and 9 x 2). After machine grading, the pieces were proof loaded on both sides on a 3 ft span. The average correlation coefficient for the E values obtained from opposite sides of the pieces was very high - 0.841 and for this reason in future work the pieces will be loaded on one side only.

The regression equations of MR_J on E_p were:

Radiata pine $MR_J = 4.816E_p - 76.3$

Douglas fir $MR_J = 3.682E_p - 270$

Of the 282 pieces tested in this series for radiata pine 6.7% were overgraded, 73.8% correctly graded and 19.5% were undergraded by the grading machine.

Strength of Laminated Beams. - To evaluate the basic unit stresses in bending specified in the Draft Code of Practice for horizontally laminated beams of radiata pine, a set of beams was manufactured using the prescribed grading and gluing procedures. Beams of the same size of grades 1, 2 and 3 were made. Using four point loading they were tested in static bending and 2 cm clear specimens were cut from the top and bottom laminations near the ends of the beams. These were also tested in static bending, using centre loading.

The principal cause of failure in the beams was distorted grain associated with knots and there is strong evidence that such distortion weakened some beams even though the knots were not actually contained in the beams, but had been near the edge of the adjacent material in the log. All the properties of the beams were correlated with knot width and MR was correlated with ME. The mechanical properties of grades 1 and 2 differed but little, but those of grade 3 were inferior.

As tested the beams met the strength requirements of the Code of Practice except for the MR of the grade 1 beams. But their parent material was much stronger than that used as a basis for calculating the unit stresses, and when an adjustment was applied on this account the bending strengths of all grades of beams were well below the prescribed minima although their elastic moduli were adequate.

It was also shown that knot-free beams of the same size would have a MR only 73% of the small clear specimens, and it was concluded that this difference was due to "depth effect". But it was later realised that the method of loading was an important contributory factor. Pettifor* has for instance shown that the MR of beams loaded at 4 points will be 11.4% less than that of similar beams loaded at the centre.

Effect of Depth on the Flexural Strength. - The flexural strength of a series of small laminated beams was measured; the beams were of increasing depth but of constant span/depth ratio.

The MR of the beams progressively decreased, and that of the deepest beam ($5\frac{1}{2}$ in.) was 82.5% of that of the small clear specimens after a correction had been applied for the difference between 3 point and 4 point loading. This investigation was of small scale and the evidence was too limited to permit a precise numerical analysis of the relationships.

Strength of Laminated Beams of two Species. - Small laminated beams of defect-free radiata pine were compared in flexural strength with similar beams in which either one or three pins laminations on each side of each beam were replaced by lamination of locally grown Eucalyptus fastigata. With the latter beams the average increase in ME was 46% and in MR 26%. An approximately linear relationship was found between strength and number of Euc. laminations.

The strength of the parent materials was measured and the relative strengths of the composite beams were predicted with sufficient accuracy by means of the horizontal transformation theory.

A comparison of the Block Shear, Cross Lap Tension and Glueline Cleavage Methods of Testing Glued Joints. - In this study the immediate dry bond strengths in glued joints in radiata pine and tawa were evaluated by the conventional block shear test, the cross-lap tension test and the glueline cleavage test; both radial and tangential shear tests were done. Three glues were used with the pine and two with the tawa.

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* Pettifor, C.B. 1939. Relation Between Strength Properties in Static Bending as Determined from Centre and 4 Point Bending. Int. Rep. F.P.R.L. Princes Risborough.

The glueline cleavage test is deliberately aimed at causing failure in the glueline, and not in the wood, so that the failing load is a direct measure of bond strength. In this case the average wood failure for the cleavage test was 10% against 56% for the block shear and 74% for the tension test. Thus, for the shear and tension tests the actual breaking loads were not effective criteria for directly comparing the quality of the glues and no relationship between the wood failures and the average bond strengths can be discerned in the data.

Discussion

Anton: Investigations at D.W.T. on stress grading of scaffold planks have proved that the average modulus of rupture at the weakest point of planks in present use is about 7000 lb/sq in. The correlation with modulus of elasticity shows that the stress grader should select material with a minimum modulus of elasticity of 1.1×10^6 lb/sq in. Using the data available it is suggested that an allowable working stress for scaffold planks of 1800 lb/sq in. be assigned. The criterion for a species to be satisfactory for this use is that it should have an average modulus of rupture of 7000 lb/sq in. with a minimum probable value of 5000 lb/sq in.

Item 3(b) Quality Control Testing Facilities for Commercial Operation of Stress Grading Machines*

A new model of grading machine known as the "Computermatic" grader is now available as a commercial product. The advantages of this model are as follows:

The grading of the timber is carried out in a single pass

The speed has been increased to 200 f.p.m.

The digital control unit incorporated with the machine provides for full automation of the stress grading process.

A modified "Microstress" grader to grade 4" x 8" was manufactured and is under commercial operation in Victoria.

For the purpose of controlling production and correct operation of the timber grading machines we require:

A bending test piece to be taken at random from every 100th length of timber reaching grade for which approval to operate the machine has been given

This test piece is to be cut from the lowest stiffness zone present in the length of timber graded.

The following tests will be carried out on this test piece, known as the "Quality Control Sample":

(a) Check ME on the flat
(b) Find MR on edge

Our experience with quality control testing indicates that with two testing machines and two operators 40 to 50 samples per day can be tested.

The Division of Wood Technology of N.S.W. is in a position to handle the quality control program and calibration of its grading machines in Australia but as more machines go into operation in other States provision should be made for laboratory testing facilities to undertake the testing of quality control samples. At present the charges are $1.00 per sample.

Mechanical grading of timber and the quality control scheme associated with it allowed us in a very short period of time and at a low cost to collect valuable information for various species.

Discussion

Huddleston: The accuracy of the grading machines is completely dependent on the quality control tests because of the method of operation of the machines. A general correlation has been worked out and this can be applied to put a machine into operation. However, a continuous check on the machine is required to ensure that the particular batch of timber is not varying from the conditions under which the figures have been derived. The Standards Association Document MP18 lays down that the controlling authority shall be the Australian Institute of Timber Engineering, N.S.W. Branch, which up to now has not been functioning in the way it was assumed to function when that document was prepared. The Forestry Commission of N.S.W. has been providing the quality control testing without any real authority to enforce it. The N.S.W. Branch of the A.I.T.E. has recently agreed that they will accept application from anywhere in Australia for the use of the A.I.T.E. brand on timber. This will be a temporary measure. When the individual States set up their own organization, they will sub-license that organization to use the brand and will pass over the quality control testing to the State branches.

In the meantime, D.W.T. is set up to accept quality control testing. D.W.T. will provide the necessary technical services if necessary or advise on the acceptance of tests carried out say by D.F.P. or the R.M.I.T. and will obtain and accumulate the test data from these sources.

A lot of information is required on the value of modulus of elasticity to be used for structures built with machine graded timber. Shear, cleavage, tension and compression strengths and all the other properties not directly measured in machine grading have to be selected and assigned to particular grades of timber.

A general discussion followed on the possibility of setting up a committee to examine the research problems relating to the use of machine graded timber in structures.

Item 3(c) Location of Grading Machines within and Outside Australia

The location and type of grading machines is given in the table below:

Type of Timber Grading machine	Location	Operator's Name
Microstress-Computermatic Prototype	Sydney, N.S.W.	Department of Architectural Science, University of Sydney
Microstress	Sydney, N.S.W.	G. Hudson's Pty. Ltd.,
Computermatic	Sydney, N.S.W.	G. Hudson's Pty. Ltd.,
Microstress	Auckland, New Zealand	Carter Consolidated Industries
Microstress	Rotorua, New Zealand	Forest Research Institute
Microstress	Auckland, New Zealand	N.Z. Forest Products Ltd.,
Microstress	Queanbeyan, N.S.W.	Donoghue and Hopkins
Microstress	Pretoria, South Africa	C.S.I.R.O. Timber Unit
Microstress	Capetown, South Africa	Lamtico Industries
Microstress	Lyttelton, New Zealand	Addington Timber Co. Ltd.,
Microstress modified	Melbourne, Victoria	H. Beecham and Co. Ltd.,
Computermatic Microstress	Sydney, N.S.W.	Division of Wood Technology
Computermatic	Mount Gravatt Queensland	Wilkinsons Timber Industries
Computermatic Microstress	Princes Risborough, England	Forest Products Research Laboratory. D.S.I.R.

Item 3(c) Table cont'd

Type of Timber Grading machine	Location	Operator's Name
Computermatic	Port Moresby New Guinea	Department of Territories
Microstress	Canberra	Forestry School, Australian National University
Computermatic	Sydney, N.S.W.	Booth Industries Ltd.,
Microstress	Umtali, Rhodesia	Rhodesian Forestry Commission

ITEM 4. PRESERVATION

Item 4(a) **Review of Research Activities***

Important aspects of our work in wood preservation since the previous Conference in June 1965, are discussed briefly in this review. Items listed for later discussion are mentioned only sufficiently to preserve continuity and perspective.

Field Tests of Preservatives. - Evaluation of various preservatives and treatments under field or service conditions is a major project which is providing a steady fund of information of immediate practical value and also of very considerable significance in more fundamental research areas. Some recent results are as follows:

Rail Sleepers. - Tests in Western Australia with creosote oil, creosote oil plus mineral oil (50:50) and with 3% PCP in furnace oil, have shown that termite attack in karri is not completely prevented even with straight creosote at 1000 psi. Use of the other two preservatives appears to be undesirable for refractory sleeper timbers such as karri in areas of termite hazard. Use of arsenical creosote may answer this problem.

The second test of radiata pine sleepers in South Australia (installed at 3 sites in 1956) has so far shown no advantage for the different cross sections used. In this test all the preservative oils including creosote plus mineral oil (50:50) and 3% PCP in furnace oil are giving excellent results, but as expected from the earlier test the CCA waterborne preservative is proving inferior because of its lower protection against weathering.

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* Prepared by N. Tamblyn.

In the Victorian tests (installed 1954-56) eucalypts of lower durability, including messmate stringybark, are performing well when treated at high pressure with preservative oils and when plated to reduce wear at the rail seat. The waterborne preservatives used (copperized chromated zinc chloride and Greensalt K) have proved unsatisfactory.

Small Specimen Tests. -- The large test of about 6000 stakes installed at sites in Papua-New Guinea, Queensland, New South Wales and Victoria is now almost 4 years old and some trends are becoming apparent. One of the most important is the confirmation which is being given of the effect of timber species on performance of some preservatives. From many sources now (laboratory decay tests, marine borer tests, leaching tests and field tests) it is becoming clear that there is often a pronounced difference in the performance of important preservatives such as creosote oil, PCP in oil, and CCA salts when similarly treated radiata pine and eucalypt specimens are tested side by side. The result is typically most unfavourable to the eucalypt which may require several times the preservative loading to give the same result as pine. To some extent this may be affected by specimen size.

The stake test of treated pine to compare proprietary metal-chrome-arsenic preservatives, which is being made in cooperation with the Division of Wood Technology, is about 5 years old. Results are already of value as they show that the low retention of 0.25 lb/cu ft gives full termite protection under high hazard field conditions for preservatives with as low an arsenic content as Tanalith C. This test of CCA preservatives has recently been extended to include some new formulations.

Cooling Tower Tests. -- The tests of preservative treated slats in cooling towers is already showing some results after about 21 months exposure. Fixed copper preservatives and creosote are performing well but treatment by acetylation or with formaldehyde to cause cross-linking have given little protection. Superficial treatments have also proved disappointing. Our best recommendation at present is pressure treatment to obtain good penetration and high loadings of CCA salts. So far there is no evidence that [illegible] oil, similarly used, will not give good protection. It should be stressed that we restrict these recommendations to coniferous timbers and do not recommend use of treated hardwoods for slats. We are perturbed that this is not always the policy in New South Wales.

Marine Tests of Wood Preservatives. -- Results of our first marine test against Teredine borers in Brisbane River, Sydney Harbour, Kwinana and Port Hedland, may be summarized as follows after 6 years exposure:

(1) P. radiata: CCA salts at 1.7 lb/cu ft are better than K33 creosote oil even at 20 lb/cu ft.

(2) E. macrorrhyncha: CCA salts at 1.7 lb/cu ft are inferior to creosote oil, even at 10 lb/cu ft. At Port Hedland all CCA treated specimens have failed spectacularly while corresponding pine specimens, side by side, are in good condition.

(3) P. radiata treated with CCA is generally a little superior to the above eucalypt treated with creosote oil.

Because these results suggest that CCA treatments may be unsatisfactory for eucalypt piling in northern water a second test has now been installed in northern ports including ports in Papua-New Guinea. In this new test, specimens have been protected from end leaching so that this factor can be eliminated in the comparison between pine and two eucalypts.

Fire Resistance of Fence Posts. - Since the last Conference the fire resistance of CCA treated pine posts has become an important issue. There is no doubt that posts treated with these preservatives, if once ignited, are likely to smoulder away due to continued glowing. If this "after-glow" cannot be prevented economically it is possible that CCA treatments for posts will be abandoned in favour of creosote oil or other relatively fire-resistant treatments.

Although the preservative manufacturers are working on this problem we have also undertaken an investigation firstly to assess the fire danger to treated posts and secondly to develop and test fire retardant treatments. Some progress has been made.

Problems in Preservation of Eucalypt Poles. - There is little doubt that the first 10 years of commercial pressure treatment of eucalypt poles has seen a considerable amount of sub-standard creosote treatment which will not achieve the predicted life of 35 years. This is a complex problem which we are constantly examining from various aspects some of which are:

(1) The use of sub-standard creosote. This has now been corrected by the new Australian Standard issued since the last Conference.

(2) Use of relatively impermeable species such as spotted gum. For such timber, CCA treatments now seem preferable and we are considering whether this recommendation should be made.

(3) The peripheral variability of eucalypt sapwood to penetration with preservative oils. Uniform drying, segregation of species, longer treatment to refusal and setting of higher average loadings are the best solutions we have. Incising has been examined but results have not been very promising.

(4) Narrow sapwood coupled with tendency to barrel checking which increases the danger of attack in the heartwood. The possibility of using an additional diffusion treatment of heartwood is being examined together with the likely benefit of arsenical creosote.

(5) Development of heartrots due to an infection present when the pole was felled. A survey has been planned to assess the importance of this, particularly in E. regnans poles and the possibility of heat sterilization during treatment is being examined.

Studies on Permeability. - A comparative study of the permeability of the sapwood of 19 timbers to creosote oil and to water has resulted in the general conclusion that in hardwoods of over 50 lb air dry density, creosote penetration is generally far less complete than a waterborne preservative, when conventional pressure treatment is given. This difference becomes progressively less in lighter timbers and below 35 lb density, creosote retention in full cell treatment may equal that obtained in the waterborne treatment. Subject to confirmation with commercial size material this suggests that we should be wary of creosote treatment of heavy timbers.

At the request of the Shell Company, we have examined their patented claim that addition of about 15% of oxide paraffin wax to creosote oil considerably improves its penetrative properties, particularly in refractory softwoods. We have made two tests and each time have found some improvement with eucalypt sapwood. We will soon be doing a final test to decide whether this is a real improvement and whether it is worth commercial attention. My own impression is not very favourable because of solidification of the wax-creosote mixture in cold weather and the more objectionable surface condition of the treated wood. However, if better penetration is obtained we may find in this some valuable clue to preservative adjustment in which objectionable features are eliminated.

Our permeability studies have also included a preliminary look at the very important problem of treating radiata pine heartwood. We have established the following with waterborne preservatives.

(1) There appears to be a pronounced effect of locality on heartwood permeability. (This could possibly be a genetic factor associated with origin of seedlings.)

(2) Pressure treatment for a long period produces a small but positive advantage.

(3) Increasing the pressure gives better penetration, however this is only a partial solution.

(4) Treatment of green heartwood is of no advantage in conventional pressure treatment.

Arsenical Creosote. - This work, in which we have studied the addition of arsenic trioxide to Australian vertical creosote to increase termite resistance, is now nearly completed. It has been shown that addition of less than ½ percent. arsenic trioxide increases toxicity to termites, particularly to Coptotermes and that this arsenic is largely resistant to leaching. A commercial run will be made very soon and we expect to set up a service test to compare creosote and arsenical creosote treatments in the Mildura area. If the commercial run is satisfactory we intend soon to recommend addition of arsenic to creosote as a regular requirement for most treatments in Australia.

Water Repellent Dipping Preservatives. - We have continued to recommend use of these preservatives for the purposes (and with the restrictions) outlined at the last Forest Products Conference. We have advised the Army to use a dipping treatment for munition boxes as an alternative to the pressure treatment with a fluo-chrome-phenol preservative specified by the British Army. It is understood that almost all our munition boxes are now dip treated but unfortunately a somewhat incompetent British specification for lauryl pentachlorphenol has been accepted and this preservative is now mainly used here for munition box treatment. We have made laboratory decay tests and found that 5% lauryl pentachlorphenol is much inferior to 5% pentachlorphenol and to 1% tributyltin oxide. Copper naphthenate was also relatively ineffective against a copper tolerant fungus. We have persuaded the Army Inspection Directorate to set up an exposed box test at Innisfail of these different preservatives.

Natural Durability. - Laboratory tests of the relative decay resistance of timbers from Australia, New Guinea and Fiji have continued and in all, about 95 species have been tested. These have been mostly rainforest timbers in which only a few species of high durability have been found.

A test of natural durability, involving 37000 stakes and representing 75 timbers, mostly eucalypts, will be installed in the next few months. It contains some durable overseas timbers and some preservative treated timbers as "yardsticks". There will be 5 field sites - near Innisfail, near Brisbane, Sydney and Melbourne, and also a dry inland site yet to be chosen.

We have studied the durability of the "intermediate wood" or "outer heartwood" of spotted gum which is a pale coloured zone of relatively impermeable wood between normal heartwood and sapwood. We have shown it to resemble heartwood in durability. Its white appearance may be due to the fact that extractives although present have not yet polymerized or oxidized to their full colour.

Laboratory Evaluation of Preservatives. - We have tested a number of organo-tin and organo-lead preparations against decay and soft rot fungi, and have found some to be highly toxic and reasonably permanent. However, there are some relatively tolerant fungi and fully effective retentions may need to be higher than those recommended by overseas workers.

Metal-chrome-arsenic preservatives containing copper, zinc and nickel alone and in mixtures, developed for veneer dip treatments, have been tested against decay fungi. Results have shown that zinc and nickel are less toxic than copper, and that the low arsenic content (to reduce sanding hazard in a plywood preservative) also reduced preservative effectiveness.

We have commenced a general examination of the toxicity to wood destroying fungi of metallic ions, singly and in association.

Effect of Timber on Preservative Performance. - As mentioned at the last Conference, and also in this present review under field tests, it is now apparent that the timber substrate can have a pronounced influence on the effectiveness of a preservative against decay fungi. Our earlier tests with CCA preservatives have now been confirmed using copper formate and also creosote oil. More extensive laboratory tests have indicated that this effect is not always consistent even within a timber species and that much more work will be needed to elucidate the causes and practical implications of these variations.

Fundamental Studies on Wood Decay.- More attention is now being given to research aimed at obtaining a clearer understanding of the whole process of decay. In cooperation with the Physiology and Microstructure Section we are studying at electron microscope level, the effect of various fungi on the fine structure of wood. We are also examining the ability of some fungi to break down lignin and cause defibration without destroying the cellulose. This is part of a long term project in which enzymes may be used to interpret details of wood structure. The possibility will also be examined of using fungal delignification as a practical aid in paper making.

Various investigations have shown considerable variation in wood destroying ability not only among fungi but also between isolates of the one fungus. To understand the reasons for this could be of considerable value and a study is now being made of the genetic behaviour of wood destroying ability and the factors associated with it.

Lyctus Investigations. - The test which we are making to determine the toxic thresholds of typical CCA preservatives to Lyctus is almost completed, and results should be available within a few weeks now. This test has been done very thoroughly with 3 timbers and 3 CCA preservatives inoculated with Lyctus discedens, Minthea rugicollis and with 2 strains of L. brunneus. From preliminary observation of results it appears likely that 0.03% As_2O_5 will be a safe level.

The test of sodium fluoride in similar thorough manner is now commencing.

Since the last Conference we have tested material from about 160 trees from Fiji and the British Solomon Islands for Lyctus susceptibility. Species are graded for susceptibility as soon as sufficient trees (usually 5 per species) have been tested.

Item 4(a) Review of Research Activities (NSW)*

The more important items are discussed briefly under headings such as mycology. In many cases however, several disciplines were involved.

So far as is practicable a species-oriented approach is made to local preservation problems, and this system is proving well worthwhile.

Mycology. - A two-year field study of blue stain, and decay in radiata pine logs, and sawn timber, was made at Oberon. Some 2500 isolates from this survey are now being identified.

To provide a basis for future salvage schemes the development of blue stain, decay, and insect attack in fire killed radiata pine was studied at Moss Vale, over a period of 15 months. At the same time the value of chemical sprays for fungal, and insect control in logs was investigated. It is likely that the cost of such spray programs will be prohibitive under Australian conditions.

Some work was done on the biological incising of spotted gum sapwood, but the results were not such as to encourage further work.

Studies continue on pencil streak, and brown stains in NSW stringybarks.

Entomology. - Two insect distribution surveys are in progress. The first is designed to map the distribution of Lyctus, Tristaria and allied genera in New South Wales and Southern Queensland; and to test whether exotic genera such as Mintla have become established in the area. The other survey, now completed, has yielded the first clear picture of the occurrence of the common furniture beetle (Anobium) in New South Wales.

Anobium is an important potential threat to softwood utilization, and studies are being made of the effects of alternating temperature and humidity on its life cycle; on the effects of tree provenance on susceptibility to attack; and on the toxic thresholds of aldrin and boron, (particleboard), tri-butyl tin oxide, (timber), and formaldehyde vapours (freshly made particleboard).

Toxic thresholds for Lyctus are being studied in CCA and fluoride treated veneers. It is proposed to study also the effects of kiln drying and hot pressing on plywood susceptibility to this insect.

At the request of Plant Quarantine a study was made of suitable schedules for the heat sterilization of blockstacked Shorea spp.

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* Prepared by D. W. Edwards.

Light trap studies are under way at country mills to determine changes in Lyctid and Bostrychid populations throughout the year, and field control studies are planned at Armidale throughout this year.

Chemistry. - Techniques for the preservative treatment of green radiata pine with copper-chrome-arsenic salts were investigated, including alternating pressure; high vacuum; step pressure; and conventional 200 psi vacuum/pressure schedules. All these methods were tried with and without presteaming. It was concluded that presteaming, followed by a conventional vacuum/pressure schedule gave results equal to or better than the other systems.

Work was also carried out on the differential movement of copper and arsenic components of copper-chrome-arsenic preservatives during the pressure treatment of dried radiata pine and on the uptake of these salts by radiata pine posts using the sap replacement system.

An investigation was made to determine suitable treatment methods for the sapwood of white cypress pine. This species is widespread in western New South Wales, and provides good fence posts but has a non durable sapwood. It was found that conventional 200 psi vacuum/pressure treatment with CCA salts, and the 1000 psi CSIRO method did not give useful retentions. On the other hand, sap replacement with CCA salts gave retentions of 9 lbs/cu ft in the outer half inch of the sapwood when calculated on total sapwood basis. This retention is much in excess of the usual treatment recommendation and further work is planned to develop a practical commercial treatment.

Field Tests, etc. - Inspections were made of CSIRO and DWT field tests of wood preservatives, and of natural durability. A marine borer exposure test was installed for CSIRO in Sydney Harbour.

Item 4(a) (Queensland)*

The preservation industry has now become firmly established in Queensland and the current position is summarised in the following tables:

TABLE 1 Annual Consumption of Wood Preservatives in Queensland

Type	Approx. Tons/Annum	Approx. Value $A
General purpose CCA	400+	240,000
Boron	500	60,000
Sodium fluoride	10	2,000
Dieldrin, PCP) Miscellaneous)	1.0	6,000 (estimated)
Total	910+	308,000

TABLE 2 Current Productive Capacity - Preservative Treatment Plants

Type	Number (Note 1)	Daily capacity s.ft
Sap stain control	11	
Veneer	26	- Note 2
Open tank processes	52(Note 3)	153,000
Vacuum pressure	26	200,000
Total	115	353,000
Equivalent annual capacity (s.ft) on 200 day year		$70,600,000
Equivalent increase in value by treatment on basis of $2/100 s.ft		$ 1,412,000
Capital outlay in plant (all types)		$ 1,000,000 (approx)
Approx. daily saving to industry by processes developed by Department		$ 2,000/day

* Prepared by K. V. Cokley.

NOTES TO TABLE 2

Note 1. This includes plants operating at actual capacity but does not include plants registered under the Timber Users' Protection Acts, but currently operating spasmodically.

Note 2. Current veneer production treatment rate through dip of 80 lineal ft/min.

Research items. - Research projects have covered the following:

1. Sleepers. (a) The trial of 8 species treated by open tank and spray methods initiated in 1950 has been completed. Results show that principal failure cause is mechanical and that hot and cold treatments in oil preservatives are effective in significantly increasing service life.

(b) Service exposure of high pressure treated and boultonized sleepers in south and north Queensland has continued. Results are beginning to show that water borne preservatives are ineffective against mechanical degrade. Boultonized sleepers are at least as good as high pressure and present data suggest less mechanical degrade.

2. Service tests of preservatives and durability. A major study involving approximately 5000 samples and 15 species initiated in 1954 has continued. Results were again good for oil borne preservatives in ground contact. Exposure trials of approximately 1100 samples (of 7 species) against Lyctus have been completed. Preservatives used were (a) Tanalith U and Tanalith C, (b) copper naphthenate, (c) zinc naphthenate and (d) pentachlorphenol.

3. Preservation of veneer and plywood.
(a) Vacuum pressure treatment by CCA of veneer and plywood presents a number of unsatisfactory and uneconomic aspects. Currently a preliminary study is being made into the use of Dieldrin, sodium PCP treatments by momentary dip as an alternative.

(b) Tests are being carried out into alternative methods to the momentary dip for veneer treatments using Dieldrin. These have been concentrated on spray procedures at the lathe and clipper.

(c) Cooperative studies are proposed on the improvement of fire resistance of plywood using post-pressing procedures with boron compounds. Preliminary trials in terms of treatment show promise.

4. Development of preservatives. Work has continued on studies of general purpose preservatives. Successful results have been obtained in formulation of a fixed copper borate. Results using zinc and aluminium have given promise.

   The final formulation is not sensitive to temperatures, water hardness or extractives.

5. Exposure trials of preservative treated timber. Service trials using preservative treated timber have continued in departmental buildings. Of significance are:

   (a) Boron treated slash pine was depleted of preservative in approximately 4 years

   (b) Hot and cold oil treatments using PCP and inclusive of laminated members have to date given very satisfactory results

   (c) CCl_4 treatments do not appear to be effective in relation to knots and branch stubs.

6. Chemical laboratory. Plant control and studies of treatment standards are continuing and for the year 1966/67 a total in excess of 6500 determinations were made.

7. High vacuum and vacuum pressure diffusion process. Work has continued and currently 80% of production through cylinders is by these techniques, inclusive of two plants approved in New South Wales and are operative in North Queensland. Patent rights on these have been accepted. When these have been finalised detailed reports will be published.

Item 4(a) New Guinea*

It is three years since it has been compulsory for all timber supplied for Government building and furniture contracts in the Territory to be treated by the dip diffusion process. We are generally very satisfied with treatment efficiency, although we can now see the need for reduction in cost by streamlined handling during treatment. Licences issued or being processed now total 56, representing 82% of the total sawmillers in the Territory. There are 5 operators treating at a rate in excess of 1 million super ft a year, 6 between 500,000 and 1,000,000, 19 between 100,000 and 500,000 and 12 less than 100,000, with 14 licence holders treating only sporadically or not at all. As far as the process is concerned, our greatest worry is safety and health. At the plant this is a domestic problem and we are solving this gradually, but waste disposal and machine dust is a more general problem. Over 3 years, a total of 932 tons

of ready-mix dry salt has been utilized for a treatment of approximately 45 million super feet of timber, while an additional 219 tons has been mixed on site for treatment of 8.5 million super feet. Over the last 12 month period, 355 tons of ready-mix salt and 104 of "on-site" mixed salt have been used to treat 24.5 million super feet. These treatment volumes are only approximate and are probably on the conservative side. We now have the services of a chemist who is at present studying the analysis techniques prior to a study of differential diffusion. We are looking very seriously at pressure treatment particularly for round timbers. There are now four commercial sized pressure plants in the Territory. One of these is our own and one is a plywood treatment plant. We are also looking at treatment schedules for our major pole size species. A main achievement in this field has been the treatment of about 350 poles by Commonwealth-New Guinea Timbers for the Electricity Commission. The Division of Forest Products assisted with treatment specifications for these and the Department controlled the treatment fairly closely. The poles were all klinki pine suppressed stems from native forests and ranged in size to 60 ft. They have been located over a wide range of sites, all in fairly high hazard areas close to Lae and we will be watching these with considerable interest. We were faced with a number of problems in the preparation of the poles and of greatest concern was the amount of compression failure, which we suspect occurred in felling. Most of this failure did not show up until after treatment and some even got as far as the site, where fairly rough handling on unloading made the weaknesses very apparent. This was a case where we encouraged fairly rough handling. In our highland areas, where timber supplies are very low, bridging materials are a major worry. Imported substitute materials are of very high cost and I hope that with DFP's help we will be able to assist these areas.

Probably the two major problems facing Territory industry and ourselves at the moment are Ambrosia attack and sap stain. Ambrosia is of double concern in the face of very stiff quarantine inspections in Australian ports. We have one example of a sawmill which exports large quantities of klinki pine into Australia and at times Quarantine have found it necessary to fumigate every second shipment. We inspect all of these shipments ourselves as they are loaded in the Territory and as far as we are concerned, they are free of attack when they leave. It is therefore rather startling to find that they are stopped for fumigation. Sap stain is a worry with our light density species and the Japanese and Australian markets for these species could be quite large if we could overcome this problem.

Item 4(a) New Zealand*

Treatment of Wood by non-pressure processes. - Further boron diffusion trials are currently being carried out to try to reduce the overall treating time which for inch pine timber treated by momentary immersion plus diffusion is about 8-10 weeks. Increasing the diffusion temperatures is the main method being investigated but this is being combined with increased initial penetration by hot and cold bath treatment rather than momentary immersion.

Redistribution of boron during drying is the main concern of the boron treating industry at present particularly with the prospect of more framing timber being dried before use. This drying causes a depletion of the core loading which may result in substandard treatment at the time of use, but it is thought that there may be a subsequent reversal of the redistribution in the dry wood. This is to be investigated.

Cold soaking posts and fence battens in creosote continues to be a popular treating method with farmers and in 1965 the Farm Forestry Association applied to have this method recognized by the Timber Preservation Authority so that they could sell their produce as treated. A detailed examination of results being achieved showed that uptakes were extremely variable but that it was possible to obtain good retentions and penetrations in well dried pine posts (and battens) from young non-suppressed trees. The only satisfactory control measure however, is to weigh every post before and after soaking and resoak any that do not increase their dry weight by 20%. If this is done and if some random penetration checks are made the TPA will now approve the treatment.

Pressure Treatment. - Two more commercial oscillating pressure method (OPM) plants are now in operation and treating sawn and round wood satisfactorily. With this form of treatment it is not possible to determine charge retentions accurately and retention zone requirements had to be laid down for each commodity. This was done by examining a large number of samples from wood that had been well treated by conventional vacuum/pressure processes and evaluating the analytical results along with laboratory results from toxicity and leaching tests. For most commodities the essential requirement is a minimum amount of copper in the retention zone, and for quality control purposes at the plant this can be checked reasonably well by spot testing with rubeanic acid. Requirements for the main commodities are:

Marine Timbers - Retention zone = $\frac{1}{2}$ in. to $1\frac{1}{2}$ in. from the surface. All samples must contain 0.5% CuO equivalent in this zone.

Poles, Strainer Posts - Retention zone = $\frac{1}{4}$ in. to $1\frac{1}{4}$ in. from the surface. 90% of samples must contain 0.26% CuO in zone.

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* Prepared by A. J. McGuire.

Posts and other ground contact Timbers – Retention zone = $\frac{1}{8}$–1 in. from surface for sapwood and outer $\frac{1}{2}$ in. for heartwood. 90% of samples must contain 0.24% CuO.

Fence Battens – Retention zone = any sapwood in the mid length cross section. 90% of samples must contain 0.14% CuO.

Light Building Timber – Retention zone = central 1/9 nth core. 90% of samples must contain 0.06% As_2O_5.

These recommendations were written into the OPM specifications by the TPA and the concept is gradually being expanded to include other forms of treatment. A new specification for pine exterior joinery carries a charge retention of 0.35 lb/cu ft. Tanalith NCA (other preservatives on an equivalent copper basis) and a core retention of 0.14% CuO equivalent in 90% of pieces, either heartwood or sapwood. It is becoming obvious that it will be difficult to achieve this in heartwood and some research will be required to determine what lower figure will give equivalent protection in heartwood, and will be possible to obtain in a reasonable percentage of pieces.

Variability in permeability of radiata pine heartwood is causing some concern with other commodities also but to date there has been no report of premature failure of treated heartwood. Work has commenced on a study of the range of both durability and permeability of radiata heartwood but so far no method of covering a large number of samples quickly and effectively has been perfected.

Vacuum/pressure trials with post size material of a number of secondary species has been in progress over the last two years and to date ten species have been examined. Four Pinus species all treated with comparable ease and efficiency to radiata or Corsican pine. These were P. muricata, P. strobus, P. ponderosa and P. contorta. Trials with P. strobus heartwood showed that this treated well in the majority of pieces and that the CCA was even better fixed than in sapwood.

Poplar posts (Populus robusta) also treated well.

Kauri (Agathis australis) treated satisfactorily, there was some evidence of copper screening but this was nowhere near as pronounced as with Podocarpus species.

Redwood (Sequoia sempervirens) and macrocarpa (Cupressus macrocarpa) did not treat satisfactorily; in some pieces the radial sapwood penetration was less than $\frac{1}{8}$ in.

Tawa (Beilschmiedia tawa) showed very patchy penetration but the results have not yet been fully evaluated.

Laboratory Toxicity Tests. - A new series of toxicity tests including six proprietary CCA formulations has been commenced. The preservative formulations being tested are:

Tanalith C, Tanalith CA and Tanalith NCA
Celcure A and Celcure A21N
Boliden K33.

Blocks are to be treated at equal retentions of total oxide equivalents for each salt and the test will be a comparative statistical analysis of leaching losses and decay losses at each retention. Six retentions are being used (0.5 - 1.0 lb/cu ft total oxide equivalent) and the test fungi will be Lenzites trabea, Poria monticola, Poria vailantii and Chaetomium globosum.

A small soil block test with blocks cut from CCA treated radiata pine heartwood indicated that a given concentration in heart may provide greater protection against decay than an equal quantity in sapwood but the test was too small to enable any quantitative assessment to be made.

Graveyard and Service Tests. - Four new graveyards have been established to give a broader coverage of the most extreme conditions of temperature, rainfall and soil type in New Zealand. Natural durability stakes (standard 2" x 2" x 2') of a number of indigenous and exotic species (including some Eucalyptus spp) have been installed and will be added to as material becomes available. Smaller sized stakes of treated wood ($1\frac{1}{4}$" x $1\frac{1}{4}$" x 14") were tried in a limited test in two graveyards and were found to be very satisfactory. This size is to be our standard for treated stakes and material is now being assembled for a major installation in all graveyards.

Service test additions during the last two years have included marine piles of radiata pine treated with CCA salts by both vacuum/pressure and OPM, large high voltage line power poles treated by OPM, and a new treated pine sleeper test which includes PCP in heavy and light oils and CCA salt with and without a water repellent additive. A service test of PCP treated radiata pine used as a silencer for geothermal steam bores is showing good results and wood may become the standard material for this use in place of steel lined concrete. Service tests of poles and fence timbers continue to demonstrate the efficacy of currently approved preservatives and processes.

*Corrosion of metals by Treated Wood. - An extensive survey of test fences was undertaken due to reports being received that treated timber posts were causing breakdown of the galvanising on fence wire. Conclusions reached were that in the unusual circumstances of posts treated with copper-chrome-arsenate preservatives being used before the preservative was completely fixed, copper-zinc galvanic couples could be formed, and loss of zinc coating could occur.

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* Prepared by N. H. O. Cummins.

Other types of preservative represented little or no hazard, and even CCA posts are normally held for long enough to permit fixation of the copper to remove any risk of corrosion. A study of factors producing corrosion is currently being carried out.

Discussion

Edwards: How is it proposed to carry out diffusion treatments of transmission poles with a narrow band of sapwood?

Tamblyn: We intend to drill a hole 6 ft or so along the pole and fill it with diffusable preservatives.

Watson: We used only one test site in Brisbane for the marine borer test, and at this site the specimens were exposed to Nausitora. Further down the river there is no Nausitora, but Bankia and Teredo are active and results there could be quite different. In the Bay, we have had quite good results with CCA treated hardwoods. CCA is superior to creosote against Nausitora.

Tamblyn: Mr. Orman mentioned subsequent reversal in the movement of boron in dry timber. Does this mean that diffusion continues at EMC and that it comes to the surface during drying and gradually moves back again?

Orman: We believe that there is some circumstantial evidence that a redistribution is continually going on within the timber itself as it changes its EMC. This was indicated as a possibility many years ago by DSIR when they first initiated boron diffusion process in timber. They found that when they held timber in stacks over a period of 5 years, that there was continual readjustment going on, even though it was dry. A specific research project on an investigation of this redistribution has been set up by us.

Tamblyn: That suggests that in TPNG our diffusion preservative is probably continually moving all the time within the wood and that complete penetration could occur. This might in fact reduce the overall toxicity of the loading which was considered satisfactory when it was strategically in the first ½ in. of the wood.

Rudman: In fluoride-containing preservatives, fluoride will hydrogen-bond and move just like water will do. In the New Guinea preservative where you have fluoride this will naturally help migration and evening out. How many OPM plants do you now have in New Zealand?

Orman: There are two new ones operating, which makes the total three. These would have all been installed by the agents. Hicksons have brought in the APM method, which does not include a vacuum, and they have one plant operating.

Edwards: Have any studies been carried out as to the economics of smaller OPM plants in New Zealand? Have you made any studies of the expected economic advantages of the system?

Orman: Companies operating the new plants seem to be quite happy with them, but there have been no detailed economic studies as far as I know.

Tamblyn: We have been told by a commercial operator in New Zealand that oscillating pressure is not proving satisfactory and they have written a report on it, which indicates that it is neither economic nor practicable. As they have the majority of pressure plants in New Zealand, I would like to hear comments as to how they came to that conclusion. The company concerned is widely claiming in Australia that they have tried oscillating pressure in New Zealand and that they have found it so wanting that they have decided to abandon it completely.

Orman: That company has adopted the APM system, which is only an adaptation of OPM and they have one plant operating in Rotorua, but I did not know that they had gone to the extent of saying they had found it an uneconomic venture.

Rudman: That would be a quick change of face, because 18 months ago they told me that they had one plant and expected to have another within 12 months.

Edwards: Could Mr. Cokley indicate whether he thinks that the fixation of copper borate will be satisfactory with softwoods.

Cokley: We have tested it out on pilot plant scale for twelve months, and the fixation is 90% plus based mainly on copper studies, using soxhlet extraction on the ground sawdust. We want to extend now to toxicity tests rather than assessment based on either boron or copper content. We have the problem of copper rejection with some species and we are not prepared to make any more than a brief mention of it until it is finalised within the next twelve months.

Bryant: Will Mr. Cokley please give us details of the process? How, in fact, do you treat timber with copper borates?

Cokley: We have concentrated on the vacuum pressure process. Two of our problems in Queensland are temperature and hard water, combined with sludging of copper-chrome arsenics with species such as spotted gum. We sought a preservative formulation that was non-sensitive to temperature and water hardness, and presented few sludging problems. We concentrated on vacuum pressure primarily for small plants attached to sawmills, but we have not yet decided on limitations of processes.

Tamblyn: If this copper borate lives up to your expectations, it is a major break-through. When will you release the formula?

Cokley: I would hope that the formula will be released within the next several months.

Tamblyn: I think that is a bit slow for our purposes. Would you treat some wood and let us test them without saying what the formula is until your own good time?

Cokley: Yes, this is one of the things I had in mind after we are satisfied on formulation stability. Up to now we have excluded arsenic and chromium, but the arsenic may be necessary in the dry wood termite area around Cairns and we can blend them, if necessary.

Tamblyn: Have you done corrosion tests?

Cokley: In the laboratory, yes, and they are satisfactory so far as we have gone. Surprisingly enough, we have found that it gives an excellent fire resistance with the reservation that our laboratory test is not a standard test. Comparative tests against CCA and normal boron treated timbers have shown this preservative to be superior in this regard in our tests.

Tamblyn: Because of the importance of this, I feel some tests should be made by Mr. Da Costa and perhaps Mr. Edwards, so that we know exactly where we stand with this preservative within a year. By the time that you are able to release your formula, we will be able to satisfy ourselves and join with you in commending it. These tests should be started almost immediately and should include some leaching and termite tests as well.

Johanson: What species reject copper?

Cokley: Most of the species that reject copper are brushwoods but, unfortunately, we have also struck it in the plantation pines. As a general pattern in these "copper rejections" we have copper precipitated in the outer 1/16 of an inch. In all cases to date, the arsenic moves straight through in some cases, the chromium also.

Johanson: Have you tried your copper borate formulation with these species?

Cokley: It filters out to a lesser degree, but the problem is still there.

Huddleston: Mr. Cokley tells us that a patent has been taken out on the long suction treatment. Could he give us any details of the patent application and the stage it has reached?

Cokley: The provisional patent was taken out approximately four years ago, with the purpose of preventing a monopoly, and to ensure that plants are operating efficiently and effectively. The patents

have been accepted for Australia: world patents in certain selected countries are being considered. The process is being used in at least 2 plants in New South Wales, as well as many in Queensland. In my opinion the process will be made available to industry on a nominal basis. Basically the patent covers the high vacuum aspect and also what we have called the "wet" vacuum. The patent application was accepted by the Patents Office on July 6th. It will shortly be issued for public review. It is for these reasons that I have been advised not to publish details at this time. Officers of the Division of Forest Products and the Division Wood Technology have been told what work has been done. On at least three occasions we have invited officers of both Divisions to come to Queensland and to see what is being done. Similarly, Hickson's and Celcure have been kept informed.

Huddleston: I have an article from a Chilean newspaper which describes the process Mr. Cokley claims to be patenting. Therefore prior publication has been made some time in 1964. I am concerned with the patent because it could restrict developmental work which is taking place in the Division of Forest Products and in our own laboratories. We will have to obtain a copy of the patent application and I feel that we will be bound to object to the patent.

Tamblyn: I believe we will also. The patenting of processes like this is generally restrictive. We didn't patent our high pressure treatment. This manipulation of vacuum and time seems to me to belong to history and I would be very loath to see just that patented. However, until we read Mr. Cokley's complete patent, it may be premature to comment, but I think, in all honesty, I would be extremely sorry to see that sort of patent taken out in Australia.

Cokley: A problem that is not specifically covered in any other items is that of Japanese and Formosan imported doors. Some of these doors contain susceptible material and the economics of treatment are questionable. Would other states, such as Victoria and New South Wales, let us know what the position is and how they intend to tackle it?

Item 4(b) (i) Research on natural durability*

Since the last Forest Products Conference, our research on natural durability has been mainly concerned with assessing the durability of rain forest species to assist the utilization programs of the forest services of Papua-New Guinea and Fiji. In all, 95 species have now been tested, the most durable being Palaquium hornei, Pleiogynium timoriense, Manilkara kanosiensis, Cathormion umbellatum, Hopea iriana, Intsia bijuga and Fagraea gracilipes. These tests have been complicated by difficulties in identifying the test material and emphasize that botanical material should be collected from all trees and identified by competent authorities.

The large scale field stake test of natural durability of Australian timbers has now been prepared and will be installed in the next few months. It includes nearly 4000 stakes representing 75 species and will be installed in five sites ranging from North Queensland to Victoria.

We have also examined the durability of the pale zone often found in spotted gum (E. maculata) between treated sapwood and the brown heartwood. This appears to resemble heartwood rather than sapwood in decay resistance and probably represents outer heartwood in which the toxic extractives have not yet polymerized and oxidised to their usual dark colour. Some other timber species show a similar pale untreatable zone, but it would be unwise to assume without further tests that it is as durable as normal heartwood. We hope, when time permits, to investigate one or two other species and would like some information as to just where this zone is likely to be very pronounced or economically important.

We also hope to do some more work on within-species variation in durability both as regards the radial variation within trees and the existence of genetic variation among trees. The radial variation is important not only in influencing the utilization of the species, but probably also in governing the development of heart rots in standing trees and of centre rots in poles. Any work on genetic variation depends on the availability of suitable populations (e.g. clones, progeny trials, known hybrids) and we would welcome information on the whereabouts of any of these. If the trees are valuable, the tests could be made on increment borer cores without sacrificing the trees. Genetic improvement of decay resistance may be important not only in durable species, but in non-durable species likely to be used as poles or as exposed joinery etc.

We would like the opinions of delegates on the following points:

1. Which timber species are likely to have large or important zones of "intermediate wood" or pole outer heartwood?

2. Whether they have any interest in selecting trees for improved durability or any knowledge of suitable material (with appreciable amounts of heartwood) for genetic work?

Discussion

Cokley: Would the methods developed by Dr. Rudman of comparing the extractive concentrations serve to give quicker indications of the durability of "outer" heartwood?

Rudman: It is unavoidable that there must be a zone in which the extractive content is building up to that final level that we call outer heartwood quite definitely. The white band in spotted gum, for example, can vary in width from nothing to about $\frac{1}{4}$ in. and will vary very extensively between trees and within tree and I imagine that there would be a radial variation in extractive content across that zone. Therefore some of it probably [illegible]

as outer heartwood. How well does the dimethyl yellow spray reagent work on that particular zone?

Cokley: On the eucalypts it works well in the definition of treatable zones which are also defined by ultra violet examination. Our main problem is concerned with sawn timbers such as chamfer boards and bridge decking.

Da Costa: As long as the margin between untreatable and treatable wood coincides with the margin between non-durable and durable wood, then there is nothing to worry about; this does seem to be the case with spotted gum. It may not be the case with other timbers. I am doubtful whether either colorimetric tests or estimation of total extractives will give us the required information, because we will be dealing with a large range of rain forest timbers of very diverse botanical natures and the only sure test is a decay resistance test.

Rudman: We are looking at the possibilities of using our X-ray spectrograph for decay resistance testing. This could enable us to determine in great detail from pith to bark on a large number of samples from the one tree or from a number of trees, but we cannot say yet whether the technique will work.

Edwards: We will be submitting to Mr. Da Costa a list of species which contain intermediate wood. Another question about which we are worried is the presence of phloem inclusion, particularly in some imported timbers, such as Kempas. The treatability of this material is variable.

Item 4(b) (ii) Natural Durability - Survey*

At previous Forest Products Research Conferences, much has been said about an Australia-wide survey to establish a basis for the compilation of a list of durability classifications for Australian timbers.

Several years ago, all States agreed that this Division should compile a list of tentative durability classifications and that timber users and producers should be asked to agree or disagree with relative classifications assigned to those timbers with which they were familiar. Pressure of other work caused the project to be deferred, but recent increases in demand for information have led to its revival. The purpose in raising this item on the agenda now is to seek active cooperation from the States in the distribution of a questionnaire to the people most likely to be able to furnish reliable opinions, and in canvassing the wide experience of forest department staff at all levels. We wish to include as many foresters as possible, as their identification of species is more reliable. They may be asked to survey local opinion regarding timbers used in their area or with which they have had considerable experience.

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* Prepared by C. D. Howick.

We in this Division are well aware of the fact that many Australian timbers have already been graded in one way or another, according to various systems and we are not challenging the validity of these gradings. However, many of these systems do not distinguish between decay and termite susceptibility, nor between "in ground" and "above ground" conditions, and because different systems have been used, it is difficult to equate one with the other.

The purpose of the survey is to rationalize, consolidate and enlarge upon existing knowledge. In order to obtain assessments unbiased by previous grading systems, we will use a completely different method of assessment. We will classify timbers according to durability of heartwood in ground contact, with respect to decay and with respect to termite attack, and also with respect to decay in above-ground applications such as joinery or fence rails. We believe that this will then represent a realistic assessment based on actual experience with the timbers in question, particularly in view of the need for separate classifications for "above ground" use.

This Division is anxious to keep the State Forest Services well informed concerning the progress of the survey. We expect it will reveal a few species about which opinions differ widely. Rather than being a basis for controversey, such discrepancies will reveal the need for cooperative investigation to discover the correct answers.

We firmly believe that information obtained from the survey will be of inestimable value in the eventual production of a standard durability classification for all Australian timbers and will greatly assist any committee called to produce such a Standard. It will also highlight the species about which we have least information, and those for which opinions conflict. The publication of an agreed durability classification for all commercial timbers used in Australia is the ultimate objective of the survey. Whether the list is published by ourselves, by the State Services or by the Standards Association can be decided at a later date.

Discussion

It was agreed that there would be general cooperation in this survey from State Departments.

Item 4(c) Laboratory evaluation of preservatives*

Laboratory bioassays of preservatives continue to form a considerable part of our mycological work. Since the last conference further investigations have been made on the effect of timber substrate on preservative performance. This has confirmed earlier indications that preservative performance is greatly affected by timber substrate not only for CCA salts, but for copper formate and for creosote. Tests with CCA show that the effect is not constant within each species, and we have not yet been able to assess the governing factors. Until more fundamental work on the causes of variation has been done, we can only suggest that some hardwoods may require much more preservative than does pine sapwood and that specified minimum retentions of preservative be kept on the high side until more is known.

Various organo-tin and organo-lead compounds have been tested. Some of these are very promising, but our results suggest that higher retentions than those indicated by overseas workers may be desirable. One important comparison is between tributyltin oxide and pentachlorphenol. Here we have only indirect comparisons and we have not yet been able to establish definitely that TBTO is 10 times as effective as PCP as sometimes claimed. Comparisons of lauryl pentachlorphenol with pentachlorphenol suggest that it is appreciably less effective, especially for surface treatments.

Tests on various metal-chrome-arsenates for use as plywood preservatives suggest that in general, zinc and nickel are inferior to copper in these formulations, but there is scope for more work. We have commenced fundamental studies of the toxicity of various metals, singly and in association, to wood-destroying fungi as a long term project on improving preservative performance, particularly against copper-tolerant fungi.

At the moment, we are making intensive investigations of the preservative effectiveness of the new high temperature coke-oven creosotes being produced by Koppers Australia Ltd. at Newcastle.

Since this type of bioassay is very laborious and also lengthy, we would be greatly helped by advance knowledge of any likely changes in the types of timber being treated or the types of preservative used. This does not mean we can test all, or even most types of either, but it does mean that in planning our research we can use such forecasts to ensure that our results have a more immediate application to industry problems.

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* Prepared by E. W. B. Da Costa and Lynette Osborne.

Item 4(c) Laboratory evaluation of preservatives (NSW)*

Anobium punctatum - Toxic thresholds for aldrin, boric acid, and tri-butyl tin oxide. - In this Commission, the British Standard BS 3652, 1963, which is similar to German Standard DIN 52.165, is used as the standard method of test to determine the toxicity of a wood preservative against attack by Anobium punctatum (De Geer), or Hylotrupes bajulus (L).

The technique for egg-laying has been modified slightly from the British and German Standard, in that artificial egg-laying sites are stamped into the test blocks which are also larger in dimensions. The larval transfer technique remains unaltered.

After these techniques have been used, all blocks are X-rayed after 6 months storage, and those with live larvae stored for a further 6 months before a final X-ray examination, when the blocks are then cut up.

Results of the toxic limits of the preservative under test are evaluated from the number of blocks in which live larvae are found.

Currently under investigation is the toxicity of aldrin and boric acid in particle board, and tri-butyl tin oxide in radiata pine, against larvae of A. punctatum. The results of these tests should be completed within the year.

Lyctus brunneus - Toxic thresholds for arsenic in "fixed" salts, dieldrin and sodium fluoride. - Work has commenced on the evaluation of the Lyctus toxicity levels of treated brushwood veneers. Veneers ($\frac{1}{8}$" flame kurrajong and $\frac{1}{8}$" yellow carabeen) were processed as follows:

Sheets of veneer were numbered in sequence as peeled from the log and each sheet cut into three 30 in. x 30 in. pieces across the width of the sheet i.e. sheet 1 was numbered 1A, 1B, 1C; sheet 2 numbered 2A, 2B, 2C, etc.

After air drying, imperfect sheets were rejected and the others further cut into 12 in. x 12 in. squares grouped according to the position in the log. Six of these pieces were randomly selected across the width at each position i.e. 1, 2, 3 etc.

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* Prepared by K. D. Fairey, J. R. J. French and R. S. Johnstone.

All pieces were saturated in distilled water for 24 hours and air dried under constant humidity and temperature conditions for 48 hours.

Two samples from each log position were used for each preservative. Eight different concentrations of each preservative were used.

Samples were treated by dipping in preservative solution for six seconds and then enclosed in a plastic bag for 24 hours to allow diffusion of the preservative to take place.

It is intended that initially one 3 in. x 3 in. sample from each sheet dipped will be exposed to attack by L. brunneus in a test jar.

After a period of not less than double the life cycle for beetles emerging from control samples the 3 in. x 3 in. samples will be cut up and examined for evidence of larval activity.

Following this examination, analyses will be carried out on those veneers closest to the preservative concentration showing least attack.

It is anticipated that preservative treatment will be completed and the samples exposed to attack by August, 1967.

Further experimental work will investigate threshold toxicities of these preservatives for other species of Lyctidae.

Item 4(c) Laboratory evaluation of preservatives (NZ)*

Analysis of Treated Timber. - Extensive use is still being made of X-ray spectrography for copper-chrome-arsenates, particularly in the field of posts, poles, and marine piling where "retention Zones" usually sampled by means of increment borers have been written in to the TPA specifications. Approximately 2 in. of 5 mm dia. boring provide an adequate sample.

"Immutan", a Hickson's product can be analysed successfully by X-ray spectrography or by conventional wet chemical methods for its arsenic component.

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* Prepared by N. H. O. Cummins.

Analysis of Treating Solutions. - It has been found that PCP solutions in heavy (No.5) fuel oil can be satisfactorily analysed by shaking vigorously with neutralised isopropyl alcohol and standing overnight before titrating the PCP against standard alkali; the very high solubility of PCP in isopropyl alcohol gives a satisfactory separation, as the heavy oil is largely immiscible with isopropyl alcohol.

"Immutan" solutions can be analysed readily by use of standard potassium bromate whilst fresh. On storage some oxidation of the arsenite to arsenate takes place, and preliminary reduction of the solution becomes necessary.

Spot Tests. - A spot test reagent for PCP and PCP/Oil known as "Penta-Check", evolved by Wood Treating Chemicals Co. of St. Louis, Missouri, U.S.A. has been extensively used and found very satisfactory at the normal levels of commercial treatment. It is not sufficiently sensitive for PCP in anti-sapstain dip baths. The solution is a mixture of copper and silver acetates with a suitable wetting agent added.

The rubeanic acid spot test for copper in preservatives has been officially adopted by the Timber Preservation Authority for determining depth of copper penetration in treated produce.

Discussion

Rudman: How does an increased loading of TBTO affect the health hazard?

Miss Osborne: In the ratios used, the health hazard is no greater than when using PCP or CCA salts.

Cokley: Do you consider that TBTO is worthwhile considering at the moment in commercial application?

Miss Osborne: Comparative laboratory tests with TBTO, PCP and CCA salts show that TBTO has definite promise. The first overseas work that we saw on TBTO gave very low required retentions, about 0.02 lb/cu ft for some wood-rotting fungi. Our laboratory tests have indicated higher threshold values, something of the order of 0.1 to 0.3 lb/cu ft.

Item 4(d) Timbers for cooling towers*

Since the last conference, considerable progress has been made with our exposure tests in cooling towers. In these tests, slats (usually 10 in. x 1 in. x $\frac{1}{2}$ in.) are assembled in small trays to be placed on the fill in towers and returned to the Division every year or so for visual examination and for stiffness tests.

A test of 24 untreated timbers installed in 30 cooling towers in all States in 1959-61 is now showing definite results. The overall amount of soft rot, and also the relative amounts of soft rot in different timbers, varied considerably from tower to tower, so that overall conclusions do not necessarily apply to all towers. The ranking of timbers for resistance was quite different to that found in ground contact, mainly because the softwoods tended to resist attack better than the hardwoods. Overall, the most durable untreated timbers were Californian redwood, Vanikoro kauri, King William pine, western red cedar, douglas fir, teak, wandoo and jarrah in that order. Pine sapwood treated with a nominal 1.25 lb/cu of CCA preservative was more durable overall than even the best of these timbers, but in a few towers it also showed appreciable attack after 3 years.

These tests of untreated timbers have also given a great deal of information on the variation in soft rot hazard in different towers, but have not enabled a complete explanation of this variation. Some towers operating on town water supplies with low total solids content and neutral or slightly acid pH seem to have a negligible soft rot hazard, whilst some towers operating on bore water or with added nutrients have a very high hazard. However, although it is generally considered that soft rot hazard is increased by high dissolved solids, by high pH and by chlorination, no definite correlation could be shown in our tests, indicating that the causes of high soft rot hazard are more complex.

Advantage was taken of several cases of commercial in situ treatments of large cooling towers by a double diffusion method to assess the effect of this on the progress of soft rot infections. It was found that the treatment caused a marked reduction, or even cessation, in the development of soft rot, but it is too early to say how long this effect will last.

A second series of tests has been set up to investigate the effectiveness of various preservative treatments of Pinus radiata slats against soft rot in cooling towers. The first results from this test are now being received. Untreated controls are showing severe soft rot as are slats treated with various surface coatings or by chemical cross-linking. Low retentions of CCA salts are showing some attack, but no appreciable attack has yet occurred in slats

*Prepared by E. W. B. Da Costa and N. E. Walters.

treated with "commercial" retentions of CCA salts, creosotes, or other highly fixed waterborne or oil borne preservatives.

It is proposed to set up a third series of tests in which various species of timber are treated with CCA salts, in order to see to what extent the retention required to stop soft rot depends on the timber. Since it has recently been shown that both leaching and preservative effectiveness of waterborne preservatives is influenced by the timber substrate and since timbers differ so widely in resistance to soft rot, it is thought possible that the good results of CCA treatment in pine may not necessarily apply to all timbers.

We would like to know what timbers are likely to be available for large scale use in cooling tower fill, provided they prove suitable. Such timbers should be readily treatable and capable of yielding strong, clear slats as thin as $\frac{1}{4}$ in.

Our results suggest that high retentions of CCA or other preservatives may be necessary to prevent soft rot in all cooling towers, but we believe this can be done. If soft rot can be eliminated, wood is very suitable for cooling tower fill and for most of the structure, but it is meeting increasing competition from other materials.

Discussion

Walters: Series 1 in these tests has been going for 7 years and consists of a test of natural durability. This test has been written up as a laboratory report.

Series 2 test is beginning to show interesting results, the most interesting refer to a tower in Western Australia. In this tower the first 5 out of 8 concentrations of a CCA preservative are starting to fail. This test has only been going for a little more than 2 years, and the concentrations that are starting to fail are 0.25, 0.5, 0.75 1 and 1.25. The highest three, 1.5, 2 and 4, are still sound. Preservative 19 is a copper-chrome borate and it is perfectly sound at 1.25 lb/cu ft. Its composition is 34% copper sulphate, 25% boric acid, 38% potassium dichromate and 3% sodium hydrogen sulphate.

Tamblyn: I think we should treat the CCA results with caution, because they refer to one tower of very high hazard, which may be very different from the mean of all towers when all results are available.

Orman: A test cooling tower structure was built at Wairakei to test various timbers and treatments for suitability as slats. After 14 months there was little deterioration in any of the pieces but this was probably influenced by heavy iron deposits from the original water supply. The test is now being re-designed so that the water supply will come from condensed geothermal steam. One of the most interesting aspects of this test will be the effect of such water on the stability of CCA salts.

Bryant: Which of the many materials available for treating the water in cooling towers do you consider to be the best additive.

Walters: I would say that sodium pentachlorphenate would be the best we know of.

Da Costa: Some years ago we tested the possibility of controlling soft rot in cooling towers by adding sodium pentachlorphenate to the circulating water and it seemed to be feasible. Blow-down and change of water to avoid building up the total salt solids too high presented problems, and there could be quite a serious hazard from spray drift from the tower. The Western Australian tower mentioned is an abnormal tower; almost certainly it contains a high content of phosphates in its water and I think there is some evidence that phosphates may interfere with the performance of CCA preservatives.

Cokley: With plantation material we have no way of differentiating heartwood and sapwood material, and, in all cases, we are finding that heartwood is giving a very low retention as compared to sapwood.

Walters: This is a problem that we have not yet solved. Once soft rot gets into a piece of wood, it completely ignores the sapwood-heartwood boundary.

Tamblyn: I wish to draw your attention to the order of natural durability in the series/tests. This order, which greatly favours the softwoods in natural durability to soft rot, together with the fact that we do not get the same leaching from softwoods when we put CCA preservatives in them, as we appear to do from hardwoods, has led this Division to the conclusion that we should not recommend for cooling tower fill anything other than a softwood timber. I believe that some treated sassafras is being used in New South Wales and possibly Queensland is using some hardwoods. I suggest that some consideration be given to the advisability in New South Wales of not recommending sassafras treated with CCA until we know more about it. I would suspect that it would come very near the bottom of this list in natural durability, and if the pattern of leaching that we have observed is common to hardwoods generally, it will leach very much faster than radiata pine and probably will not give very good service.

Edwards: Has the evidence for leachability of CCA salts been based entirely on eucalyptus species or has some evidence been based on sassafras as well? If we supply you with a list of timbers likely to be used in cooling tower fill, and other states do likewise, I presume you will make a selection and impregnate these at various retentions and put them out in the exposure tests.

Da Costa: The series 3 test is in fact a test of the effect of timber species on the behaviour of CCA preservatives for cooling towers. Because each timber species we test requires a considerable amount of work, we must restrict it to timbers likely to be available for large scale use. It may be a matter of each choosing say 3 other timbers in addition to the ones we already have.

Edwards: Is there any evidence available to show that the leachability of CCA salts from sassafras is significantly more extensive than from P. radiata?

Tamblyn: No. No-one has done any leaching tests that I know of on sassafras, but it would not be very hard to do. There is a lot of evidence to suggest that it might not give good results. The best way to settle this is surely to suspend the recommendation for treated sassafras pending some fairly quick laboratory tests on leachability and possibly on toxicity in leached material. I should think six months would be enough. I must also remind you that the Australian standard to which we are all party, specifically states that only treated softwood timbers shall be used for fill and therefore we cannot recommend treated sassafras in cooling towers because of this.

Item 4(e) Importance of decay in timber before pressure treatment*

The use of treated poles is now well established but there are still many technical problems to be overcome to obviate completely the risk of early and unexpected failures, which not only cause high replacement costs but can endanger linesmen and others. One aspect is the occurrence of decay and fungal stains before the wood is treated. There are two separate problems (a) decay and stain developing in the treatable sapwood during air seasoning and storage, and (b) decay in the untreatable heartwood, especially from heart rots present when the tree is felled.

(a) Sap rots in poles for treatment. - Decay in the sapwood is probably most serious in pines, though it would also be a problem in rain forest trees and even in small fast grown eucalypt poles with wide sapwood. It is sometimes obvious because of surface development of fruit bodies or mycelium but is often very difficult to detect, especially as it often occurs only in patches and may not be visible

* Prepared by E. W. B. Da Costa.

on the docked end of the pole. Any large rot pockets near ground level could be dangerous now that small treated poles are designed for realistic working stresses with smaller margins of safety. Draft SAA specifications exclude all rot pockets in the critical zone, but this must be difficult to police in practice.

Apart from loss of strength, decay or severe staining of sapwood in poles could lead to abnormally large uptake of preservatives. This could be objectionable through extra bleeding of oils or through colour variation. A few badly stained poles in a charge could lead to a very wide scatter of retentions and to inadequate treatment of other poles if treatment is done to a charge average. This problem is likely to arise not only in poles but in sawn timber especially where logs are stored for some time before conversion.

We do not at present think this is a serious problem in Australia generally, though it may be so for a few treating plants or for some treatment charges, but until we have more definite evidence it is hard to assess it. We need to make a proper survey at treating plants to obtain some statistical data on the incidence and severity of fungal attack. In the meantime, we should insist that treaters and inspectors examine critically (by probing as well as visually) any poles which show fungal attack or which have been in store for a long time, to ensure that no decay is present in the critical strength zone. If we find that there is a serious hazard anywhere, it could be met by more rapid seasoning or by prophylactic chemical sprays as have been used in New Zealand.

(b) Heart rots in poles. - Heart rots are particularly important in pole species since some of the causal fungi will be able to continue to develop in a pole in service whereas they would rarely survive or develop in sawn timber. We should distinguish between "heart rots" - rots occurring in the standing tree, usually including the central part of the trunk; and "centre rots" - rots occurring in the central part of a pole, beneath the sound treated wood. These may be either heart rots or "secondary rots" occurring after felling or after treatment, and we have virtually no information on the proportions of each for any species, and very little information on the incidence of centre rots in general.

Centre rots are becoming more important as the increasing shortage of suitable poles suggests increasing use of species of low natural durability. In Victoria, for example, supply difficulties, especially for large power poles, could be greatly eased by use of Eucalyptus regnans regrowth from the 1939 fires. There are many trees becoming available of excellent pole form, but preliminary surveys suggest that in some areas there is a high incidence of internal decay. Many of the decay pockets seen extended only a short distance

along the trunk, which means that they would not always be detected on the ends of the pole. Since we have evidence of very rapid failure of ash poles and posts from centre rots, the possible extension of undetected heart rots is a major objection to the use of ash poles.

The problem could be overcome by heat sterilization of poles during creosote impregnation but we need to develop economically feasible methods of heating and to be sure that secondary rots, entering through checks after treatment will not be sufficiently prevalent to make this inadequate. Heat sterilization of a 15 in. butt diameter transmission pole to give a temperature of 160°F at the centre could mean using creosote at 200°F for 16 hours or more and special treatments may be necessary, such as axial boring of the critical strength zone or use of boultonizing.

At present, we propose (a) to make a survey of the treated ash poles placed in service experimentally over the years and to compare the incidence of centre rots with that of acceptable species. (b) to try to ascertain by dissection and by identification of fungi whether these are caused by heart rots and (c) to develop suitable techniques for pole sterilization. We hope the Victorian Forestry Commission will be able to assist by making a survey of the incidence and type of heart rots in E. regnans and other potential pole species.

We seek comments on the following points:-

Can they provide any quantitative figures relating to incidence of sapwood decay and stain in poles at treatment? Also, could they help with a survey on this point?

What is the incidence of heart rots in the various pole species, and particularly in any non-durable species which are, or may be used for poles? Are there any plans for surveys on this point?

Item 4(e) Decay in timber before treatment in N.S.W.*

Peniophora sp. (probably P. gigantea) has been found in P. radiata log exposure tests at Oberon and a number of pine posts correctly treated with CCA have been submitted to us because of service failure probably due to pre-treatment decay. Because of these facts, and in view of the New Zealand experience it has been decided during the coming year to:

Carry out field studies of decay development during pre-treatment seasoning of P. radiata posts;

* Prepared by D. W. Edwards.

Investigate further, treatment methods for semi green posts.

Discussion

Huddleston: We regard the likelihood of pre-treatment decay occurring in timbers to be used for marine piles as of particular importance. Timbers inspected and accepted for poles are often subsequently used as piles and the critical strength zones in which inspectors are interested are, of course, different for the two requirements. We are anxious that Mr. Da Costa's work should proceed and we will assist in whatever way possible.

Tamblyn: Now that smaller poles are being accepted, strength is more critical and maximum attention should be given at all times to the condition of the sapwood before treatment. This can only be achieved by immediate spraying or dipping in fungicide-insecticide mixture as soon as the pole is received.

Da Costa: The cooperation of State Forest Services is required so that we can advise on the formulation of a satisfactory pre-treatment fungicide-insecticide.

Edwards: We have investigated this problem over a period of six years and have not yet come up with a satisfactory solution.

Cokley: In Queensland we have been testing sprays for fourteen years and results are not sufficiently satisfactory to make a general recommendation. It is difficult to estimate the extent of incipient decay without destroying the pole in the process.

Item 4(f) Tests of timber exposed above ground*

Since the last Conference, we have given considerable thought to the application, or rather the lack of application, of our ground contact durability rating system to timbers in exposed use above ground. This matter has been raised by industry who have complained that ground contact ratings are unfair to timbers used for external joinery, weatherboards etc. because many timbers (such as Douglas fir) which are classed as non-durable in the ground, perform very satisfactorily in external joinery.

While we do agree that the results with Douglas fir are repeated with many other timbers, and are probably related to their impermeability to intermittent wetting, we have been unable, from existing knowledge, to rate many timbers for relative durability in external use above ground.

* Prepared by N. Tamblyn.

This matter has been discussed by the Preservation Committee and it has been agreed that we should organize a cooperative test to examine the decay resistance of untreated timbers when exposed above ground. It is proposed to use a specimen involving one or more joints from which water is likely to be absorbed during periods of rain. Painted and unpainted specimens will probably be used.

It may take several years before results are available and until then we do not see any way in which criticism of our ground contact ratings can be fully met. Clearly the climate is all-important in these above ground ratings and we would expect that a fairly complicated picture will emerge when tests are done on painted and unpainted joint specimens in several localities, with and without dip treatment in preservatives.

Item 4(f) New Zealand*

Valuable information on the durability of timber exposed above ground was gained from fence battens in a service test of posts and battens that was replicated on 6 sites. Battens were hung clear of the ground, placed touching the ground, and sunk 9" into the ground. Decay was greatest in the third case and least in the first (as expected) and only the least durable material (untreated pine) in moist localities decayed when not in contact with the ground. The test did show that in all 3 cases an intermediate loading of CCA salt (0.41 lb/cu ft Tanalith C) gave good decay protection and the amount of decay after 6 years was less than with heartwood of macrocarpa, red beech (Nothofagus fusca), Eucalyptus saligna, E. botryoides, E. pilularis, E. scabra, and E. obliqua (all locally grown Eucalypts about 30-50 years old.)

A further test to examine above ground durability (of a number of preservatives and retentions as well as untreated heartwood) is being installed along the lines of the X joints used by Verrall in his dip treatment tests.

Discussion

Recent surveys made on paint problems indicate that differences in climate within the Melbourne metropolitan area could be as significant as those occurring between Melbourne and Sydney. Above-ground durability assessments are also complicated by differences in building practice. A survey of performance of certain timbers in existing houses might produce results far more quickly.

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* Prepared by A. J. McQuire.

Marshall: A survey would also indicate which particular species of timber had been incorrectly used in certain applications such as joinery. Supplementary information may be obtained from field tests, and wood for one such test in New South Wales has been installed for some twelve months.

Howick: Details of above-ground durability will be sought in the proposed natural durability survey.

Edwards: We propose to survey the performance of weatherboards in the Sydney area. Initial attack by decay usually occurs on the south eastern (weather) exposure.

Tamblyn: Accurate results can only be obtained by analysing statistics from both surveys and field tests.

Item 4(g) Research in mycology (NSW)*

The ecological succession of sapstain and decay in P. radiata logs and sawn timber has been intensively studied at Oberon during the last two years. The study has covered several aspects of timber storage:

Log storage in forest for 1, 2, 3 and 12-15 months
with (a) Bark on and
(b) Bark off

Sawn timber storage
(a) Timber milled from logs used in (1) above and strip stacked

(b) Timber from run-off-mill logs -
(i) Kiln dried - Stripped under cover
- Stripped without covers

(ii) Green - Stripped
- Blockstacked
- Sapstain dipped before stripping.

Over 15,000 super feet of timber was used from which 10,000 fungal isolates were obtained. Of these, 2,500 have been retained for further study.

At Oberon, sapstain attack occurred in logs between October and April and the degree of damage was related to the period of storage. Boards milled from unstained logs from this test showed fairly light fungal degrade after stack storage. Boards from stained logs showed

* Prepared by R. Keirle and D. W. Edwards.

little further stain development in the stacks.

Sapstain treatment of boards was effective for about three months at any season of the year.

The degree of stain was most intense in block-stacked material. Some stain occurred in both kiln dried and green stripped boards, but none was found in the covered kiln dried boards and there appeared to be little or no difference between the two former stacks.

Studies were then made of the effects of temperature and moisture on the local development of stain and decay in logs at the forest and mill, and on chemical log protectents.

Ecological studies were also carried out on selected sites after the great fire which destroyed the Penrose and Wingello State Forests at Moss Vale in March 1965. Samples of flora and fauna were collected at monthly intervals, and log sections and boards cut from fire damaged pine were checked for fungal and insect attack.

The safe salvage period for standing fire-killed pine was estimated to be from five to eight months, after which sapstain developed rapidly. The critical period for wood decay was twelve to fifteen months. It is felt that weather conditions favourable to fungal development could reduce these safe salvage times to six weeks (sapstain) and three to six months (decay).

No insect attack was found in dead, standing pine, but termites and scarabs were present in burnt logs.

A trial of log protectant sprays for felled fire-killed pine was made at Wingello. Two sprays were used - sodium-PCP/BHC and PCP/BHC. The oil-borne pentachlorphenol-benzene hexachloride spray gave better results than the aqueous sodium PCP for both stain and decay control, but the cost of such sprays was considered prohibitive. Both sprays appeared to have controlled insect attack for nine months.

Work continued on the stains and decays associated with insect attack in overmature messmate stringybark at Oberon. Several decays have been found associated with brown stains in this species, and some progress has been made in elucidating the causes of pencil streak.

Item 4(g) New Zealand*

Stain and rot fungi in forest products. - The culture collection of wood inhabiting fungi is slowly being expanded, most additional isolates being obtained during routine survey work of current projects. For this reason the collection is becoming biased towards microfungi. As yet no collection of fruiting bodies for isolation has been undertaken, but herbarium facilities in the new mycology laboratory will give much needed impetus to this essential side of wood preservation research.

A start has been made in keying out the cultural characteristics of wood-rotting Basidiomycetes using a punched card system and some preliminary work has been carried out in evaluating additional aids for the identification of these organisms. Spot tests for phenolic oxidases look particularly encouraging.

Future survey work planned includes a study of stain fungi in P. radiata sawn timber and a general survey of soft-rot fungi in New Zealand.

Fungal infection of timber during seasoning and storage. - A study of the outside storage of pulpwood chips in New Zealand has been completed. A winter and a summer storage pile of P. radiata wood chips were examined for the rate of colonization by fungi and the extent to which associated mould, stain and decay developed with time. The effect of the resultant biological deterioration on pulp yield and quality was also studied.

Differences in the microclimates of the piles were reflected in the type and distribution of decay. Temperatures were generally higher in the summer pile than in the less compacted winter pile; they were highest in the interior of the summer pile, but at the top and in the intermediate regions towards the sides of the winter pile. Moisture content of chips increased in both piles during the storage period and after six months was highest in the winter pile.

Basidiomycetes were the main agents of decay in the winter pile after six months, their activity being confined to the interior where temperatures were lower. By contrast, soft-rot fungi caused most of the decay in the summer pile after a similar time and were active mainly in the top and sides of the pile; temperatures in the interior were generally too high for fungal growth. Soft-rot was widespread in the winter pile after one year. The development of mould and stain was similar in both piles. Peniophora gigantea,

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* Prepared by J. A. Butcher.

Odontia bicolor and an unidentified basidiomycete were the dominant wood-rotting fungi. Helicosporium aureum and Helicomyces (bellus?) were the main agents of soft-rot.

Physical properties of pulps made from chips six months in storage were unchanged apart from tear factor which was slightly reduced. In both piles storage longer than six months led to marked reductions in tear. After one year yield and brightness were slightly lowered.

Staining of red beech sapwood during seasoning. - From the results of isolations from stained red beech sapwood two fungi appear to be involved in causing this degrade. These fungi, Ceratocystis piceae and Phialophora fastigiata are now being tested under laboratory conditions. Small beams of freshly cut sapwood are sterilised with propylene oxide and then inoculated with a mycelial suspension of the fungus under test. Beams are suspended above sterile water in sterile petri-dishes and incubated for six weeks. The fungi will be re-isolated on the termination of the experiment.

Ecology of fungi occurring on timber. - An experiment is under way in which the succession of fungi on untreated P. radiata sapwood stakes in ground contact is being examined over a period of one year. Series of isolations are being made at regular intervals from four main zones - 2 in. above ground, ground-line, 2 in. below ground-line and 3 in. from the base of the stake. Results of isolation are tabulated for each zone and have been expressed on a presence or absence criterion, frequency of occurrence being considered as a measure of ease of isolation rather than of percentage occurrence. Data on changes of moisture content and pH of the wood have also been recorded. A distinct succession of organisms has been established and these may be linked with a succession of infections e.g. mould to soft-rot to Basidiomycetes. Decay capability tests are being made on all of the isolates obtained.

Using selected fungi, dominant organisms of each type of infection - the succession is being repeated under laboratory conditions. Initially this experiment has been designed to look at changes in moisture content, pH and dry weight of test pieces under the various combinations of exposure used, but data on the gross changes in the chemical composition of the wood under progressive decay is also being obtained. The latter will be re-examined in a more intensive study.

A similar study is being made on preservative treated stakes but this work lags behind the untreated material as the succession is so much slower. The preservatives have been used at one quarter of the recommended ground contact retention in an attempt to speed up the succession.

Physiology of fungi occurring on timber. - Work in this sphere is at present limited to a study of the basic physical and nutritional requirements for growth of the fungi obtained in the succession experiments. At present all fungi isolated are being tested to determine their optimum temperature and pH for growth and their response to various carbon and nitrogen sources (inorganic and organic). A more detailed study will be made of those organisms used in the laboratory experiments.

Fungal infection of preservative treated wood. - Isolations are being made during routine work of the succession experiment and all isolates are being retained in a permanent culture collection. Most attention is being directed towards CCA preservatives, but others such as pentachlorphenol and multisalts with relatively little or no copper are also being examined. The last two are of particular interest as they are preferentially attacked by soft-rot fungi and may be considered as a selective baiting technique for their isolation.

At a future date, when sufficient information is at hand, isolates from treated timber will be assayed to determine their tolerance to the preservatives used and their possible role in the degradation of these preservatives.

Discussion

Da Costa: As we continue our general studies of decay in the field both from our own research projects and from enquiries coming in we accumulate more and more information on the ecology of decay, and within the last ten years there has been considerable increase in the number of people interested in this question.

We think there should be most scope for exchange of information. In Melbourne, for example, we have two common fungi causing decay in buildings. They are Fuscaporia contigua, which causes a white stringy rot on exposed joinery and fencing, and is probably the most severe decay fungus in buildings in Melbourne, andwweaaaso have the European dry-rot fungus, Merulius lacrymans, becoming an increasingly common cause of breakdown of flooring in old buildings. We do not know whether either of these fungi occur to any extent in other capitals. There should definitely be most exchange of information of this sort. We are also interested in the question of fungi associated with adequately treated timber. These are critically important to us as they serve to indicate what we can expect in years to come when most of the timber used in situations of high hazard is treated. We are therefore interested in obtaining samples of adequately treated timber that has suffered from fungal breakdown.

Harding: In South Australia our timber suffers from severe blue-stain decay mainly as a result of early attack by Ips.

Threader: We have experienced some blue-stain problems in fire-killed trees of pole size. Attack was initiated from around knots and later spread throughout the timber. A.P.M. was able to utilize timber killed by a fire in 1965 for a period of about 9 months.

Edwards: We will pass on information from our surveys and wherever possible when taking samples of decayed timber we will pass a sample on to DFP.

Item 4(h) Fire resistance of treated poles and posts*

Since commercial preservation started here, the copper-chrome-arsenic preservatives have been used in increasing proportions, particularly for fence posts, because they are easier to use than creosote, more tolerant of moisture content variation in the timber being treated and clean to handle. They have also established an excellent record of reliability in service.

Farmers are now "sold" on the advantages of treated round posts; annual production is about 1½ million and increasing.

The only factor that could seriously upset this development is the susceptibility of CCA treated timber, pine in particular, to fire damage. Once a dry CCA treated pine post is ignited it will continue to smoulder and will often burn right through.

The Division has shown that the chances of a fence being affected by fire in its lifetime are very slight, but this is small consolation to anyone losing fencing in a fire, particularly when he knows that it will resist decay and termites for 30 years or more. Unfortunately the risk of fire damage has been exaggerated by some people to the point where it could affect the future of the industry.

With transmission poles the position could also become serious. In Tasmania only a small proportion of CCA treated poles exposed to the February bushfires were destroyed. However, the sheathing of some high tension poles with galvanized iron at ground-line, a reasonable precaution at the time, drew attention to their vulnerability. In areas where grass is burnt regularly by accident or design, wood poles should be fire resistant. The probability that controlled burning will become more frequent as a fire control measure must also be taken into account. A number of cases have been reported where CCA treated fence posts caught alight during burning off and were destroyed because the landowner was not aware of the risk.

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* Prepared by F. A. Dale and D. McCarthy.

It is sometimes argued that because farmers do not insure their fences the risk of losing them is too small to worry about, but the arguments in favour of fire resistant fencing are much stronger. We believe that CCA treated posts must be made fire resistant and that this must be achieved within the next few years.

A fire resistant treatment should be cheap, non-leachable weather resistant, non-toxic to stock as well as being compatible with the established CCA preservative. We have not overlooked the possibility of tailoring the preservative to the flame proofing and/or glow retarding agent.

As a first step we have made a fire tunnel where treatments can be compared under simulated summer grass fire conditions. A section of round post 15" long x 2" - 3" diameter is conditioned at 110°F for 5% e m c and pre-heated to 130°F just before testing. It is set up in the tunnel in a bed of sand and surrounded by 100 gram of dry wood wool in a wire mesh cage. A stream of air at 110°F is drawn past the test piece at 3.4 mph and the wood wool is ignited with a hot wire and primer. The fire is observed through Pyrex glass windows and the duration of the fuel fire, the time the post burns with a flame and the duration of afterglow are timed with a stopwatch. If the post is still burning 10 minutes after ignition it is quenched in water. The test gives reproducible results and a CCA treated pine post without retardant will always ignite and keep burning under these conditions. A creosoted pine post will ignite, but will smother itself in a few minutes.

A wide range and variety of treatments have been tested. Creosote or heavy oil treatments applied to CCA treated posts are not effective and surface coatings are generally disappointing. A flat white alkyd paint will usually prevent ignition, but its life is limited and its cost is considerably more than 10 cents per post, which is probably the maximum premium that could be asked for a fire retardant post.

Generally it may be assumed that surface coatings are not likely to be as effective as those treatments which achieve some penetration. Treatments such as a replaceable bandage or protective casing may have some merit.

From a treatment viewpoint the ideal fire retardant additive would be incorporated in the preservative solution. However, it is probably unnecessary to fireproof beyond the outer $\frac{1}{4}$ in. so that fixation inside this zone is not essential. Other possible economic treatments are CCA pressure treatment followed by a hot and cold bath treatment or a simple dip.

With CCA posts the afterglow problem is as previously mentioned of major importance. When burning occurs carbon is oxidised and carbon monoxide and carbon dioxide are produced. Glow retardants catalytically favour the production of carbon monoxide so that the heat produced is insufficient to maintain glowing. The outstanding examples of glow retardants are phosphates and boric acid. Unfortunately, these chemicals are normally completely leachable. Ways and means of fixing these chemicals are being actively pursued. However, it is a problem of considerable complexity involving treatment techniques and chemical reactions as well as economics. Another possible avenue of achieving a satisfactory product is the incorporation of urea or a urea type compound in the preservative and its subsequent polymerisation with formaldehyde in the presence of small amounts of phosphoric acid.

Any promising treatment will have to survive a severe simulated weathering and leaching test before it can be recommended and a device for this purpose is underway.

The CCA preservatives are performing so well in service that this problem must be solved. Any premature moves for their replacement by creosote or other preservatives could cause the preservation industry irreparable harm.

Discussion

Harding: What about the fire retardant properties of boron and copper compounds?

Tamblyn: Most fire retardant chemicals have to be used at very high loadings of at least 2-3 lb/cu ft. This is clearly far above the loading we would use for copper borate. This preservative may not be the answer, therefore, even if one of the ingredients has good fire retardant properties. We are particularly interested in the advantages and economics of fire retardant treatment for fence posts. About one million posts are treated every year and many of them are subjected to fire hazard conditions. If a couple of million posts were to burn in one year, the situation would be extremely serious. All we want to do is to find a treatment which in grass fire conditions will be effective as a fire retardant. This is an urgent problem.

Jacobs: How long do CCA treated posts take to ignite and for how long do they burn after the fire has passed?

Dale: They take little more than one minute to ignite under standard conditions. They will continue to burn until all the post is destroyed, even right to the bottom of the post in the ground. The cross section of a 3" post can be destroyed in twenty minutes.

Harding: I believe that chromium is largely to blame. If one could leave chromium out and put some boron in would this obviate the problem?

Tamblyn: We have tried this but it is a very corrosive mixture.

Item 4(i) Methods of improving pole treatments*

Commercial pole treatment has stabilized over the last 12 months and with the virtual cessation of PMG demand in the coming year, the industry will have to concentrate on the power pole market for its main business.

While the quality of pole treatment has improved considerably, a number of premature failures have occurred in treated poles and we consider that further improvement is essential so that the minimum life of poles can be guaranteed. Unless this can be done an increasing share of the market will be lost to steel, concrete and even fibreglass. Their manufacturers will certainly guarantee minimum lives and the cost of the last two materials at least will come down as production increases and methods improve.

Quality control of creosote treated hardwood poles, with which this Division is most concerned, has been improved by:

Better segregation of species before treatment

Treatment for longer periods under pressure

Periodic weighing of all poles in a charge

Treatment to higher minimum charge retentions

Better control of moisture content before treatment.

We would like to see the following improvements:

Treatment to refusal, using the Rueping cycle if necessary, to obtain economic retention

Treatment at higher temperatures to improve penetration and sterilization.

We have investigated the following means of improving penetration and retention:

Incising at ground-line

Addition of "Slack-wax" to creosote.

Neither of these investigations has been completed, mainly because our initial experiments have failed to give a clear cut result, so that further work requiring closer control, more replications and more accurate analysis is required. The line of investigation and results so far obtained are as follows:

1. Incision. - Incisions made with an "oyster-blade" knife, 4" apart along the grain, ½" apart across the grain and inclined at 30° to it result in an average improvement of 1½ pcf creosote retention in the high pressure treatment of eucalypt rail sleepers. This pattern would certainly improve retention and uniformity of distribution in sapwood but only at the expense of a substantial loss in strength. We therefore concentrated on incisions parallel to the grain on the theory that an improved penetration pattern would result if the incisions were close enough together. Using hot paraffin wax and a dye, an elliptical zone of complete penetration around each incision about 3" long x ½" wide was obtained in Eucalyptus obliqua sapwood.

However, when sapwood was incised at 3" pitch with staggered rows ⅜" apart and treated with creosote, the resulting improvement in retention, determined by extraction, was only about 1-2 pcf. Improvements of the order of 5 pcf would have to be consistently obtained to justify incising. Also, even parallel incising may have some effect on strength and this would have to be determined and taken into account in pole design.

Further work is planned, particularly using refractory timbers such as spotted gum, where some success with incising has been claimed by a commercial treatment plant. Side benefits which could accrue would be reduction in splitting and quicker drying.

2. Addition of "Slack-Wax" to creosote. - Overseas reports have claimed improvement in penetration and retention from the addition of 15% of "slack-wax", a crude petroleum wax residue, to creosote.

Results so far obtained with limited tests of heart and sapwood of both hard and softwoods do not bear this out, but there could be an improvement in spotted gum and red stringybark. As these species are difficult to treat normally, a further series of tests with them is in hand.

A serious disadvantage of the mixture is that it is solid up to 100°F. It also makes freshly treated material very slippery and difficult to handle. In view of these the treatment would have to offer other advantages, such as improved resistance to weathering, besides improved retention and penetration, to be seriously considered as an alternative to straight creosote.

Other methods of improving pole treatment. - Following the discovery of a number of creosoted poles with internal rot at the ground line and further attack on creosote treated poles by termites at Mildura, a method has been devised to ensure that creosote under pressure will always reach the centre of the pole in this zone during treatment. This consists of boring a hole from the butt along the centre of the pole. At first sight mechanical difficulties would appear to make this impossible or very slow. We used a hollow round bar with a high speed cutting tip and by feeding water to the tip under pressure have been able to remove the chips and keep the cutter cool at the same time. With a simple setup, even dense timbers such as mountain grey gum can be bored with a 3" cutter at feed speeds of over 2 ft/minute, using about 6 hp. With sufficient power there is no reason why feed speeds up to 10 ft/minute could not be achieved. Holes 6 ft deep have been bored and this could be extended to 10 ft without trouble.

Butt boring of poles would allow free access of hot creosote to the heart at ground line, during treatment, giving complete sterilization and the hole could be plugged with a wad of diffusible preservative if required before installation. The hole may assist butt drying and reduce splitting. A machine for the purpose could be built for less than £5000.

Discussion

Edwards: One of the preservation companies is installing tests of spotted gum poles treated with CCA and water repellent.

Beesley: We are particularly interested in having records, information or advice concerning any premature failure of pressure treated poles, whether by decay or insect attack.

De Costa: I think the forest services should think very hard about the relative importance to their forest pathologists of the losses from heart rot which are a direct loss in merchantable timber. In terms of hard economics this may be more important than some of the work they are currently doing.

Item 4(j) Impermeable heartwood in Pinus radiata*

Some time ago the Radiata Pine Association was considering whether an unconditional guarantee could be given for radiata pine building timber treated with a copper-chrome-arsenic preservative. At this time we pointed out that the problem of impermeable heartwood in radiata pine, and most other softwoods, was a real one and that the treating industry should look carefully at the penetration being obtained before offering unconditional guarantees against decay or insect attack.

The reaction of the treating industry to our warning was of some interest as it appeared that most had not thought at all on this matter and generally believed that radiata pine was almost completely permeable in conventional treatments. As a result, the impermeability of pine heartwood which we have recognized for 30 years or more, has suddenly assumed the status of a new problem for the pine treating industry and they are anxious to find a way of coping with it.

We have done some work on this problem as indicated in my Research Review but have no immediate solution to it. The degree of impermeability of heartwood varies with locality and is also probably a genetic factor. Some treatments (higher pressure for longer periods) are partially effective depending on locality but none that we have tried has provided a solution which is technically and economically satisfactory. We know that some promising results have been obtained by the Division of Wood Technology, using long steaming treatments before impregnation, but as this is very recent work, we have not learned yet whether it is commercially acceptable and effective. The fact that the problem of impermeable heartwood in conifers is world wide and largely unsolved, leads to the conclusion that we may have to seek other methods than pressure impregnation to solve it.

Apart from manipulation of pressure treatments we see 3 other possible ways of approaching this problem and would like some discussion on the following:

> Segregation of timber at the sawmill so that heartwood will be largely eliminated in material intended for pressure treatment

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* Prepared by N. Tamblyn.

Abandonment of pressure treatment of building timber in favour of a dip diffusion treatment in multi-salt preservative of the type developed for use in Papua-New Guinea. This diffusion treatment does quite readily penetrate heartwood as it does not depend on inflow of solution

The location of elite trees with permeable heartwood and their clonal propagation.

Item 4(j) (New South Wales*)

An investigation has been carried out in an attempt to clarify the problem of impermeable radiata pine heartwood. "Impermeable", it is assumed, means unable to be uniformly penetrated by commercial vacuum pressure operation.

Experimental work on heartwood from Gurnang S.F., New South Wales, has been completed (see Item 4(r). This timber is not commercially treated as yet and it is not known whether it would be considered refractory.

Using normal CCA treatment methods, heartwood (4" x 1" boards) from Gurnang when treated green showed irregular penetration. After a six months air drying period, similar heartwood from the same source showed evidence of the same irregular penetration pattern after pressure treatment. On steaming before impregnation, penetration appeared to be completely uniform. The moisture content of this heartwood was about 87.0% before steaming. No moisture determination was made after steaming.

Additional green radiata boards were obtained from the same source. After steaming for 8 hours to a maximum temperature of 260°F, the moisture content had fallen from 52.0% to 46.8% - a drop of 5.2%. Penetration, after steaming and impregnation, was again good as compared to the irregular pattern obtained when it was treated unsteamed.

Green radiata pine boards (both sapwood and heartwood) obtained from the Myrtleford area were steamed for periods of 4 and 8 hours to a maximum temperature of 260°F. The boards were pressure treated after cooling, together with unsteamed controls. The moisture content here fell from 39.9% to 38.3% during the eight hours steaming. Present indications (using rubeanic acid and chrome azurol S to detect copper) are that the preservative has satisfactorily penetrated the heartwood. This should be confirmed when full cross sectional and core analyses for copper, chromium and arsenic content are carried out.

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* Prepared by R. S. Johnstone.

Discussion

Tamblyn: I am very impressed by Mr. Edwards' report and I feel we should congratulate them on what looks like quite a breakthrough. I hope it is the success that it now appears.

Orman: In New Zealand one of the problems when steaming, particularly of structural sizes, is the strength reduction.

Cowan: We have tried the steaming process in South Australia with all sizes and classes of radiata. After steaming at 235°, the results showed an improvement but were far from satisfactory. Quite large sections of the heartwood were not penetrated.

Huddleston: There is a small percentage of radiata pine that will not accept preservative even in the sapwood. I believe the steaming treatment has proved effective for that particular material.

Cokley: We have no practical way of separating sapwood from heartwood by visual means and therefore segregation is rather difficult. Are you advocating a non-fixed diffusible preservative to overcome this problem?

Tamblyn: Our preservative is partially fixed. It is standing up to conditions in Papua and New Guinea and has now given ten years trouble free service in Port Moresby in painted weatherboard.

Huddleston: The diffusion treatment would have to be better than Tanalith U before it would be acceptable in New South Wales.

Item 4(k) Report on Hylotrupes Bajulus*

Delegates to the last Conference may remember that up to that time, inspection of imported softwood houses in Victoria had revealed 45 cases of infestation, all of which were fumigated. At the last Conference, there was - and I quote from the proceedings "unaminous agreement that the Conference Secretary should convey to the Victorian Housing Commission the recommendation that action be taken to reinspect fumigated houses and those surrounding them". This of course, was to ensure that secondary infestation had not occurred.

The Victorian Housing Commission was informed of this recommendation in August 1965, and copies of that letter were sent to the Heads of State Forest Services. In September of that year, the V.H.C. intimated that it was not agreeable to any large scale reinspection of all houses, but that consideration would be given to a sample check.

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* Prepared by C. D. Howick.

This Division decided that the best time for reinspections to be carried out was after the summer of 1967, and last March we submitted final proposals to the Housing Commission. We had studied the distribution of infested houses on the three estates concerned, and we proposed reinspection of 60 houses around nine focal points where infested timber had contained a significant number of flight holes. We suggested that these 60 houses be inspected in 1967 and 1969, with a final inspection 3 or 4 years later when they would have been erected for 20 years.

We were then advised that the Commissioners had directed "that in view of the delay in making this request, no action be taken". The Division replied by pointing out the technical reasons for the choice of 1967 as the time for commencing reinspections, and we asked the Commission to reconsider. This resulted in the Commissioners directing "that in view of the fact that signs of the borer had not been discovered during normal maintenance inspection since infestation was detected, no action on the part of the Commission for further inspection was contemplated".

We then pointed out that according to our records, of the 45 houses found to contain Hylotrupes - infested timber, 34 were located during surveys, 8 were reported by tenants, and only 3 were discovered during normal maintenance inspections. This letter was written on 25th May and we have had no reply.

In view of the very serious consequences that would follow if Hylotrupes should become established in Victoria, we obviously do not wish to leave the situation as it stands. We have recently advised the Chairman of the Forests Commission of Victoria of the full facts of the matter, as we are rather at a loss to know where to go from here, and we invite comments from delegates.

Item 4(k) New South Wales*

Since the 1965 Conference, the following additional occurrences of suspected Hylotrupes attack have been recorded by the Division of Wood Technology:

TABLE 1

Date	Location	Remarks
June, 1965	Picton, NSW	Private home (Leichhardt Construction). Nogging attacked. No live infestation found. House fumigated with methyl bromide.
August, 1965	Forestville	Private house (imported Dutch home). Live larva found in small piece of timber, used as packing. Infested timber not the same species as remainder of house timbers. Fumigation not carried out. On re-inspection in 1966, no further evidence of infestation found.
January, 1966	Sans Souci, NSW	Piano accordion. No live infestation found. Fumigated with methyl bromide

Hylotrupes inspections carried out for the period 1965/67:

TABLE 2

Type of Building	Number of Inspections 1965-66	1966-67	Remarks
Leichhardt Construction Houses	273	60	No further infestation found
Housing Commission Homes	54	52	
TOTAL	327	112	

* Prepared by J. R. J. French.

Results of the present inspection and the follow up re-inspections indicate that no further evidence of Hylotrupes damage has been found. In the event of future methyl bromide fumigations to be carried out in New South Wales, a specification for the fumigation of buildings using this fumigant has been prepared by this Commission, and may be obtained on request.

This insect has not shown itself to be established, as yet, in this state, and only isolated cases have been found (e.g. S.M.A., Cooma, 1964, Picton, 1965). The efficiency of in situ treatments to control localised infestations, e.g. - in softwood timber used in repair work in hardwood constructed homes, appears to require further investigation.

Discussion

Irvine: Unfortunately, the situation is exactly as Mr. Howick has put it. There has been no progress made with the Housing Commission. I do not think that any approach by this conference to the Housing Commission will be effective. I think the approach may have to come from the Australian Forestry Council.

Huddleston: Has the Victorian Forests Commission considered undertaking inspections and carrying out treatments on their own account?

Irvine: We have, in fact, financed work by the Housing Commission inspectors. At the present time we have not considered financing a further inspection.

Huddleston: In New South Wales the Forestry Commission has assumed responsibility for carrying out these inspections. We employ our own inspectors; we seek permission to inspect the houses and, in those cases where we have found infestation, we have arranged for it to be treated. Fumigation of houses has actually been carried out at the expense of the Forestry Commission, because Plant Quarantine have consistently refused to accept any responsibility for it.

Irvine: The facts are that if a quarantinable disease is found in any material imported into Australia, it is the responsibility of the owner to carry out the measures required by Quarantine. All fumigations and inspections are charged by the Quarantine Service.

Harding: The Commonwealth Quarantine Service in South Australia, working through the Department of Agriculture, has undertaken a number of investigations. In some cases, they have gone inland to areas where they knew there was a possibility of infestation, have found it and have charged the owners with the cost. Maybe this is why the Victorian Housing Commission is objecting.

Huddleston: We feel that if owners have to pay for the cost, incidence of attack will be hidden and we won't get their cooperation in reporting it. It could be hidden for a sufficient period for the insect to become established, and for this reason, we have assumed the responsibility of meeting the costs of eliminating it wherever we found it.

Ryley: The last inspection we did was about two years ago, when we inspected all the houses where Hylotrupes was found or 10% of these in a particular area, whichever was the greater, and we found no further trace of it. We propose that inspections be carried out again in 1969.

Temblyn: I feel it would help if a resolution was passed here which could be brought to the attention of the Standing Committee.

NOTE: See Resolutions nos. 3 and 4, Appendix 1.

Item 4(1) Properties and uses of arsenical creosote*

Properties. - Investigation of various aspects of arsenical creosote (AC) has included preparation, stability, leaching properties, adsorption, fixation, termiticidal properties and testing for corrosion of metals.

Arsenic trioxide rapidly dissolves and then slowly reacts with creosote constituents. At higher temperatures reactions are faster and also more arsenic is incorporated. AC once formed is stable at various temperatures up to 220°C but at higher temperatures it slowly decomposes. The arsenical combinations thus formed are heterogeneous in their properties, some tend to remain in the creosote medium while others are strongly adsorbed on wood substance when AC is introduced into wood. Some of the arsenical combinations are hydrophyllic while others are hydrophobic. Continuous extraction with water of the treated blocks of two Eucalyptus spp. at 40°C failed to remove all the arsenic after almost two years of leaching and about 40% still remained in the blocks.

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* Prepared by R. Johanson.

Concentration. - At 100°C about 0.4 to 0.5% of arsenic trioxide forms complexes and it is considered that this concentration is sufficient to increase the termiticidal effectiveness of the creosote. This conclusion is based on the data available on the toxicity of arsenic in different forms. It appears that the threshold value is about 0.011 lb/cu ft of As_2O_3 and this will stop termites consuming more than 6% of wood in laboratory compulsion tests. (For convenience this quantity of arsenic is designated as one termite threshold unit TTU). Depending on the hazard and leaching conditions in the field, higher loadings may be required to provide an adequate safety margin. The relationship $C = n\ (TTU)\ \frac{100}{x}$ has been used to obtain arsenic concentration in creosote at various creosote loadings and different safety margins (C = concentration as % As_2O_3; n = number of threshold units; x = loading of creosote in lb/cu ft).

Termites. - In collaboration with the Division of Entomology, CSIRO, tests are being carried out to assess termiticidal effectiveness of AC. It was found that AC protected P. radiata specimens against Coptotermes acinaciformis whereas creosote alone at 0.5 to 5 lb/cu ft was unable to do this. Concentration of As_2O_3 in specimens was about 0.033 lb/cu ft. When specimens were weathered, and the arsenic was removed to half this quantity, AC was still effective against termites. Under the conditions in the confined space of the compulsion tests, Nasutitermes exitiosus exposed to the treated Ceratopetalum apetalum proved very susceptible to creosote and the effect of arsenic was almost obscured. On weathering, some of the wood treated with standard creosote was consumed by N. exitiosus but far less of the specimens treated with arsenical creosote were consumed.

Corrosion. - Effects of creosote and AC on various metals have been tested, with and without the addition of an aqueous extract of E. obliqua. The results obtained indicate that there should be no corrosion problem in substituting arsenical for standard creosote in Australian pressure treating plants.

Treatment of poles. - At present the behaviour of AC is being investigated in a commercial pressure plant at Officer, Victoria. In particular, analysis will be made to determine if, in poles, any uneven distribution of arsenicals occurs during passage of the preservative along the vessels. The poles treated with AC together with the poles treated with standard creosote as controls, will be installed in areas of high termite hazard by the State Electricity Commission of Victoria.

Much is known and published on the nature of arsenical creosote and our investigations have reached a stage where we can confidently proceed to the commercial treatment of poles.

Discussion

Cokley: I would like to congratulate Mr. Johanson on this work and point out that our offer regarding the exposure of test samples whenever he is ready still holds. Is it your intention to extend this type of work to fence posts, or are you only concerned with pole treatment?

Johanson: At present we are primarily concerned with poles.

Edwards: I would like to add the congratulations of New South Wales to Mr. Johanson and the Division of Forest Products for this development.

Cokley: Will the addition of arsenic to the creosote influence any recommendations we may have made regarding the hazard to stock.

Johanson: We have approached the health authorities, but when they found out the quantities involved on the surface they were not particularly interested.

Item 4(m) High temperature black coal tar creosote (HTC)*

Koppers Australia Pty. Ltd. are investigating the manufacture of creosote from black coal tar ex BHP coke ovens. A new distillation plant is being built in Newcastle and production of creosote is scheduled to start early in 1968. Koppers have asked us to give a preliminary appraisal which is to be based on similarities between Australian and American creosotes in type of coal, carbonization method, distillation range, density and in some of the chemical composition.

This interim appraisal is to be followed by toxicity threshold tests in which comparison will be made with American creosote preferably of known field performance and with Australian vertical retort creosote. The chemical composition of HTC is very different from that of Australian vertical retorn creosotes. With low phenolic content and almost devoid of paraffins and naphthenes, but with high content of aromatic compounds, the new creosote may require different treating procedure and it may provide an interesting if not a formidable challenge to the treaters.

High temperature creosote is almost exclusively used in USA where it is highly regarded as the most versatile and reliable preservative for treatment of softwood. However, nothing is known of its behaviour with Eucalyptus spp. in Australia, although some encouragement may be derived from the fact that in South Africa, eucalypt rounds have been treated with HTC.

Phenolic content in HTC is about 3% whereas in vertical retort creosotes on an average phenols represent more than 20% of the total. This relative lack of phenols could lead to a formation of sludge when extractives from eucalypts accumulate.

Penetration properties of HTC in Eucalyptus spp. are not known. HTC contains high boiling fractions with 20% of residue remaining above 355°C whereas in Australian vertical retort creosotes there is no such residue. Higher treating temperatures than usual may be needed to obtain satisfactory penetration of HTC. Answers to these and other questions will be needed before HTC can be recommended for the preservative treatment of Australian timbers.

This Division considers that appearance on the local scene of high temperature creosote is of importance because it may be the only type of creosote available in Australia in any quantity in the next 5 to 10 years.

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* Prepared by E. Johanson.

Item 4(n) Lyctidae: Breeding and toxicity testing*

Since the last Forest Products Conference, the breeding of new species of the family Lyctidae has continued. At present the following species are being bred in sufficient numbers for use as test insects:

Lyctus brunneus	Strain 1
Lyctus brunneus	Strain 2
Lyctus discedens	
Lyctus africanus	
Minthea rugicollis	

The work is divided broadly into two fields, a study of the biology and habits of species of Lyctidae and the toxicity threshold determination of various preservatives.

The second strain of L. Brunneus was developed because it was felt that the original L. brunneus strain, after being inbred for some fifty generations may not now be typical of the species. To do this, infested material was collected from Queensland, New South Wales and Victoria. Beetles were collected from this material and both males and females were crossed with individuals from different localities including a proportion from laboratory bred stock.

In addition to the above species, Lyctus planicollis cultures were imported from the United States of America. This species has been successfully bred in large numbers under laboratory controlled conditions, but it has shown a distinct preference for deciduous exotic timber species such as Juglans sp and Quercus sp. A number of Australian and South Pacific Island timbers have been inoculated using this beetle without success. Lyctus planicollis can be propagated in messmate stringybark (E. obliqua) but the average progeny yield per female is less than 10 compared with 40 for both walnut and oak. Because of its preference for deciduous timber species, it is suggested that this is the reason it does not seem to have become established in Australia.

The toxicity of arsenic to Lyctus spp. - Previous tests using arsenic and arsenical compounds (with the arsenic expressed as anhydrous arsenic pentoxide) had shown that a retention of 0.03% based on the oven dry weight of the wood prevented attack by Lyctus brunneus. However, this was the lowest concentration of arsenic tested and it was not known if the toxic threshold had been reached.

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* Prepared by A. Rosel.

With the increased use of copper-chrome-arsenic preservatives as lycticides it was decided to re-investigate the toxicity of arsenic and determine its actual toxicity threshold. This test is being done on three timbers of low, medium and high density (Flame tree, white birch and spotted gum). The preservatives used are arsenic (as anhydrous arsenic pentoxide) and two copper-chrome-arsenic formulations containing relatively low and high percentages of arsenic pentoxide. The percentage retentions calculated as As_2O_5 based on the oven dry weight of the wood vary between 0.01 and 0.035. The following test insects have been used; two independent strains of L. brunneus, and one each of L. discedens and Minthea rugicollis. The test which entailed the use of 360 wood specimens and nearly 6000 beetles has now reached the inspection stage and final results should be available shortly. At this stage, it is evident that the new L. brunneus strain is no more resistant to arsenic than the old inbred strain. There is also sufficient evident available to show that the inhibiting arsenic concentration for L. brunneus is sufficient to prevent attack by both L. discedens and Minthea rugicollis.

When the toxicity threshold is known it will be increased to a figure giving a suitable safety margin for treatment purposes. Although the safety margin for boron is fairly small, the method of introduction of the toxic (i.e. by diffusion) results in the minimum concentration being in the core, at which section the boron content is estimated. Elsewhere there is a steady increase in concentration towards the periphery. In the case of the copper-chrome-arsenic preservatives, the pressure method of application results in a much more uniform distribution of toxic throughout the wood. In view of this, we feel that the safety margin in this case should be of the order of 100 percent. Discussion and comment by the delegates is particularly invited on this point.

Discussion

Rosel: Since the preprint was written, it has now become evident that a figure of 0.02% is the lethal threshold figure for arsenic. It remains the same for arsenic in the pure form as when it is combined in the CCA formulations.

Edwards: We are a little concerned that the laboratory strain you have been maintaining for quite a long while might have developed a high degree of resistance.

Rosel: We did include some of the original strain, but we also had an equal mixture of Queensland, New South Wales and Victorian insects and this was another strain in itself: mixing the four together consequently gave a different strain. There was no significant difference in the pattern of attack of our 50-generation inbred strain compared with the new strain.

Edwards: You say that the preferred threshold is 0.02% arsenic. What do you think about 0.01% arsenic? Do you think that this is in fact a concentration of arsenic where you won't see any obvious signs of attack?

Rosel: We were almost tempted to include the 0.01 figure, but it is just possible to detect some signs of attack and therefore we felt that 0.02 was a safer level.

Item 4(p) Report of the wood preservation committee *

Since the last Forest Products Conference there have been 2 meetings of the Wood Preservation Committee - one in Sydney in December 1965 and one in Melbourne in November 1966. Both meetings occupied 2 days and both were attended by all 4 members (Messrs. Cokley, Edwards, Threader and Tamblyn). Mr. Clifford attended the last meeting with Mr. Threader as an alternative representative for the Victorian Forests Commission.

The meeting in Sydney spent much time discussing problems of the Australian Standard on preservative treatment of building timber which is being prepared by Standards Committee TM14. This Standards Committee had referred various matters to the Wood Preservation Committee for decision and recommendation. These included the penetration patterns to be set in the Standard; the problem of a branding system which would not infringe State legislation; the inclusion of boron compounds in the Standard for building timbers protected from leaching; and the desirability of eliminating a timber density correction for preservative loadings when expressed as lb/cu ft.

Apart from the above, the meetings in Sydney and Melbourne were mainly occupied in discussing the many matters, which at the last Forest Products Conference were referred to the Wood Preservation Committee. The more important items may be summarized as follows:

1. Treatability of Australian timbers. - It was agreed that a detailed study should be made on the permeability of 20 Australian timbers (5 trees per species) and that this work should then be reviewed before continuation.

2. Impermeability and durability. - The relationship between permeability to water and performance of a timber when used above ground, under conditions of intermittent wetting was discussed. It was agreed that a field test was necessary to classify Australian timbers for this particular use.

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* Prepared by N. Tamblyn.

3. Disposal of treated waste. - Disposal of waste containing toxic preservatives was discussed and it was decided that the Wood Preservation Committee should not intrude on a matter which is primarily the concern of State Health Authorities. It was however, agreed that Committee members should be ready to help and advise industry how best to meet any health requirements.

4. Approval of new preservatives. - The responsibilities and liberties of the Committee with regard to comment on, or approve of, new preservatives was discussed. It was agreed that in such cases the Wood Preservation Committee must act on its own responsibility without other obligation than to inform the Forest Products Conference of any major decision of general interest. It was also agreed that the Wood Preservation Committee was not obliged to withold approval or comment pending decision by the Standards Association Committee TM14.

5. Hylotrupes. - The probably future need for treatment in Australia of all building timber susceptible to Hylotrupes was discussed. The general feeling of the Committee was that eventually this borer would become established in Australia. However, because of the very serious economic and practical difficulties of treating all radiata pine and other susceptible timbers the Committee was not prepared to make any immediate recommendations. It was considered that a paper on this subject should be presented and discussed at a future Forest Products Conference before the matter was taken further.

6. Immutan. - The Committee considered various aspects relating to the use of Immutan (which is a mixture of sodium fluoride and arsenic) and recommended unanimously that it be considered an undesirable formulation for use in Australia for technical, industrial, health and psychological reasons.

7. Water repellent preservatives. - The Committee discussed again dip treatment in water repellent preservatives and ruled that this treatment cannot be regarded as a substitute for conventional pressure treatment in areas where conditions or species make treatment necessary. Dip treatments do however, have value for non-durable but relatively impermeable species used in exposed situations provided that the dip-treated timber is always protected by paint or similarly effective surface coating. There is insufficient evidence to approve use of these dip treatments as substitutes for conventional priming paint, though where resin contents exceed 15% the evidence is not unfavourable. These dip treatments are considered to have particular merit for exposed joinery where joints would otherwise not be protected.

8. Dip and pressure treatments for veneer. - It was considered that preservation of veneer by dip treatment was generally preferable to pressure treatment because it produced more uniform loadings in sapwood and heartwood and hence reduced possible gluing problems.

9. Hardwood cooling tower fill. - The Committee discussed approval of sassafras (Doryphora spp.) treated with CCA preservatives for cooling tower fill. There was some difference of opinion on this, the Division of Forest Products being in favour of using only treated coniferous timbers for fill because of their greater inherent resistance to soft rot and the usually inferior fixation of CCA preservatives in hardwoods.

Discussion

Tamblyn: I believe some pressures have arisen in New South Wales for the acceptance of Immutan, a preservative based entirely on sodium fluoride and arsenic, which the Preservation Committee unanimously decided against.

Huddleston: Pressures have been resisted effectively so far.

(The report was then adopted unanimously by delegates).

Item 4(r) Preservative treatment of green P. radiata* (NSW).

Aspects of preservative treatment of green P. radiata with CCA salts investigated were (1) variations in treatment methods and (2) treatment of green natural rounds after steaming.

(1) The methods of treatment used were as follows:

(i) a commercial full cell treatment,

(ii) a high vacuum (29" mercury) plus 200 psi pressure treatment,

(iii) a normal vacuum followed by pressures stepped at 40 psi intervals to 200 psi,

(iv) a normal vacuum followed by a cyclic, atmospheric/200 psi treatment (alternating pressure).

* Prepared by R. Johnstone.

Each method of treatment was carried out with, and without, an overnight pre-steaming treatment of up to 15 psi.

Treatments were carried out on 4" x 1" boards from one locality (Gurnang S. F., near Oberon, N.S.W.). The boards were cut from a 33 year old site, polythene wrapped after milling, and treated within three days. Samples comprised both sapwood and heartwood and after treatment were stripped out and air dried for several months before inspection. The moisture content of the boards at the time of treatment was about 124% (sapwood) and 87% (heartwood).

Samples were analysed (both cross-section and core) for copper and arsenic and examined for copper penetration.

The results could be summarised as follows:

(i) no significant difference occurred between any of the treatments unless pre-steamed.

(ii) high vacuum treatment (after steaming) resulted in a higher heartwood retention of copper and arsenic than the other techniques.

(iii) steaming before treatment gave a considerably increased arsenic retention, particularly in heartwood.

(iv) Pre-steaming resulted in an apparently uniform copper distribution in both sapwood and heartwood compared to zones of high and nil copper in the unsteamed boards.

(2) Freshly cut natural rounds were steamed for periods of 2, 4, 6 and 8 hours respectively at a pressure reaching 21 psi (260°F) at the end of the steaming time. After cooling, the timber was pressure treated by the normal full cell process. Treatment was carried out on both peeled and unpeeled timber.

The timber steamed for 8 hours only has been examined and indications are that good penetration has been achieved. Retention based on charge usage (including controls) points to a minimum retention of 0.78 lb/cu ft.

Natural round timber steamed before de-barking showed good penetration except for a wedge of apparently untreated material.

From the final evaluation of this work the optimum steaming time should be obtained to give a satisfactory retention and a uniform preservative distribution.

No discussion

Item 4(s) Preservative treatment of Cypress pine (NSW)*

Attempts have been made to impregnate the sapwood of cypress pine with CCA salts. These efforts were stimulated by the availability of large quantities of cypress thinnings in the Baradine area which would be suitable for fence posts if treated; natural round timbers were used predominantly but some 4" x 1" boards were tested.

The results showed that very poor penetration could be expected with pressure treatment under the conditions of test. The methods of treatment and results are listed below:

(1) Source Baradine area
Treatment normal vacuum plus pressures of 50, 100, 200, 500 and 1000 psi.
Results air dry boards showed a copper penetration of 2 mm in the sapwood and a negligible penetration of heartwood. Green natural rounds gave a penetration of about 3 mm. There was no observable difference in penetration over the 50 - 1000 psi range.

(2) Source Narraway S. F.
Treatment pre-steaming at 15 psi followed by normal vacuum and pressure. Natural rounds with both wide and narrow sapwood areas were tested.
Results wide sapwood (16 mm) steamed 6 mm penetration
" " unsteamed 2 mm "
narrow sapwood (8 mm) steamed $3\frac{1}{2}$ mm "
unsteamed $2\frac{1}{2}$ mm "

(3) Source West Pilliga S. F.
Treatment pre-heating to about 160°C. followed by normal vacuum and pressure.
Results quite heavy penetration was obtained (based on charge usage) but the distribution of preservative was very patchy in sapwood and heartwood. Severe checking occurred on heating which, in addition, seriously weakened the timber.

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* Prepared by E. S. Johnstone.

(4) Source Baradine area
Treatment steeping the butt of the de-barked natural round post in a 3.5% solution of CCA salt (sap replacement). The posts were placed in the solution within 20 minutes of felling and allowed to stand in the solution for 4 weeks.
Results penetration was fairly uniform in the six posts tested and preservative depth (based on copper test) ranged from 7 mm to 15 mm at a distance of 3 feet from the butt end. The mean preservative loading at this point in one post was 5.3 lb per cu.ft of sapwood.

Discussion

Cokley: I agree completely with Mr. Edwards. at the moment our findings are that we cannot successfully pressure treat cypress.

Edwards: We are prepared to extend our work on this, but not for the next 8 or 9 months, as we are busy on similar work associated with radiata pine.

Dale: We have been advised from Darwin that the forestry people there have treated Callitris intratropica at 200 lb/sq in. and got 28 lb of solution in both sap and heart. We have written for further information.

Item 4(t) High vacuum treatment (NSW)*

Enquiries have been received from New South Wales sawmillers and timber preservers in regard to the use of extended high vacuum treatments as the answer to the immunisation and preservative treatment of green (off-saw) N.S.W. eucalypts and brushwoods with CCA salts. This method of pressure impregnation is widely used in Queensland with apparent success in the preservative treatment of transmission poles (mainly E. maculata Hook) and indigenous brushwoods.

Before this method could be recommended, it was felt desirable that some evidence should be obtained as to its advantages over the normal commercial treatments now in use in N.S.W.

Nine different species of brushwood (4" x 1") containing all sapwood were taken from a sawmill straight off the saw bench. Matched samples were pressure treated with 6% CCA salt at 29" Hg vacuum and 25" Hg vacuum respectively. Results showed no significant difference in copper penetration between samples of the same species treated under the different vacuum conditions.

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* Prepared by R. S. Johnstone.

Timber	Moisture Content (%)	Cross sectional penetration
white birch	46.0	100%
yellow carabeen	41.9	50%
prickly ash	53.8	100%
booyong	43.7	10%
sassafras	52.6	20%
silver sycamore	45.4	70%
corkwood	54.8	2%
bollywood	50.3	70%
brown birch	61.7	2%

Four different brushwood species (4" x 1") containing all sapwood were sampled green and pressure treated with 1.5% borax solution at 29" Hg vacuum and 25" Hg vacuum respectively. All samples treated gave full cross-sectional penetration.

Timber	Moisture Content (%)	Cross sectional penetration
yellow carabeen	approx. 60-70	100%
red carabeen	"	100%
bollywood	"	100%
pigeonberry ash	"	100%

Discussion

Cokley: We have found that the controlling feature is the capacity of the vacuum pump as compared to the cylinder size. We have calculated that the practical results of each treatment in Queensland is a saving of 25% per day in production. Your results would consolidate what we have found in regard to boron and that in addition to the pressure penetration occurring during cylinder treatment we get post-treatment diffusion.

Item 4(u) Copper pentachlorphenate treatment of brushwood veneers (NSW)*

Copper PCP has been used in New South Wales as a wood preservative for the "rot-proofing" of veneers for a number of years. Veneers have been treated by a double dip-diffusion process with copper sulphate and sodium PCP.

Five years ago a ground contact exposure site was established at Wauchope in cooperation with the firm manufacturing the plywood. A recent inspection of this test site has shown that, after this period, plywood stakes made from veneers treated with either copper PCP or Celcure A were still in a perfectly sound condition. Decay in the untreated controls and samples treated with zinc PCP was evident within the first year of exposure.

A second exposure site was established to assess the level of copper PCP required to inhibit decay. Samples treated with sodium PCP only were added in addition to untreated controls. After two years' exposure, the controls and sodium PCP treated samples were severely attacked by decay.

The results indicate that a degree of fixation and resistance to fungal attack have been achieved by the two-bath copper sulphate/sodium PCP system.

Discussion

Tamblyn: Were the veneers stained with the purple colour of the copper pentachlorphenate? If so was this a commercially acceptable discolouration?

Edwards: Yes. The majority of the species tested are those whose colour caused some masking effect to the discolouration from the preservative. The exposure sites are surrounded by a treated soil barrier to exclude termites so that we are testing decay resistance only.

Wickett: We have a manufacturer in West Australia who is particularly interested in preservative treatment of veneers and the production of preservative treated plywood. I would, therefore, like as much information as possible.

Tamblyn: The Committee will advise you of its decisions.

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* Prepared by R. S. Johnstone.

Item 4(v) Heat sterilisation of block-stacked timber for the control of wood-destroying insects (NSW)*

Current practice in New South Wales requires 165°F (74°C) in the centre of the stack for stripped parcels of imported sawn hardwoods. With possible savings of space, time, and labour in mind, the effectiveness of heat sterilisation of block-stacked timber in destroying insect infestations was investigated.

The method consisted of placing adults of the test insects Coptotermes lacteus Frogg., Nasutitermes exitiosus Hill, Lyctus brunneus (Steph.), Lyctus discedens Blackb., Tribolium confusum Jacq. du Val, and Sitophilus zeamais Motsch., into meranti boards, which were then block-stacked and heated in a reconditioner.

Results indicated that both the internal and external boards reached similar temperature after 8 hours. Insect mortality at the end of this period was 100 per cent.

It is suggested that satisfactory heat sterilisation using steam within a reconditioner requires a minimum board temperature of 104°F (40°C) for 8 hours. Individual parcels of these dimensions (12 x 2 x 1½ foot) may be sterilised without stripping, though each parcel will require to be separated by strips (stickers).

Discussion

Orman: We have investigated the feasibility of heat sterilisation of block-stacked timber and found it uneconomical not to fillet. In other words we have found it necessary to strip the timber out before sterilisation commences.

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* Prepared by J. R. J. French and R. S. Johnstone.

Item 4(w) Lyctus beetle distribution survey (NSW)*

A survey of the distribution within Australia of Lyctus brunneus and other powder post beetles (Lyctidae) was commenced in 1965.

This survey was undertaken for two reasons:

to determine what species of Lyctids are found in Australia;

to obtain live beetles of Lyctus brunneus and other Lyctids from a number of different areas. These live beetles will be used to establish stock cultures for preservative testing and other experimental work.

The survey includes the installation of "trap-boards" in timber yards and timber mills throughout New South Wales. These are at present installed in thirty six localities in NSW and through the cooperation of the Queensland Department of Forestry have also been placed in a number of areas in Queensland.

The "trap-boards" currently in use consist of sapwood boards approximately 9 in. x 2½ in. of three different timbers; flametree (Brachychiton acerifolium); spotted gum (Eucalyptus maculata); and meranti (Shorea spp.). The three boards are bolted together using narrow aluminium separators between adjacent boards.

So far four "strains" of Lyctus brunneus from widely separated localities on the NSW coast have been established as stock cultures. "Trap-boards" infested at a number of other localities are at present being held in the laboratory pending the establishment of further stock cultures.

It is intended to establish eight or ten Lyctus brunneus "strains" as stock cultures. Most of these will be from NSW. Cultures of other Lyctids, i.e. Lyctus discedens and Tristaria grouvellei will also be established if possible.

An investigation of label data information from specimens in museums and other institutions will be undertaken in the future to determine what species of Lyctidae have been recorded from Australia.

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* Prepared by K. D. Fairey.

Discussion

Bryant: We have been puzzled as to why we never find Lyctus attack in paling fences when so much hardwood is used in NSW for this purpose. We have felt that this is probably because of either the weathering of the starch from the sapwood or some change which takes place, perhaps the starch being attacked by fungi or moulds when it is in the fence. Have other states found Lyctus attack in fences and, if not, why not?

Tamblyn: In Victoria too, we have this phenomenon of increased resistance or lower susceptibility of palings to Lyctus. I think it may get too hot in these very thin palings in the summer time and that may be sufficient to discourage attack.

Da Costa: I think there are three possible explanations: the high temperature, the leaching of the starch, and the fact that any exposed sapwood in a paling fence is riddled by fungi very early on. This may destroy the starch fairly rapidly and be antibiotic to the Lyctus.

Item 4(x) The development of less toxic fungicides than pentachlorphenol in "natural" finishes. (NSW)*

Lightly pigmented oil finishes are of increasing popularity as decorative coatings for exposed timber surfaces but because of the attraction of the oil to fungi it is necessary to incorporate a deterrent. The original U.S. Forest Products Laboratory formula recommended pentachlorphenol and this is still being used, though organic mercury compounds are understood to be used too. So called wood-preserving oils marketed by some oil companies also contain pentachlorphenol.

These finishes are of such a thin nature that the "do-it-yourself" householder, who applies a large proportion of these finishes, inevitably gets a lot of the finish on his hands, particularly when coating eaves lining, high walls, etc. and there must be a definite health hazard.

Investigation of the efficiency in linseed oil of less hazardous alternatives is required.

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* Prepared by K. Bootle.

Item 4(z) Incidence of Cryptotermes brevis in Queensland

Discussion

Ryley: Cryptotermes brevis, as you all know, is an imported species of dry wood termite. It was discovered in Queensland in early 1966 through a sample forwarded to CSIRO, Canberra, some years previously. The matter was reported to Commonwealth Quarantine, who took it up with the State Primary Industries Department which is the local quarantine establishment, and, after endeavouring to get the Commonwealth to assist or do something about it, it was left to Queensland as Commonwealth Quarantine said that Queensland was the only State in which it had been found. As a result we have done a survey of some houses in Maryborough. We originally inspected 237 houses to a radius of about 1/4 mile around the house which was infested. We did a preliminary inspection to find out which houses had evidence of dry wood termite attack, because we have a local species there which is very prevalent, and 122 of these houses showed evidence of dry wood termite attack. Out of these were selected 66 to do a further detailed inspection, which involved removal of timber from the home to obtain soldiers for identification. Of these 66 houses, we found C. brevis in 7; the local species C. primus was active in 22 houses in the frame and in 23 houses, in the stumps. Our present intention is to extend the survey in Maryborough and possibly to other places in Queensland, fumigate the houses in which it has been found, as a holding measure. We feel that until we know the full extent of it, we cannot make a final decision on what should be done. Further figures from the next survey will indicate whether there is a chance of eradicating the insect or whether it has spread too far. From visual observation, the damage caused by C. brevis, which to date has only been found in hoop pine, appeared to be more severe than that caused by the local species C. primus.

That is the position at this stage and the houses should be fumigated before Christmas. We understand that this species was found some years ago in Sydney, apparently in furniture. We believe it was destroyed and there was no further evidence of it in Sydney. I believe that Commonwealth Quarantine have been asked to check and advise as to whether it has been found anywhere else in Australia.

Edwards: Have you any indication as to when these infestations actually started in Maryborough?

Ryley: No. The house in which it was first discovered had been recently bought by an employee of our Department. He sent a specimen down to CSIRO in Canberra, and it was there for some time, I understand, before Mr. Gay identified it as C. brevis.

Edwards: It has not been found in any hardwoods or scrubwoods?

Ryley: No, only in hoop pine.

Howick: Is Mr. Ryley convinced that C. brevis is a far more serious insect than the local species, C. primus?

Ryley: We are only basing our opinions on information contained in overseas reports. Visual observations by our entomologist indicated that damage was more severe where C. brevis was located.

Tamblyn: C. brevis attacks a large number of timbers, hardwoods as well as softwoods. Our local endemic species are fairly fussy about the timbers they attack. C. brevis has been extremely vigorous and omnivorous insect wherever it has occurred anywhere in the world.

Item 4(aa) The preservative treatment of sleepers*

Discussions are being held with the Queensland Railway Department relevant to replacement sleepers and girders and the possible extension of the range of acceptable species. Major problems in the application of preservative treatment are:

Conventional water borne preservatives are not considered satisfactory.

The principal cause of failure for Queensland is mechanical. Previous surveys showed up to 80% failure through this cause.

Economics and distribution of sleeper supply sources. Service results in terms of treated sleepers for Queensland conditions may be summarised.

Creosote supplies are diminishing.

Creosote pressure treated (200 psi) sleepers installed at Roma Street in 1934, gave satisfactory service.

A total of 659 sleepers (8 species + Q G R Standards) using creosote oil open tank and spray treatments at Normanby installed in 1950 and completed in November, 1966 due to line re-location.

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* Prepared by K. V. Cokley.

Pressure (high) and boultonised sleepers installed at Milton and Deeral.

The overall result to date may be summarised as:

Open tank creosote oil gave service results of 17 years + in species of normal durability of less than 14 years untreated.

Water borne preservatives do not appear to be giving satisfactory protection against weathering.

High pressure treatment of local suitable species, other than blackbutt does not appear promising.

Semi commercial results on hot and cold 50/50 creosote oil mixtures using brush box have given loadings of 4 lbs/cu ft on total volume, with penetrations of 1/16" plus.

In summary of these factors it is the considered opinion of this Department that:

(a) The preservative should be an oil based type primarily intended for protection against weathering but possessing a reasonable preservative value against decay. Preferred treatment mixtures are:

3-5% PCP in oil (use of local supply oils)

30/70 creosote oil mixtures

(b) Preservative treatment should be based on:

Hot and cold system

Boultonising

(c) The hot and cold system would enable the Railway Department to install mobile plants heated by steam locos.

Discussion

Tamblyn: I think you should look at this very carefully before you commit yourself to a recommendation for open tank treatments. This Division has very extensive rail sleeper tests installed around Australia and involving at least ten thousand sleepers, and we are not happy about recommending open tank treatments - all countries of the world have discontinued this method of treatment for sleepers. In America where open tank facilities are widely used for the treatment

of poles, 99.9% of sleepers are treated by pressure. We should be very wary of recommending a second rate treatment and I believe that in recommending it in Queensland you are creating a problem for us in other States where we are trying to convert the authorities to pressure treatment for rail sleepers.

Cokley: We have been working on this problem for seventeen years in an attempt to arrive at a satisfactory solution. Concrete sleepers have been made and are under test in Queensland. With the species which are in good supply, the tests carried out by DFP gave the conclusion that high pressure treatment was not very promising. Hicksons have made independent tests and their conclusions are that blackbutt is the only Queensland species that is promising as a sleeper timber when treated by high pressure methods. All our results indicate that an oil treatment considerably reduces mechanical breakdown. The biggest problems in Queensland are those caused by rail cut and spike kill.

Tamblyn: It is quite wrong, to say that high pressure treatment has in any way failed. Hickson's appear to be perfectly satisfied with high pressure treatment of rail sleepers. To this end they have recently installed a high pressure cylinder in Tasmania. Queensland sent down to us rose gum, satinay, turpentine and brush box for pressure treatment and they were treated at 1000 lb/sq in. We managed to get 10 or 12 lb/cu ft into rose gum and satinay and 7 lb/cu ft in turpentine. Brush box, of course, was a difficult species and at 1000 lb/sq in. unincised for 8 hours it took up 2 lb/cu ft. How you can talk about 4 lb/cu ft by open tank treatment I cannot understand. I suggest the economic problems are largely solved by giving industry an opportunity to make these treatments. Why should Queensland railways meddle around with open tank treatments when industry, given a chance, will supply all the treated sleepers needed provided you are prepared to pay 10/- extra for every sleeper for a guaranteed life of, say, 25 years?

Dale: The procurement, drying and handling of sleepers is a large part of the treatment cost. The cost of the high pressure treatment is not a major part of the total cost. Nor is the extra preservative take-up in high pressure treatment, but the improvement that is obtained by high pressure treatment is certainly going to make a great deal of difference to the economic picture. It is already evident in our Victorian test where 200 lb treatment is starting to fail in some species but 1000 lb treatments are still in perfect condition. We just don't believe that hot and cold bath treatment is worth doing except for sleepers with 1/3 of sapwood on the upper edge. It isn't practical to get 4 lb/cu ft in the usual eucalypt heartwood by hot and cold bath.

ITEM 5. TIMBER SEASONING

Item 5(a) Review of Research Activities

1. DIVISION OF FOREST PRODUCTS*

Since the last review, continued emphasis has been given to research designed to increase the efficiency and productivity of seasoning operations.

The major contribution has perhaps been made on the drying of round timber in preparation for preservation treatment, with the aim of improving the supply of poles for the various pole using authorities. In the drying of sawn timber, attention is increasingly focused on the drying process as a whole to evaluate how the various drying methods can best be combined to achieve the most economical processing of timber from the green stage to the dry condition.

Drying of round timbers. - This subject has been extensively reported in our Annual and Half Yearly Reports which are available to delegates. It will also form the topic of two submissions to the Conference in the present session (Item 5(c)).

Summarising the work accomplished during the last year or so, we can say that kiln drying has proved to be the most successful method for radiata pine poles, whereas boultonizing has been applied very successfully to karri, jarrah and to spotted gum.

We have shown that radiata pine can undoubtedly be kiln dried in 2-3 days with negligible degrade, and at acceptable cost. The study of boultonizing of karri is now largely completed and firm recommendations can be given to industrial operators.

Air drying. - In Item 5(b), we propose to discuss briefly our present thoughts on air circulation patterns in industrial drying yard layouts, and our work on relating observations on models in our wind tunnel to industrial full scale operation.

Drying of sawn timber. - Apart from a large number of individual problems which have arisen from time to time in the industry in various States, our research has been concerned mainly with radiata pine and Tasmanian hardwoods.

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* Prepared by W. G. Kauman.

The former will be reported by Mr. Campbell under Item 5(h), and is concerned with the drying of preservative-treated radiata pine and prevention of checking in thick stock, and with excessive resin bleeding in 2 in. thick treated pine at a New South Wales plant.

The problem in Tasmania consists in excessive checking in backsawn stock of ash eucalypts during drying, especially in the north and northwest coastal districts. This degrade arises at an early stage during drying, and although checks tend to close later, they open again during the reconditioning treatment. Similar troublesome checks are observed on the edges of quartersawn stock in 1½ and 2 in. thick material.

The Division was approached some time ago by the Tasmanian Timber Association with a request to assist with this problem, and a research program has been drawn up by the Officer-in-Charge, Mr. G. W. Wright, and is now in execution. We are particularly interested in treatments which reduce permeability in the surface of the wood in order to reduce moisture gradients or alternatively increase permeability throughout the thickness of the material to accomplish the same objective.

Treatments which are being tried include surface coating with various micro-crystalline waxes, presteaming, prefreezing, and application of conventional salt seasoning and dimensional stabilization agents. The study has only been under way for a short time, and it would be a little premature to give any interim results.

At the request of the Queensland Timber Board and Cypress Pine Association, we have also recently started seasoning experiments with cypress pine.

The influence of "die-back" infection on the seasoning behaviour of jarrah. - West Australian authorities are greatly concerned with an infection known as "die-back", caused in jarrah forests by an organism identified as Phytopthora cinnamomi.

At the joint request of the West Australian Forests Department and West Australian timber industry, the Officer-in-Charge, Mr. G. W. Wright, visited WA earlier this year to investigate this problem. He prepared sample boards from six trees that had died from die-back infection, six trees infected but still alive and six sound trees as controls. One third of the boards were given a salt treatment, one third were coated with wax, whereas the remaining third was untreated, and the material was then stacked for air drying. Tests are still in progress.

Drying behaviour of Pacific timbers. - In cooperation with the forest authorities of Fiji and of the British Solomon Islands Protectorate, we have continued to investigate the seasoning of species from these Territories. The aim of this study is not so much a complete determination of seasoning behaviour, but rather an exploratory assessment to determine the seasoning properties in relation to possible uses, without necessarily arriving at the most precisely adjusted seasoning schedule. During the past year, approximately eight Fijian timbers and eleven Solomon Islands species have been thus examined. The results are communicated to the services concerned, and are also made available through our Half-Yearly reports.

Dryer design and kiln aerodynamics. - During the last two years, our design group has re-assessed the present position in dryer design. In addition, we have continued to give the required service to industry and have answered a large number of enquiries on the design of timber kilns, predryers, and other types of drying units.

The participants in this Conference are well aware that a number of new types of drying units are being developed in various countries, including Australia. I should like to draw attention particularly to the very interesting work being done in New Zealand by the Forest Research Institute in Rotorua as well as a number of industrial firms and consulting engineers. We are following this work with close attention and have evaluated in a preliminary way a number of these designs with respect to their possible application under Australian conditions. Careful consideration has been given to the installation of experimental and pilot plant facilities in this Division to explore this trend, with the aim of developing sound engineering designs for drying units that will enable our industry to attend to some drying tasks that have arisen in recent years. Among these tasks are the drying of round and large dimension timbers, either in preparation for a preservation treatment or for later re-manufacturing, the production of heat other than from steam boilers, and more economical methods of drying both softwoods and hardwoods.

An interesting sideline of our endeavour has been the design of laboratory kilns for our own new seasoning laboratory and for the Forestry School of the University of Melbourne. There is considerable interest in this kind of unit, both in Australia and overseas.

Moisture movement and collapse studies. - Our long term research in seasoning is concerned with understanding the mechanism of moisture movement in wood, and the physics and physical chemistry of collapse and recovery. During the past two years, this work has been given a new impetus through the appointment of Dr. W. G. Kauman as joint supervisor for two New Zealand students in the School of Forestry at the University of Melbourne. One of these,

Mr. John Kininmonth, is undertaking research towards a Doctorate of Philosophy and the other, Mr. John Turner, towards a Master of Science.

Mr. Kininmonth is mainly concerned with measuring the saturated permeability of wood to liquids. He has constructed equipment to determine permeability under pressures up to several atmospheres and is at present carrying out the necessary measurements. Mr. Turner's project is concerned with the evaluation of stresses, sets and time-dependent deformation during the drying of N.Z. Nothofagus fusca (red beech). This study, it is hoped, will bring to light new information on the development of checks and collapse in a difficult species, and will also be useful to the New Zealand timber industry which is increasingly using this species.

In our laboratory, we have examined the penetration of liquids into wood, the permeability of unsaturated wood and paper to water vapour, and the theory of time-dependent deformation in wood. A first discussion of this theory has been published.

In the collapse field, attention has been concentrated on the mechanism of recovery during reconditioning. The linear extension of a specimen during reconditioning is being measured with considerable precision in relation to the heat input and to the uptake of moisture during the treatment, using specially built equipment.

In cooperation with an officer of the French Forestry Research Station at Nancy, we are studying the variation of moisture distribution within individual growth rings during the reconditioning treatment. This is done by means of X-ray densitometry measurements, which enable us to relate the increase in dimensions due to recovery to the changes in moisture content from point to point in the specimen. We are at present developing the necessary computer programmes.

Dimensional stabilization. - Work on this subject has continued along the lines reported previously. Using polyethylene glycol and glycerol, very significant reductions in shrinkage have been obtained in the laboratory. We have just started to try the treatments with material of commercial size. Mr. G. W. Wright, who is very interested in this project, has been looking at the economics of dimensional stabilization, but it is too early to predict whether the presently known treatments would be economically feasible on an industrial scale.

Training and technical assistance. - The Section has continued training overseas students and providing technical assistance not only to the Australian industry and wood user, but also to a number of overseas countries by way of correspondence, discussions with visitors, and so on.

Our Seasoning Correspondence Course is operating satisfactorily, and we have also contributed a number of lessons to the new correspondence course on Timber Production Management run by the Hobart Technical College. A Seasoning Course was held in Adelaide last year.

At the request of the Department of Trade and Industry, we assisted a visiting Trade Mission from Chile interested in Australian manufactured equipment for the processing of timber. We are also cooperating with Chilean authorities in an experimental project concerned with the determination of equilibrium moisture content throughout Chile. At present, the results are being analysed by us in a CSIRO computer, using programmes developed during our own experiment on this subject some years ago.

II. NEW ZEALAND*

Kiln drying. - Steady progress has been made in the general re-assessment of kiln drying schedules at present recommended for commercial use, with experimental and in some cases commercial drying successfully completed. The trend has been towards mild initial settings followed by more severe conditions for the major part of the drying cycle, which is rounded off on a milder conditioning setting for, perhaps, one day or less. Schedules in all cases include a final steaming, usually at a setting 10°F above that used for drying, lasting for 4 hours per inch of thickness.

Studied were:

1 inch Douglas fir (Pseudotsuga menziesii)	Low degrade and distortion, rapid drying. Knots check
2 inch Douglas fir (Pseudotsuga menziesii)	Low shrinkage, low degrade even on severe schedules, so most economical to dry as fast as possible
1 inch Larch (Larix decidua)	Prone to surface checking, but dries rapidly and evenly, even on the mild recommended schedule
1 inch O.B. rimu (Dacrydium cupressinum)	Early stages must be mild, more severe later if followed by a milder equalising setting for 1 day

* Prepared by D. H. Robinson and D. H. Williams.

1 inch Tawa (Beilschmiedia tawa)	Slow drying, degrade prone if hurried
2 inch Tawa (Beilschmiedia tawa)	Slow drying; has to be dried to a lower EMC before equalising to get the centre dry. Quarter-sawn takes 30% longer than flat-sawn.

In addition, a study on larch scaffold planks of 9" x 2", both air and kiln dried, showed that the species was too prone to distortion to be of value for this purpose without regrading after drying.

Following requests regarding the length of time needed in a kiln to sterilise timber, the temperature response of boards in the centre of block stacked filleted packets of 1" and 2" green radiata pine was monitored on a kiln setting of 160°F and steaming. The results showed that the extra time needed for the block stacked material would merit the cost of filleting.

Forced air drying (pre-driers). - Experimental work on both heated and unheated forced air drying to determine the drying rates of the major N.Z. species has been completed. Approximately one week in the drier is equivalent to one month of air seasoning. Interest and response from the industry was so great that two further projects were initiated.

A commercial 10,000 bd ft drier used as "once through" unheated drier and a recirculated heated drier (oil burner) has shown the benefits of adding heat, especially during the winter months. The economics both of capital investment and running costs are extremely promising, unquestionably when used as a predrier (25% m.c.) of exotic species to be topped off in a kiln or pressure treated. The lag in drying along the length of the drier is considerable - as much as half the drying time is spent evening out the load. This illustrates the need for either reheating after every second packet or some form of progressive drier with loading access in each by means of side doors.

A start has been made to determine the optimum rate of air movement to be designed for in forced air drying. Matched stacks 4 ft deep of 1" and 2" radiata pine have been dried in two experimental driers at different rates of air movement between 150 and 1000 ft/minute. The main benefit so far has been in the reduction in lag across the stack. However, in the 2" pine during the winter months, the drying was considerably faster at the higher velocities.

In all experiments so far, both on a laboratory and commercial scale, degrade has been negligible and the end product of good quality and uniform moisture content.

Air drying. - In commercial air drying studies at Rotorua, reports have been prepared on:

1 inch Radiata pine	Dries well in summer, slowly in winter, and best with least stain and degrade when covered
2 inch Radiata pine	Dries well in summer, not at all in winter unless covered
1 inch Larch	Dries evenly and easily, but covers are needed to prevent excessive degrade in the top layers
1 inch Tawa	" "

General. - The use of poly-ethylene glycol of mean molecular weight 1000, as a degrade inhibitor was assessed using Knightia excelsa, our most susceptible native timber. It was found that any application of PEG 1000 reduced degrade but that application (either as 33% solution in water or simply melted and painted on the surfaces) followed by a diffusion period was best.

A study has commenced on moisture meter correction figures for a resistance type moisture meter (the Techtron) on red beech (Nothofagus fusca) and it is hoped to extend this work to our other native beech species. It is difficult, particularly when testing material air drying, to ensure that the board is evenly dried. Even with a low moisture meter reading, calculated moisture content differences of 30% between cross section m.c. and the m.c. of the central one-ninth of the cross section are common.

A start has been made on the design of a laboratory wind tunnel and instrumentation to study the aerodynamics of drying. It is hoped to relate experimentally the stack width and frequency of reversal to the air flow rate and the effect on kiln schedules.

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Following the reviews there was considerable discussion on forced air dryers. The industry is becoming interested particularly in NSW and some guidance as to their effectiveness is needed. DFP is following the developments closely and considers that this type of dryer is very promising. NZ has used them for both exotic and native softwoods, but from their experience with hardwoods they doubt the effectiveness of this type of dryer with the more refractory eucalypts.

Item 5(b) Air drying (DFP)*

Since the previous review, work in this area has been concerned with the evaluation of air drying yard layouts, using scale model timber stacks in the Division's low speed wind tunnel.

The air circulation pattern in a number of basic layouts is being determined for various incident wind directions. The effect of foundation design on air movement through the model stacks is also being examined.

Conclusions from the model studies will be tested in commercial seasoning yards, and field techniques for determining air drying yard performance are being investigated.

Life tests on a number of flexible plastic stack covering materials are in progress.

Item 5(b) New South Wales**

The air drying of cypress pine has been investigated in two areas of New South Wales for summer drying conditions. As this timber has been traditionally milled green, there is very little drying of this timber carried out at sawmills at present. It is usually dried after being machined green.

Green milling has been customary for two main reasons. These are:

Cypress has a low shrinkage (about 2.5% both radially and tangentially), and the practice has been to allow it to dry on the flooring joists of the building before being cramped and nailed. Although an unsatisfactory method of drying, the low shrinkage at least ensured that at worst the tongues did not shrink completely out of the grooves

The belief that the timber could not be milled dry, because it became too brittle, with knots especially causing a lot of trouble.

From our investigations, it was found that the timber could be milled satisfactorily at about 15% moisture content, with little more degrade than when milled green. As the timber occurs in areas of low e.m.c., the timber could easily dry to 10% or lower, and then dressing degrade increased markedly.

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* Prepared by R. M. Liversidge and R. Finighan.

** " " J. Harrison and P. Marshall.

Green moisture content. - The green moisture content of cypress pine sapwood was found to be 100-125%. The heartwood ranged from 40-60%. The average green off saw moisture content of the boards was about 50-80%.

Drying rate. - During summer, 1" cypress boards dried to 15% in from three to five weeks. The shorter time was obtained under optimum drying conditions, i.e. daily temperatures of 80-100°F, no rain, and good winds. With any rain or dull weather, the drying time was extended.

A close check is required on the moisture content, otherwise further drying (down to 8-10%) quite readily occurs which results in difficulty in machining.

Degrade. (a) Checking: As with many timbers, this is to a large extent dependent on the exposure of the timber to the sun. Leaving boards for as little as two hours in the hot sun leads to surface checking. If the timber is rapidly stripped, or left under cover for a short period prior to stripping, checking degrade can be kept low. The amount of checking in the stacks due to the drying is fairly low.

(b) Warping: This appears to vary with the different areas. In some areas warping is negligible, but in others twist or wind can occur, and stack weighting would be required for best results.

Kiln drying of cypress pine boards. - As a corollary to the air drying of cypress boards, the kiln drying schedule was also obtained. The particular point here was that a high temperature schedule was prepared, starting at 160°F. while the boards were green off saw. This has the effect of reducing the drying time from 8-10 days down to 4-5 days, with no increase in drying degrade. Timber from Queensland as well as New South Wales was tested.

The schedule is as follows:

M.C.	D.B.T.	W.B.D.
Green	160°	14°
40%	160	20
30%	160	30

A four hour reconditioning treatment is also recommended.

Item 5c(i) Boultonizing of karri*

Boultonizing provides a means of controlling drying degrade in karri poles. Conclusions to date are based on results from 38 specimens approximately 9 ft long and obtained from 16 trees from the Northcliffe and Pimelia (W.A.) areas, with mid-length diameters of 10-14½ in., and sapwood thickness between ⅞ and 1⅞ ins. Boultonizing was usually for about 9 hours at 230°-240°F., and 8-25 ins. Hg vacuum. Creosote retentions and final moisture content data were determined from two moisture content plugs per specimen, sectioned tangentially to give from 2 to 4 sapwood increments from each plug.

Creosote retention was shown to depend on moisture content, total sapwood thickness and the depth of the centre of any given sapwood increment from the surface of the pole. Pole diameter and duration of treatment had no effect on retention.

The main objective of further studies will be to see if there is any significant difference in drying behaviour and creosote retention between large and small sized poles, taking into account the effect of density.

Pilot plant. - Some approximate data on the influence of changes in level of vacuum and creosote temperature on the rate of efflux of creosote and water into the condenser were obtained.

The working tank has been modified in an attempt to overcome problems associated with sludge formation and the attendant problem of water build-up in the system.

Discussion

Cokley: What is Mr. Barnacle's opinion of boultonizing as a commercial pole treatment.

Barnacle: Boultonizing appears to be most successful with poles of species having a density above 50 lb/cu ft but it is rather difficult to get the required preservative loading in species of this density. To get complete sapwood penetration in poles with a sapwood thickness greater than 1 in. the boultonizing period would have to be extended beyond 9 hours. In this material an adequate retention of preservative would only be obtained if boultonizing was followed by some other treatment such as hot and cold bath or pressure.

Cokley: Does boultonizing have application for treatments other than creosote, for example penta, on materials such as 1" boards.

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* Prepared by J. E. Barnacle and F. J.Christensen.

Barnacle: Very limited tests have shown boultonizing causes little degrade in 1" Karri boards but whether this would make them suitable from a preservative point of view is not known.

Cokley: Would the Division be prepared to test some of our species if we send down the boards.

Barnacle: Assuming official approval is given we would need to know your objectives before we could comment on the suitability of the treatment.

Muncey: I think the prospects are favourable towards some work along these lines.

Item 5c(ii) Kiln drying of radiata pine poles and posts*

Difficulty in meeting the demand for satisfactory hardwood transmission poles, especially large ones, is causing concern in at least two States. In these instances, some relief to the problem can be obtained by using special seasoning methods to overcome the excessive air drying degrade developed in poles from certain species which are available in large quantities but at present are unacceptable. Even so, increasing use of softwood poles may be expected as the Australian plantation programme is oriented to softwoods.

Softwood poles are generally easy to air dry with little degrade but, in certain areas of Australia, slow drying during extended wet periods can result in the development of decay. This can be avoided by accelerated drying, which also has the advantages of (i) reducing pole stocks, (ii) making constant production possible the year round, (iii) reducing the possibility of variations in the standard of preservative treatment, and (iv) allowing urgent or special orders to be filled at short notice. These advantages must be balanced against the increased cost of drying and capital expenditure on plant.

Experimental drying studies on 175 P. radiata poles, 24 to 42 in. butt girth under bark and 30 ft long were made in a commercial plant in western Victoria to determine drying rate and degrade development under high temperature conditions. At dry bulb temperatures of up to 230°F. and wet bulb depressions of 50-75°F., poles dried in 2-3 days with negligible degrade to a moisture content of less than 30 per cent measured at a depth of 2 in. from the surface.

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* Prepared by F. J. Christensen and J. E. Barnacle.

Approximate drying costs for 10,000 poles per annum have been estimated by G. W. Wright at 80¢ per pole for 6 months' air drying, and $1.70 per pole for 2½ days in a predryer heated by a fuel oil fired steam generator. Capital expenditure for plant and stock would be of of the order of $70,000 for air drying compared to $35,000 for predrying, the difference being due to the smaller number of poles in the yard.

Thus, high temperature drying would appear to have distinct advantages for P. radiata poles. It is suggested that further investigation of the accelerated drying of softwood poles and the development of special driers for this purpose would be profitable.

Item 5(d) E.M.C. Studies in New South Wales*

By using a direct reading moisture content indicator developed at the Division of Wood Technology, the e.m.c. of six areas of N.S.W., including Canberra have been studied for the past two years. The situations investigated were for unheated indoor conditions, and a summary of the results obtained are as follows:

1. Radiata pine	Coffs Harbour	Batemans Bay	Bathurst	Canberra	Dubbo	Broken Hill
max.m.c.	14.9	14.4	12.5	11.4	15.0	11.0
min.m.c.	13.4	15.1	10.3	9.8	10.3	8.3
Average	14.2	14.8	11.4	10.6	12.7	9.7
2. Tallow-wood						
max.m.c.	14.8	15.1	12.6	12.5	12.4	12.5
min.m.c.	14.3	14.6	10.8	11.0	10.3	11.0
	14.6	14.9	11.7	11.8	11.4	11.8

The next phase of this study is to place the indicators in a sheltered outdoor location in these areas. It will be interesting to compare results with the CSIRO predicted EMC's for these areas.

* Prepared by P. Marshall (NSW).

Item 5(e) - Moisture meter sampling by remote measurement*

I. DIVISION OF FOREST PRODUCTS

Accurate measurement of the moisture content of stacks of timber is an important factor affecting both the economics and quality of drying. Irrespective of the method of measuring moisture content, the most difficult problem facing the kiln operator is selecting and placing an adequate number of test boards in a stack to give a true indication of the average (or perhaps maximum) moisture content of an entire stack holding some thousands of super feet of timber.

For a given species, the time of drying of sawn boards is influenced by (i) anatomical features, (ii) proportion of sapwood to heartwood, (iii) initial moisture content (iv) permeability, (v) tendency for "wet spots" to occur, (vi) development of drying degrade and (vii) position in stack, as well as by (viii) the drying characteristics of the particular equipment used.

The only practical methods of measuring the moisture content of stacks of drying timber are (i) periodic weighing of sample boards or (ii) an electrical moisture meter connected to electrodes inserted in test boards. There is much to commend the latter method, particularly its speed and convenience, but a number of factors can limit its accuracy.

In addition to the problem of effective sampling common to both methods of measurement, each has its own disadvantages. For the conventional sample board method, the principal ones are (i) the considerable time involved in preparation, weighing and calculation, (ii) the possibility of error in weighing and calculation including accurate determination of the initial moisture content of boards and (iii) for timber dried in a kiln, the loss of drying time while sample boards are weighed and set drying conditions are disturbed. For remote measurement with a moisture meter, disadvantages include:

(i) the narrow range of accurate measurement ca 6 to 25 per cent),

(ii) the risk of breaking lead wires or damaging their insulation,

(iii) the measurement of moisture content at virtually a "point" in a test board, and

(iv) the greater capital cost than for the sample board method.

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* Prepared by F. J. Christensen.

Accuracy of measurement with the moisture meter method is affected to a greater or lesser extent by a number of factors. Partial or full corrections can be made for the effects of (i) species, (ii) changes in the temperature of boards, and (iii) electrodes inserted either along or across the grain, but no allowance can be made for the effects of (i) polarization, (ii) change in electrode contact resistance, (iii) electrode voltage gradients on resistance, (iv) electrolytic deposits in the vicinity of electrodes, (v) inherent variation in resistivity within a species, and (vi) heat transfer along copper leads to electrodes inserted inside test boards. Accuracy can also be influenced by (i) electrode contact area and (ii) the presence of moisture gradients as a result of which the moisture content measured is the maximum occurring between the electrodes. With some combinations of the above factors, the error in moisture content measurement could exceed $\pm$ 5 per cent at values below 25 per cent.

These objections should be weighed against the benefits to be gained from being able to monitor moisture gradients and moisture contents below average values of about 20 per cent in a very limited number of test boards without disturbing the timber being kiln dried.

II. NEW SOUTH WALES*

A method of checking the moisture content of timber during kiln drying by using electrodes in the timber connected to a moisture meter in the control room has been developed. Details of the technique have been published in the March, 1967 issue of the Australian Timber Journal (vol. 33 no. 2).

The method was developed in conjunction with the production manager of Vanderfield & Reid, Sydney, who have been using it for over two years, and during the last 18 months have not used one sample board. The drying times have been markedly reduced and the quality of the dried timber has improved.

These claims may be considered to be exaggerated but the reasons for the success are as follows:

1. Faster drying. - Essentially this is due to the high temperatures employed, even with green timber. Results of our work on the high temperature drying of hardwoods were first tabled at the last conference in 1965, whence 1 in. boards were dried from green at temperatures of 160°F to 180°F, with resultant increases in drying rates. As a result, a charge of 2½ in. thick hardwood was satisfactorily dried from green to 22% in a matter of 10 days,

* Prepared by P. Marshall.

using this technique and these temperatures. A similar charge dried at conventional temperatures took 22 days to dry to a moisture content of 25%. Both kilns operated 24 hours on a 5 day week.

2. Quality control. - The quality of the drying and dried timber is controlled through the moisture gradient.

Having the electrodes in the case and core sections of the timber means that the respective moisture contents can be read quickly and the kiln conditions changed to suit. Commercially, two readings a day are normally taken on thick timber, and more on thinner sizes.

By controlling the kiln conditions the moisture gradient can be controlled, leading to lower stress in the timber and hence to a decrease or even elimination of checking, mostly the latter. It is for this reason that we have termed the whole process "Gradient Drying", even for 1 in. stock. The kiln drying schedule then only becomes a guide, and is not essential (e.g. there is no published schedule for 2½ in. hardwood, or 3 in. oregon). This is advantageous, as the recommended schedule occasionally results in high degrades.

A factor that causes some queries is that the meter is well known to be more inaccurate at high moisture contents, so how can it be used for accurate drying? Frequently, when the timber is green, the readings for moisture content are well off the meter scale. This does involve following the issued schedule or a developed high temperature schedule until meter readings are obtained, usually when the timber is from 40% to 60%. From then on, although the absolute moisture content may not be correct, the moisture gradient is quite accurate.

The final moisture content required has to be determined to allow for the species correction as well as the temperatures. This is not a complicated or difficult process, as most timbers in the moisture content range of 12-15% have a relatively low species correction.

There have been a number of enquiries from several states as well as overseas on the technique and five of the instruments are now on order.

Item 5(f) Some problems in drying Radiata pine*

Recently two problems associated with the drying of preservative treated radiata pine were reported to the Division. The first was concerned with surface checking that was occurring particularly in the sapwood, during redrying of 1¼ in. and 1½ in. thick stock. Some reduction in the checking was achieved by giving the treated stock a presteaming treatment prior to drying.

New Zealand experience has shown that steeper moisture gradients are set up in treated radiata pine than in untreated material, and that slight surface checking may occur in treated material during redrying. It is suggested that the type of the pre-treatment drying given could affect drying behaviour in the post-treatment period. A recommendation was made to the plant concerned that the effect of a preliminary air drying treatment prior to kiln drying be examined during the pre-preservative treatment drying stage.

A modification of their redrying schedule was also recommended, mainly in regard to the initial wet bulb depression used i.e. to use a 7°F. instead of 15°F. It is planned to carry out trials at the Division, immediately after pressure treatment, using presteaming and various kiln drying schedules. It is thought that excessive pit aspiration could be one of the main factors responsible for the checking in the post-treatment drying period, particularly if the timber is dried to low moisture content prior to pressure treatment with waterborne preservatives.

The second problem was excessive resin bleeding in a load of 2 in. thick preservative treated pine during redrying at a New South Wales plant.

The timber was initially kiln dried in Victoria prior to pressure treatment with zinc-chrome-arsenical preservative. Some treated specimens were subjected to drying tests to check on the effect of temperature on resin bleeding, using an initial D.B.T. of 120°F. and W.B.D. of 15°F, and final conditions of 140°F. D.B.T., 30°F. W.B.D.

In a second run, the initial conditions were 150°F. D.B.T. and W.B.D. of 15°, final 180°F. D.B.T., 30°F. W.B.D. The first run took 8½ days to dry from 56% to 10% and the second approximately 5½ days from 63% to 9%. Both runs were steamed for 4 hours at 212°F. at the end of kiln drying but at no stage was there any significant resin exudation.

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* Prepared by G. S. Campbell.

The only time any appreciable exudation occurred was in one sample in a third run, when at approximately 12% moisture content, the conditions were increased to 200°F. D.B.T. and 40°F. W.B.D.

It is felt that a severe drying schedule, if used in the early stages of drying, could be a significant factor in producing excessive resin bleeding during the redrying of pressure treated radiata pine.

Item 5(g) Air drying of Pinus elliottii posts (NSW)*

To obtain information on the drying of slash pine posts, several were obtained from a private pine plantation at Tea Gardens (N.S.W.) and air dried in Sydney.

Drying times were found to be as follows:

Green to 30%	3 - 4 weeks
" " 25%	5 "
" " 20%	7 "

The moisture gradients through some of the posts were determined at average moisture contents of 25% and 18%. The results were as follows:

Average M.C.	25.9%	18.4%
Case	21.3%	10.8%
Inter. (1)	25.3%	18.0%
Inter (11)	27.0%	23.0%
Core	35.0%	29.0%

Drying took place in Sydney over the dry spring months.

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* Prepared by P. Marshall.

Item 5(h) The use of surface films for preventing checking degrade during drying (NSW)*

The use of permeable surface coatings on timber to restrict its drying hence minimise checking degrade during drying has been investigated. Originally dextrin and carboxy methyl cellulose solutions were tried, but these were found to be rather expensive and the former rather messy to handle.

Sodium alginate was tried and found to be effective and economical. The technique is to prepare a solution of 1% to 2% sodium alginate. This forms a viscous solution into which the timber is dipped and allowed to drain. The timber is then stripped out for drying. The alginate remaining on the timber dries to form a thin film over the surface.

This surface film is not impervious to moisture loss, as distinct from end coating types of material, but it restricts the surface drying of the timber. This in turn reduces the moisture gradient through the section, reducing drying stresses and thus minimising face checking.

Initially the alginate was used as a medium for holding a strong solution of common salt or urea in order to effect chemical seasoning as a dip process and this was found to be effective for drying tulip oak (Heritiera spp.) especially back sawn material. One inch and two inch material has been dried with virtually no degrade, although untreated matched controls showed considerable face and end checking. With careful drying even four inch squares have been successfully dried.

More recent work has indicated that a 1½% alginate solution alone, because of its restriction on surface drying is effective in minimising checking. Trials of both alginate with urea and straight alginate have been carried out on commercial quantities of various species of timber in country centres, but results have not yet been obtained.

The film does not slow the drying rate to a very great extent. On 4 in. x 2 in. tulip oak during air drying tests showed even moisture content differences of only about 5%.

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* Prepared by J. Harrison and P. Marshall.

Discussion

Marshall: The idea of chemical seasoning as a means of controlling surface checking is not as good as it appears. We find it necessary to soak thick timber for 2 to 3 weeks in urea, in which time the urea diffuses through to the centre but the surface is still loaded. The one to two day soak is not true chemical seasoning.

We are looking for a momentary dip that will give a high concentration of chemical in contact with the surface. Sodium alginate proved best as it forms a pervious film when it dries and there are no machining problems. It is different from the normal idea of surface coatings. The sodium alginate was found to be effective by itself as it reduced the moisture gradient in the timber.

Field tests on tulip oak and brush box showed that coated material dried without degrade, but the untreated controls all checked. The next move is to try out the coating on collapse susceptible ash type scantlings.

Campbell: At the last conference we reported on the use of surface coatings to control surface checking in Kapur - a Malaysian species. We used a microcrystalline wax emulsion at the time and were able to eliminate completely checks which in the controls developed up to $1\frac{1}{4}$ in. deep. We are now looking at the suitability of surface films for controlling surface checking in the ash type eucalypts.

We also found that the momentary dips in a chemical solution are useless and we experimented by adding various chemicals to the wax emulsion. We are carrying out work on backsawn ash-type eucalypts on behalf of the Tasmanian Timber Association, but have not yet found a suitable way of controlling checking by the use of surface coatings. We feel that collapse is a complicating factor.

Bryant: We intend trying out commercially the use of sodium alginate on brush box framing.

Item 5(i) Economics of seasoning East Coast eucalypt hardwood in scantling sizes

Discussion

Marshall: This item is largely a request for information. We are interested in the fact that Vermont Timbers are stripping out and drying scantling timbers for framing, also short lengths which are subsequently finger jointed for the same purpose.

We have tried to get some idea of the economics but in their reply they gave no figures for drying times, moisture contents, drying costs etc.

Has anybody any information on the economics of drying scantling material, whether reconditioning is needed.

Kauman: We have no information on the economics of this, but the matter is on our programme and we will keep in touch with those interested.

Hornibrook: I am in favour of partial seasoning of certain species that have a relatively high shrinkage factor. Shrinkage of unseasoned nailed components can result in the components becoming separated. This is common in domestic work where loadings are not particularly high. If green spotted gum is used, the effect is not so bad, but on the other hand, with blackbutt, which has a fairly high shrinkage factor, damage to the building structure can sometimes be seen. A reduction in moisture content to semi-seasoned conditions would facilitate better utilization of this species.

Huddleston: We believe dry scantlings should be obtainable. The movement which comes in unseasoned hardwood particularly is such that it is almost impossible to get a building of the standard that people are inclined to ask for at the present time. Shrinkage will always cause problems and I am convinced that we will have to use seasoned timber for building framing. This probably won't be practical with the present type of building framing, but it should not be beyond our capabilities to develop new building methods to overcome the difficulties that will be met.

Item 5(j) Directly heated kilns (NSW)*

Because of the large quantities of waste burnt at practically every sawmill, the question of the possibility of using even some of this available heat for the purpose of drying timber is raised time and time again. The problem is not confined to this country, as various reports of overseas attempts on this problem can be found in the literature.

The best solution is to install a boiler and use some of this fuel to raise steam for running steam heated kilns. This is not always the solution, for apart from the cost of the boiler there is the continued running cost of the boiler operator, and in some places even the availability of this type of skilled labour is a problem.

The question was raised by a New South Wales joinery manufacturer whose output did not justify a large or expensive kiln. He had just installed an incinerator, and a kiln design was prepared using this as the source of heating and humidification.

The heating system comprised a series of 6 inch diameter cast iron pipes placed in the incinerator, whose inlets and outlets were each coupled to a common main air pipe. The heated air was passed into the kiln, being introduced opposite each fan to ensure mixing of this hot air with the internal kiln air. Air was drawn from one of the stack hobs (which was made hollow) through a blower and back to the heating coils in the incinerator.

For humidification, a small 2 inch pipe system was devised, which was in effect a water tube boiler. A constant level of water was kept in the pipes from a ball cock cistern outside the burner. The two inch outlet from the boiler went to a two way valve. Turning the valve one way directed the steam into the hot air inlet pipe to the kiln, and the other way allowed the steam to blow to waste.

A venting system, both inlet and outlet, was provided on either side of the blower, to allow cool air into the system or permit hot humid air to be rejected. The kiln itself was only small, of 2000 su.ft capacity, and was of a standard cross shaft design.

The effectiveness of the kiln could be judged from the fact that some 1 in. Tasmanian blackwood was overdried by the inexperienced owner to a moisture content of 9%. By applying a high humidity equalising treatment, the moisture content was adjusted back to 12-13%.

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* Prepared by P. Marshall.

This type of kiln has an advantage over the oil fired directly heated kiln, in that the air used is clean and not a mixture of exhaust fumes containing some soot, and the humidifying system does not have to be overdesigned to compensate for the continual exhausting of the humid atmosphere which occurs in the oil fired kiln.

This system would be satisfactory for one kiln, since with more than one the arrangement of heating and humidifying lines becomes complicated. However, it is considered that this could be a very suitable heating system for predriers, where the heat load is reasonably constant.

Discussion

Marshall: The field of directly heated kilns is one which CSIRO has left untouched for many years. I think this area should be looked at more closely as there are cases where the economics of the convential kiln are in doubt.

Muncey: We are starting to wonder about the previous approach to seasoning timber, and this and other ways of doing things differently are certainly going to get some attention in the near future.

Kauman: From our research review you will have noticed that we are very much aware of this problem and we have it under active consideration.

ITEM 6 WOOD CHEMISTRY, PULP AND PAPER

Item 6(a) Research Review

I. DIVISION OF FOREST PRODUCTS *

Origin and nature of wood polysaccharides

Chemistry of the cambium. - In order to elucidate the broad relationship between nutrient supply and the processes of secondary growth, studies have been carried out on the constituents of the cambium and their seasonal variation. The following materials have been identified chromatographically in the cambial fluids of Eucalyptus regnans, in order of abundance: Acids - malic, shikimic, succinic, citric, malonic and tartaric. Carbohydrates - sucrose, myoinositol, glucose, fructose, raffinose, stachyose; Nitrogen compounds - α-alanine, glutamic acid, serine, γ-aminobutyric acid, aspartic acid, valine, proline, pipecolic acid, ethanolamine, β -alanine, tyrosine, phenylalanine, iso-leucine or leucine, glycine, threonine, glutamine or citrulline (or both), methionine (as sulphone), homocysteine or homoserine.

In studying the mechanism of cambial development, it is of interest to examine the effects of seasonal variation on the composition of the sieve-tube and cambial fluids. Samples of fluids from the cambial zone have been collected at monthly intervals, and the variation in solids content has been measured. Maxima appeared to occur in February and August and minima in November and May.

Carbohydrates of Eucalyptus delegatensis. - The isolation of non-cellulosic polysaccharides from chlorite holocellulose has been investigated. Successive acidic sodium chlorite treatments gave an increase in pentosan and uronic acid up to the third treatment, followed by a decline. Holocellulose, prepared by three chlorite treatments, was treated with 24% potassium hydroxide at 3°C for increasing periods, and it was found that an extraction time of 30 min. gave a 23% yield of non-cellulosic polysaccharides, mainly 4-O-methyl-D-glucuronoxylan. This material is being used for structural studies.

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* Prepared by Dr. H. G. Higgins.

Assessment of raw materials. - The influence of fibre morphology on papermaking properties has received further attention, and the principal morphological effects are now understood well enough to predict the pulping potentiality of a timber species with reasonable confidence. Direct pulping studies are also being pursued on timbers from areas of potential economic interest. The following species from the Territory of Papua-New Guinea have been examined by chemical and semichemical pulping processes: Sterculia conwentzii, Magnifera minor, Xanthophyllum papuanum and Sloanea spp.

The New Guinea species Gnetum gnemon is unusual in being classified botanically as a gymnosperm while showing a number of angiosperm characteristics. A chemical examination of the wood of this species has now been completed. It shows a high xylan content (14.8%), low mannan (2.4%), galactan (0.5%) and arabinan contents (0.5%), a high methoxyl content of the lignin (21.3%), a low yield (2.3%) of crude glucomannan, and a low ratio of uronic acid to xylose units (1 : 4) in the isolated non-cellulosic polysaccharides, and of mannose to glucose units (1.4 : 1.0) in the isolated glucomannan. All these features are within the range found for angiosperms, so that the species would be classified phytochemically as a tropical angiosperm.

Chemical and mechanical pulps have been made from 11-year-old Pinus radiata thinnings from Gerrigeroo, New South Wales. The papermaking properties are generally similar to those of mature trees of the same species, except that the chemical pulp has a lower tearing resistance, which is associated with the shorter tracheids in the young trees.

Arrangements have been made with the Queensland Department of Forestry to carry out a limited pulping program on thinnings from Pinus elliottii, P. caribaea, P. taeda and Araucaria cunninghamii. The possibility of developing the pulping industry in this State will depend largely on the availability and suitability of material from plantations of these four species, and detailed information on the quality of pulpwood available is required both by forest authorities and by potential manufacturers. An investigation of the relationship between wood characteristics and the quality of merchantable timber from the plantations has been carried out in cooperation with the Queensland Department of Forestry, and much of the information obtained is relevant also to the question of pulpwood quality.

Pulping and delignification. - The considerable success achieved in the application, by the Australian pulp and paper industry, of neutral sulphite pulping to various Eucalyptus species has stimulated further research directed towards extending the range of usefulness of these pulps, with particular attention to methods of obtaining a favourable balance between yield, strength and brightness. Comparisons were made between the pulping characteristics of fresh commercial chips from old wood and regrowth wood: under the conditions used, yields were at least 15% higher for the regrowth material and examination of the relative amounts of ethanol, hot water and alkali solubles indicated that much of the difference could be accounted for by the difference in the extractives content. The relative rates of change of residual sulphite in the black liquor and of pH were also studied. The effect of pressure relief during cooking was found to be slight. A range of NSSC pulps was prepared at temperatures from 150 to 190°C, and with cooking times up to 6 hr (or 11 hr at 150°) from chips from a regrowth log of Tasmanian Eucalyptus obliqua. Yield, lignin content and various structural, mechanical and other properties of the pulp were measured before and after beating. Within the range of variables defined above, pulp quality is improved by the use of longer cooking times and higher temperatures up to 180°C, but the advantages are offset by reduced yields and darker pulps. Even the lightly cooked pulps developed good bursting and tensile strength on beating in the PFI mill, but high tearing strength (tear factor 90) was obtained only for the well cooked pulps, presumably because the less delignified fibres, which are more difficult to separate mechanically, are consequently more susceptible to fibre damage during the disk refining process. Comparison between pulps prepared at different time-temperature combinations showed that, at constant yield, papermaking properties, sulphite consumed and freeness had similar values for each combination. The effect of yield on strength properties was very marked: burst factor, for example, was more than doubled, for a given beating treatment, over the yield range from 80 to 65%.

Study of black liquors. - Pulps prepared under different conditions, and from chips from both old and regrowth eucalypt wood, and the corresponding black liquors, have been subjected to nitrobenzene oxidation, and the aromatic aldehydes formed by degradation of the lignin have been determined by gas chromatographic analysis. Detailed attention has been paid to optimum chromatographic conditions and to calibration, particularly in respect to both syringaldehyde : vanillin ratios and their absolute values relative to an internal standard. Black liquor samples drawn off at intervals during a long cook of eucalypt regrowth chips showed a clear increase in syringaldehyde : vanillin ratio as cooking proceeded. Differences were also observed directly between the residual lignin in the pulp and the lignin in the black liquor.

Spectroscopic studies have also been made of the changes in the lignin and carbohydrates during pulping. Methods of separating lignosulphonic acids from the black liquors by means of column chromatography have been applied. Infra-red and ultra-violet spectroscopy have been used in the identification of fractions isolated by gas chromatography. Temperature programming has been found to improve the separation greatly. This aspect of the work is directed partly towards clarifying the reaction mechanism, and partly to assessing the potentialities of the black liquor as an economic source of chemicals. Detailed studies have been made of the products of partial oxidation formed in the new Zimmerman process recently installed at APPM, Burnie.

Removal of deposits from pulp mill equipment. - A major problem in the Australian pulp and paper industry is the accumulation of undesirable deposits of metal-ellagic acid complexes at various points in the production process. These deposits arise from the interaction between metal ions and materials derived from eucalypt wood, and the problem has been particularly marked in pulping the over-mature trees which constitute a large part of the available pulpwood reserves. An example of the difficulties encountered is the accumulation of these complexes on pulp washers, the cleaning of which formerly involved the use of concentrated nitric acid in a long and rather hazardous process. A method has now been developed which reduces the time required by a large factor, and which removes the hazards associated with the nitric acid process. The new process, which involves the use of calcium hypochlorite in a specific pH range, was developed in collaboration with an Australian mill which has now installed the necessary equipment for its application and which is achieving excellent results. The applications of the process throughout the industry are being explored.

Beating investigations. - In an endeavour to improve the efficiency of the beating process, the effect of beating at high stock concentrations in the PFI mill has been studied with both eucalypt and radiata pine sulphate pulps and eucalypt NSSC pulps. Eucalypt pulps show a much greater response to beating under such conditions. It has been found that the changes in clearance between the roll and housing of the PFI mill are a guide to the effectiveness of the beating action, the papermaking characteristics of the pulp improving only while the clearance continues to decrease. Pulps beaten at very high stock concentrations (over 30%) usually show an increase in clearance.

The energy consumed during beating increases rapidly at the higher stock concentrations for both eucalypt and radiata sulphate pulps. The improved strength properties associated with beating at stock concentrations of 10 to 30% must be assessed against these higher energy requirements.

The effects of pulp charge, beating load and stock concentration have been evaluated for eucalypt NSSC pulps, in terms of strength development, energy consumption, clearance between the beating surfaces and nodule formation. At 10 to 12% stock concentration the best strength development, the lowest energy consumption and the minimum clearance between beating surfaces were observed. At high stock concentrations (20 and 30%), high tearing resistance and stretch were developed, but energy consumption was high. The results suggest that an initial beating at high stock concentration followed by one at low stock concentration may be an efficient treatment for this type of pulp.

Additives for papermaking. - The extent to which additives applied for specific purposes at the wet end of a paper machine are retained by the pulp fibres is an important economic consideration. Additive retention has been studied in the systems alum-fibre-water and starch-alum-fibre-water. Significant variables in the latter system are pH, degree of starch dispersion, starch-alum ratio, order of addition of components and stock concentration.

Experiments on the interactions within a series of pulps and starches which were chemically modified so as to change their electrokinetic properties led to the following conclusions:

The degree of dispersion of the starch granule influences retention under some conditions;

when starch and fibre bear opposite charges, the magnitude of the charges involved does not appear to affect the degree of retention;

when starch and fibre bear charges of the same sign, it appears that the retention behaviour is controlled by the surface potentials of both components.

The retention of wet-end additives (starch and titanium dioxide) was studied further in the presence of a cationic polyacrylamide retention aid. The results showed that the order in which various components are added to the system is important in controlling the degree of retention, but that the effect of order of addition is different for the two additives. The relative efficiency of the various orders of addition appears to be controlled by the relative rates of adsorption of polymer on to the surface of the fibre and additive particles, and/or the relative surface areas of these two components.

The possible use in papermaking of starch from the burrawang palm has been investigated. As a wet-end additive it compares favourably with wheat starch on the basis of starch retained, but not on the basis of starch used, as retention is comparatively poor. This behaviour is apparently related to the low viscosity and good dispersion characteristics of the starch, which could, however, be an advantage in coating and size-press applications, and also in adhesives.

CONSOLIDATION AND FORMATION

Permeability, compressibility and consolidation of fibre networks. - Several sectors of the papermaking process are being subjected to analysis with the long range aim of improving product quality and rate of production through a better understanding of formation variables. Studies are proceeding on the drainage behaviour of pulp, fibre flocculation as it affects paper formation, and the mechanical properties of fibres and paper sheets. In the work on the drainage of fibre pads, some success has been achieved in applying theories, based on the drag exerted by a flowing liquid on a cylindrical filament, to the prediction of specific permeability. Related experiments are concerned with the compressibility of wet fibre pads, and particularly the role in pad compression of lateral conformability, which may be influenced by cell dimensions and delignification.

Electrokinetic properties of fibre-water interfaces. - The electrokinetic properties of the fibre surface are relevant to the retention of additives and dyestuffs, the drainage characteristics of pulp, the flocculation of fines, and, less directly, to swelling, interfibre bonding and strength of paper. Measurements have been made of the zeta potential of modified (acetylated, propionylated and cationic) long-fibred bleached kraft pulps. The cationic pulps were prepared by treatment with bromoethyldiethylamine hydrobromide. The measurements were carried out on pulp pads in a stream current apparatus with Ag-AgCl electrodes in the presence of 10^{-4} N NaCl. The zeta potential of the control pads averaged -11.3 mV and that of the treated pads ranged between - 14.6 and +11.6 mV.

MOLECULAR BIOPHYSICS OF WOOD CONSTITUENTS

Hydrogen bonding and molecular structure. - A variety of physical techniques have been brought to bear on problems of hydrogen bonding, crystal structure and conformation in wood polysaccharides and related compounds. The collaboration of the Division of Chemical Physics, CSIRO, has been sought in some aspects of these studies. Techniques used include polarized infra-red spectroscopy, nuclear magnetic resonance, and X-ray and electron diffraction. Compounds which have been studied include cellulose from various sources, xylan,

their corresponding oligosaccharides, some methyl aldopyranosides of doubtful conformation, and various glucose and xylose derivatives. Particular attention has been paid to improved methods of crystallization. (Phenomena connected with hydrogen bonding have also been investigated in various phases of the papermaking process.).

X-ray diffraction studies of wood constituents and related compounds. - The observed X-ray reflections for cellulose I from Chaetomorpha darwinii indicate a triclinic unit cell of dimensions (a) 16.53 Å, (b) 10.34 Å, (c) 15.54 Å, α 90.0°, β 97.7°, γ 91.7°. These are very similar to the cell dimensions for Cellulose I in Valonia ventricosa.

Similarities in the apparent hydrogen bond pattern of cellulose II, and of that of the higher oligomers of β-D-glucose, as shown, for example, by the hydroxyl stretching bands in the infra-red spectrum, have led to an intensive study of the crystal structure of cellotetraose. Small crystals in the form of very thin laths (0.2 mm x 0.1 mm x 0.01 mm or less) were obtained from aqueous solution by the slow addition of acetone. In spite of their size and quality, several specimens were mounted and long exposure moving film records obtained. The material crystallizes in the triclinic space group P1, and the following cell parameters have been determined: (a) = 4.50 Å, (b) = 7.34 Å, (c) = 22.53 Å, α = 95.1°, β = 90.6°, γ = 98°, V = 732.3Å^3, Z = 1, D_m = 1.49 g/cc, D_n = 1.51 g/cc. The crystallographic results appear to eliminate the possibility of anti-parallel chains.

Methyl α-D-mannoside, which crystallizes from warm ethanol has also been studied. The crystals are of the orthorhombic space group $P2_12_12_1$ with cell dimensions (a) = 9.47 Å (b) =9.32 Å and (c) = 10.08 Å and with four molecules in the unit cell.

Attention has also been paid to the crystal structure of ellagic acid, a compound which occurs in considerable amounts in the wood of eucalypts used commercially for pulp production, and full three-dimensional diffraction data have been collected. Approximate cell dimensions are: (a) = 3.74 Å, (b) = 11.45 Å, (c) = 12.61 Å, β = 92.2°. Work is being directed towards a full structure analysis of each of these materials. (In collaboration with the Division of Chemical Physics).

Polarized and low temperature infra-red spectra of carbohydrates.- A selenium polarizer has been constructed, and improved polarized spectra of mono- and oligosaccharides have been obtained. Low temperature (90°K) spectra of the same materials have also been obtained. and appreciable changes in the hydroxyl stretching region have been observed, including sharper bands, increased absorbance and

a shift to lower frequency. The number of bands in γ-D-glucose in this region exceeds the number of distinguishable hydroxyl groups as determined by X-ray crystal analysis, indicating that at least one hydroxyl group must be involved in a cooperative vibration. Further evidence of cooperative group vibrations has been obtained from a study of the spectra of partially deuterated methyl β -D-xylopyranoside and methyl 1-thio- β -D-xylopyranoside.

MISCELLANEOUS CHEMICAL STUDIES

Formation of glucuronic acid during chlorite treatment of glucans. - Experiments with amylose, a more accessible glucan than cellulose, have shown that considerable amounts of apparent uronic acid are formed upon repeated treatment with acidified sodium chlorite, and that upon acid hydrolysis, the soluble fraction of the products yields D-glucuronic acid and its lactone and several oligosaccharides, but no gluconic or saccharic acids. These results suggest that the increases in uronic acid during the preparation of chlorite holocellulose from wood may arise from partial oxidation at the primary hydroxyl groups in cellulose.

Composition of fungal cell walls. - Encrusting materials were removed from the hyphae of a number of species of fungi from diverse taxonomic groups, and evidence on the composition of the cell wall was obtained by infra-red spectroscopy. Cellulose was a significant wall constituent of the phycomycetes Phytophthora cinnamomi and Pythium sp.; the others were composed mainly of chitin. Epicoccum sp. may contain both cellulose and chitin.

Comparison of cellulose within the tree. - Samples of the bark, sapwood, heartwood and knots of Acacia penninervis have been converted to γ-cellulose, and then nitrated. Viscosity measurements on solutions of the nitrocelluloses indicate that the degree of polymerization of the cellulose in each sample is similar (ca. 800).

INSTRUMENTS AND METHODS

Opacity measurement. - A method has been devised for determining the opacity of paper by measuring the intensity of incident radiation at 450 nm required to give a pre-determined intensity of transmitted light. For titanium dioxide filled papers, the opacity figure obtained appeared to be linearly related to ash content.

Mechanical properties of single fibres. - Techniques have been developed for mounting hardwood pulp fibres in the single fibre rheometer without fear of breaking, and for gluing the fibres to the supporting cards so as to eliminate end effects.

Sheetmaking technique. - A modified sheetmaking technique has been developed so as to obtain results with the standard handsheet machine which are more directly comparable with commercial paper machines. Higher stock concentrations are used and the method is more suitable than the standard one for studies on the effects of additives.

Adhesion between additive particles. - A simple device has been constructed which permits direct observation of the behaviour of additive particles adhering to a fibre under conditions of hydrodynamic shear. With the aid of this device, the effects of surface charge and of polymeric retention aids have been investigated.

Computer programmes. - The following programmes have been written and used:

COORD: Accepts coordinates based on monoclinic and triclinic crystal axes (either as fractions of cell edge or in angstroms) and converts to Cartesian coordinates.

ZETA: Accepts, on porta-punch cards, time of passage of particles moving under influence of electrical field, and calculates their electrophoretic mobility and zeta potential.

PORE: Accepts flow rate, pressure, pad thickness, pad area, fibre diameter, fluid viscosity, fluid density, and calculates experimental permeability (Darcy), theoretical permeability (Emersleben) and Kozeny constants. SF19: Fast calculation of structure factors for the space group $P2_12_12_1$; increments can be added to the atom coordinates as a set. SF14B: Fast calculation of structure factors for the space group $P2_1/C$, with b axis unique.

II. NEW ZEALAND*

Wood chemistry. - During the last fifteen months studies have been carried out on the polysaccharides of Pinus radiata from the Nelson area and from the Kaingaroa State Forest. Components of the polysaccharides were not isolated but instead the wood samples were hydrolysed and the constituent sugars determined by quantitative paper chromatography. A few kraft and bisulphite pulps prepared from Kaingaroa trees have been analysed also.

A start has been made towards the identification of some of the structural polysaccharides of P. radiata. From holocellulose preparations a sequence of alkali extractions has removed a product which contains arabinose, xylose and probably a uronic acid and a second material composed of galactose, glucose and mannose. The latter is more readily purified than the former but a recently reported extraction technique is being examined because it purports to lead to purer xylan fractions.

Variation of polysaccharides in the pith to bark sequence in P. radiata. - Sawdust from a single Nelson tree and from three Kaingaroa trees was hydrolysed or else converted to holocellulose and hydrolysed. Sawdust hydrolysates had a lower content of glucose than the corresponding holocellulose hydrolysates suggesting that the conditions employed led to incomplete hydrolysis. The samples were from groups of five rings from discs of the 10th and 25th internodes in the 35 year old Kaingaroa trees or from a 25th internode disc of the 25 year old Nelson tree.

The data in the following table are averages for sawdust in the three Kaingaroa trees and are in good agreement with the Nelson wood holocellulose preparations allowing for the above comment:

Sugars	Percent of sugar in hydrolysates						
	Disc at 10th internode		Disc at 25th internode				
	rings. 1-5	6-10	1-5	6-10	11-15	16-20	21-25
Galactose	5.0	4.1	8.7	5.9	4.2	4.0	4.9
Glucose	62.8	64.2	62.3	64.4	66.9	67.5	69.6
Mannose	18.2	19.2	16.4	17.7	18.2	18.8	16.9
Arabinose	2.4	2.3	2.3	2.3	1.8	1.7	1.3
Xylose	11.5	10.3	10.3	9.7	8.9	8.1	7.3

* Prepared by V. Harwood.

The marked increase in glucose and decrease in xylose in the pith to bark sequence are seen at both internodes. Also wood at the 10th internode is very similar to wood in the inner rings at the 25th internode suggesting that young cambium up to age 10 produces polysaccharides of the same general nature regardless of where it is laid down relative to the stump.

Analyses of polysaccharide composition in kraft and bisulphite pulps. - Four kraft pulps were made from 10th and 25th internode wood from the three Kaingaroa trees. Screened yields were in the 44 to 46% range at Kappa numbers 17.6 to 21.5. The pulps from 10th internode wood contained less glucose and more xylose than the 25th internode pulp.

Much larger differences in sugar compositions were found between the hydrolysates of four sodium bisulphite (pH4) pulps prepared from P. radiata in which cooking time at maximum temperature was varied from 0.5 to 2.5 hours. These had a screened yield range from 52 to more than 80% and their glucose contents varied from 88 to 68% in the same sequence; mannose from 6% to 18%; xylose from 6% to 10%, and galactose was found in softer pulps than arabinose, but neither was detectable in the 52% yield pulp.

Chemistry of wood carbohydrates. - Holocellulose in 76% yield was prepared from methanol-extracted sawdust from one of the Kaingaroa trees by three treatments with buffered chlorite solution. The holocellulose was extracted successively with cold water, 24% KOH and 17.5% NaOH containing 4% boric acid. The extracts respectively amounted to 1.2, 11.2 and 6.8% of the sawdust and the residue was 42.3%.

The analyses of the four materials are as follows:

Fraction	Extractant	"Uronic Acid"	g	G	M	A	X
A.	H_2O	3.1	16.6	15.6	53.2	2.1	9.1
B	24% KOH	4.7	9.6	7.0	15.2	9.2	53.5
C.	NaOH H_3BO_3	-	3.5	30.4	64.1	-	2.0
Residue	Insoluble	-	0.7	98.6	0.5	-	0.1

Values in the column marked "uronic acid" were determined against standard solutions of glucuronic acid. The true identity of the spot, which remained near the origin in the chromatographic separation, remains to be established.

Fraction C is pure enough for structural studies but attempts are being made to remove hexosan impurity from the xylan in fraction B. Also a newly reported $Ba(OH)_2$ - KOH extraction technique has resulted in a xylan fraction contaminated with about 5% of hexosan.

Pulp and paper. - Studies carried out during the last two year period include the sodium bisulphite pulping of the New Zealand beeches, sodium bisulphite and acid bisulphite pulping studies on P. radiata, and a brief wood quality study on P. radiata in which kraft pulping experiments were carried out.

Item 6(b) Summative analysis of sapwood and heartwood of Acacia penninervis *

(All results are expressed as percentages of the oven-dry weight of original cell wall substances)

Constituents	Sapwood	Heartwood
1. Extraneous Substances		
(a) Ash	0.2	0.4
(b) Protein	1.5	1.2
(c) Corrected hot-alkali solubles	3.3	2.8
Total Extraneous Substances	5.0	4.4
CELL-WALL SUBSTANCES		
2. Polysaccharides		
(a) Non-cellulosic polysaccharides (N-C.P.)		
Pentosans in isolated N-C.P.	18.3	18.7
Uronic acid anhydride (U.A.A.) in isolated N-C.P.	0.7	0.3
O-Me uluronic acid anhydride in isolated N-C.P.	2.8	3.9
Hexosans in isolated N-C.P.	1.3	1.2
Undetermined material in isolated N-C.P. (by difference)	0.2	0.9
Pentosans lost during isolation of holo-cellulose and N-C.P.	4.3	3.7
U.A.A. lost during isolation of holo-cellulose and N-C.P.	0.9	0.2

* Prepared by J. Smelstorius.

Cont'd on next

Constituents	Sapwood	Heartwood
O-Acetyl lost during isolation of N-C.P.	4.2	4.0
Total N-C.P.	32.7	32.9
(b) Cellulosic polysaccharides	43.3	41.9
Total Polysaccharides	76.0	74.8
3. Lignin		
(a) Acid-insoluble lignin	17.7	17.8
(b) Acid-soluble lignin	5.2	5.6
(c) Alkali-soluble lignin	1.8	2.0
Total lignin	24.7	25.4
4. TOTAL CELL-WALL SUBSTANCES	100.7	100.2
5. Total Constituents in Wood	105.7	104.6

Item 6(c) Possibilities for the extension of the pulp and paper industry *

Plans for the overall extension of the pulp and paper industry in Australia need to be formulated in a systematic way. Some inter-governmental councils may possibly consider this question from time to time, and of course it is looked at in an expert way by various paper companies from the point of view of their specific interests, and by Forestry Commissions in the various States, again from their own point of view. But what I think we should also attempt to do is to look at the question in a national way.

What are the raw materials at our disposal? Wood is of course the main source of fibre in the pulp and paper industry. In Australia we have our eucalypts which for some purposes can be classified into the over-mature and the regrowth trees. We know the difficulties encountered with the over-mature material; we know the difficulties we have with trees which fall into both these categories when they are too dense, i.e. with a basic density exceeding about 45 lb/cu ft. We have a number of other indigenous species which are being used to

* Prepared by H. G. Higgins.

some extent e.g. myrtle beech and southern sassafras. We have large areas of plantation-grown conifers particularly, in the southern half of the continent, radiata pine, and, in Queensland, slash, loblolly and caribaean pine and hoop pine. We have also considerable amounts of bagasse available at a few centres, in Queensland mainly, and this could be diverted to papermaking if alternative fuels were used in the sugar mills. The economics of this material is not very favourable at the moment, but it certainly warrants keeping in mind. Straw is another potential raw material, and this has been used from time to time for board manufacture, but it has the disadvantage of a relatively low cellulose content compared to wood. We also have waste paper, which is collected in the capital cities in Australia, and of course we still rely quite heavily on imported pulp. These are the materials we have at our disposal, and with a vigorous, developing economy the industry is able to use them in pre-determined proportions and so obtain some interesting results in respect to paper properties.

Any extension to the pulp and paper industry as such depends basically on the extension of pulping activities, although it might be argued that Australia, as a pulp importer, should integrate its pulp and paper economy with a pulp exporting country such as New Zealand. This process is in fact being facilitated through the Free Trade Agreement.

What forms is the expansion of pulping within Australia liable to take? There is the possibility of extending kraft pulping, but one should bear in mind the problem of atmospheric pollution, which renders kraft mills undesirable in highly populated areas, and also the necessity to instal chemical recovery plants to make this process economical. As against that we have high yield pulping and much emphasis is being placed on this today and this will undoubtedly increase in importance in the expanding Australian economy. The neutral sulphite process has proved to be an excellent one as applied to our eucalypts. We also have successful cold soda processes and groundwood processes, and we can also consider bisulphite and other combinations of sulphite processes particularly in relation to our pine plantations. One could mention other possibilities, but these appear to be the most relevant in this context.

You are no doubt aware of the very large amounts of water which are used by pulp and paper mills. Means are being developed for making paper without water, but for the time being these new methods apply only to restricted types of paper. As the industry is organized at the moment water must remain one of the main essentials. There is also the question of effluent disposal which imposes certain limitations on expansion in areas where it is impossible to discharge the effluent liquids or slurries into the local stream-system without

adversely affecting agriculture and other industries.

Effluent treatment and disposal is becoming more important with the expansion of the industry of the population, and will in fact form the topic for the Symposium at the Appita Conference in New Zealand next year.

The other obvious thing to consider in pulp mill expansion is an adequate wood supply, and one doesn't want to have to transport the wood too far from the forest to the mill. We must also consider the availability of labour, markets and transport facilities.

What are the areas of possible pulping expansion in Australia? First of all let us just mention the areas which have already been developed. There is the Latrobe Valley area in Victoria which draws on mixed eucalypts and on the rapidly expanding radiata pine plantations. Kraft pulps are made here and plans are well developed for the manufacture of NSSC pulps. There is southern Tasmania where we have a range of eucalypts, regnans, obliqua, delegatensis, globulus and so on and where newsprint and NSSC pulps are made. In northern Tasmania we have large amounts of E. delegatensis, a number of other species and some pine plantations. The complex at Burnie manufactures a range of paper products from soda and cold soda pulps, and new operations are planned for the Wesley Vale area. In the south-east of South Australia, bisulphite pulp is produced from radiata pine and made into tissues, and pine groundwood is produced as a component for board furnishes.

Looking round at our forest resources, we can readily discern areas of possible pulping expansion. In southern Queensland there are plantations of conifers, and some chemi-mechanical pulp is already being made at Petrie. In the Eden area of New South Wales and Victoria we have large amounts of E. sieberi and other species. There is the Coff's Harbour area of New South Wales where a pulping industry would be dependent mainly on E. saligna, grandis and pilularis, and there is the south-west of Western Australia with large amounts E. calophylla, marginata and diversicolor. The north Queensland rain forests have a wide variety of species. In Victoria, quantities of E. globulus, obliqua, regnans and myrtle beech grow in the Otways area. A large quantity of mixed tropical hardwoods and pockets of klinki pine are available in New Guinea.

It seems that we are on the verge of great expansion in this industry, which has already been doubling its production every seven years. It is rather remarkable that states like New South Wales and Queensland, with their considerable forest resources and with an expanding market for pulp and paper products, have not yet established large pulp mills. However, mills cannot be set up for

purposes of prestige: manufacturing companies must take into consideration not only the availability of pulpwood and the proximity of markets, but the economic advantages of expanding on or near an established site, if other conditions are favourable. In this respect the pulp and paper industry differs from, say, the mining industry, where the occurrence of a high grade ore body will overwhelm other considerations.

Another matter to consider is the possibility of small scale pulping, which has always presented difficulties in the economic sense. However, this may be the sort of solution which Australia needs in some areas where there are pockets of wood which are not really large enough to sustain a chemical pulp mill.

There is also the question of the assessment of pulpwood quality, which will be considered in a little more detail later. However, I would like to make a few remarks on this subject. The high basic density of some eucalypts, compared to those softwoods commonly used for pulping, is a distinct disadvantage in that fibres with a thicker cell wall have poor lateral conformability. That is they cannot collapse easily into ribbons during the papermaking process to form a well bonded sheet. However, a point we sometimes tend to overlook is that where there is a high extractives content the measured basic density may be fictitiously high as a reflection of cell wall thickness, because the extractives may be largely in the cell cavities. These are removed during pulping and although they contribute to the measured basic density they do not apparently contribute greatly to the cell wall thickness. Of course they are a distinct disadvantage in other respects, not only in respect to forming deposits in the pulp mill, but also because they lead to higher chemical consumption during pulping.

A distinction has to be drawn also between interfibre bonding properties, such as burst and tensile strength, and tearing strength. Tear is not adversely affected by thicker-walled fibres. The stronger the fibre the better the tearing strength providing there is a modicum of interfibre bonding. Consequently tearing strength follows an altogether different pattern to the interfibre bonding properties. However, the tearing strength also depends strongly on fibre length, so that the hardwoods are clearly inferior to softwoods in this respect. In a predominantly hardwood pulping economy such as we have in Australia this can be a disadvantage because it means that considerable quantities of long-fibred pulp must be used to bring the tear up to the required standard. Similar considerations apply to the wet strength of the paper which will largely determine the speed at which the paper machine can be run. However, in a softwood pulping economy these factors no longer apply in the same way, because there is likely to be a high proportion of long-fibred pulp in the furnish anyway. Under these

circumstances greater recognition has to be given to the advantages of hardwood pulps. The incorporation of hardwood pulps in a papermaking furnish has a number of advantages which are being increasingly recognized. They can improve surface properties, they can improve formation, bulk, opacity and flatness of the paper sheet.

Higher density in pulpwood is usually a disadvantage, in respect to paper properties, but this may be off-set to some extent by the fact that more material by weight can be accommodated in the digester during the pulping process; under some conditions this stage may determine the productivity of the plant.

I would like to emphasize, in conclusion, the necessity for collaboration between us in developing a philosophy in respect to expansion of the pulp and paper industry in Australia - a philosophy which will run parallel to and be integrated with that which is perceived by individual companies and by individual Forestry Commissions and by this Division.

Item 6(d) Pulping of plantation-grown conifers*

P. radiata thinnings from New South Wales. - Ten trees of P. radiata considered as typical of the Gerrigeroo plantation were felled and samples from the butt, middle and top logs forwarded for pulping. The trees selected were all planted in 1954.

Chips were prepared from all logs and mixed to give a composite sample. Pulps were prepared by the sulphate and NSSC pulping processes and by mechanical treatment in a laboratory defibrator. Pulp evaluation studies showed that the papermaking characteristics of the various pulps compared favourably with pulps prepared from 30 year old trees of P. radiata.

P. elliottii and P. taeda thinnings from Queensland. - Samples from 40 trees of P. elliottii, and 40 trees of P. taeda have been received for pulping investigations. Composite samples will be prepared by grouping according to age and district. Actual pulping studies will commence in the near future.

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* Prepared by A. J. Watson.

Item 6(d) (New Zealand*)

Sodium bisulphite pulping at pH4, of P. radiata gave screened pulp in yields of from 47 to 50% when 18 to 21% sodium bisulphite on over-dry wood was employed and the period at maximum temperature (165°C) was 2.5 hours. The pulps had Kappa numbers of about 30 and had good brightness (55 to 60° reflectance). The pulps (from mill chips) after 3750 revs beating in the Lampen mill had breaking length values of from 7.0 to 8.0 km, a tear factor of about 95, and burst factor of 45. Hydrolysates of the bisulphite pulps contained 88% glucose, 6% mannose, and 6% xylose. Sodium bisulphite pulps thus contain less xylan and more mannose than kraft pulps (the analysis of which is about 88% glucose, 4% mannose, and 8% xylose), but the sodium bisulphite pulps contained, as might be expected, more xylan than acid-bisulphite pulps in the same yield range.

Acid-bisulphite pulping studies on P. radiata were also carried out. In calcium base cooking radiata pine samples prepared from roundwood billets containing 25 growth rings or from thinnings or top logs containing 15 growth rings were employed. The first sample to be examined which contained 25 growth rings gave screened pulps in 50% yield in the Kappa number range 23 to 30. The other samples gave 47 to 48% yields of screened pulp with Kappa numbers of from 20 to 30. In general the yield of screenings was about 2%. All the pulps prepared were of good brightness 50 to 65% reflectance.

The strength properties of the calcium base pulps were of the same order, apart from their somewhat low tearing strength, as those of commercially available sulphite pulps. Pulps beaten for 3750 revs in the Lampen mill had tear factors of 70 to 80, burst factor values of from 44 to 54, and breaking lengths of from 7.5 to 9.7 km.

In a wood quality study the yields and properties of kraft pulps prepared from P. radiata discs containing 10, 20, 25, and 30 growth rings (from three 39 year old trees) were determined. The yield of kraft pulp from wood containing 30 growth rings was 48% in comparison with a yield of 45% obtained from wood with 10 growth rings, however, the feature of most interest was the response of the pulps to beating. Pulps prepared from wood with a high proportion of mature wood (e.g. wood with 25 or 30 growth rings) had higher tear factor than those obtained in wood with 10 growth rings, but pulps prepared from the latter material were easy beating and had higher burst and breaking length values than pulps from wood with 25 growth rings. The easy beating properties of pulps prepared from wood containing only 10 growth rings is presumably related to the thin walls of the fibres in juvenile wood.

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* Prepared by J. M. Uprichard.

Item 6(e) Pulping of New Guinea woods*

The following species have been examined since the 1965 Conference: Sterculia conwentzii, Mangifera spp., Sloanea spp., Xanthophyllum papuanum, Eugenia spp., and Dysoxylum spp. Work has not yet been completed on the two last mentioned species. High quality sulphate and NSSC pulps were obtained from Sterculia conwentzii, their papermaking characteristics resembling pulps made from E. regnans. The other species, with the possible exception of Xanthophyllum papuanum, gave pulps with satisfactory papermaking properties. All species examined had higher than average fibre length for hardwoods. This resulted in all pulps giving papers with good tearing strength values.

Item 6(f) Assessment of pulpwood quality**

All pulping studies made to date have supported the earlier predictions on the value of basic density for assessing the value of a species as a possible source of pulpwood. As a general guide it can be said that species with a basic density of less than 30 lb/cu ft can be expected to give pulps with good papermaking characteristics while those with a basic density higher than 45 lb/cu ft cannot usually be considered as a suitable pulpwood species. Basic density values are known for a wide range of species, thus permitting a preliminary assessment of pulpwood quality without having to accumulate further test data. Even when basic density values are not available it is much simpler to obtain such information rather than make actual pulping studies on all available species. Pulping investigations are very time-consuming and require specialized skills and equipment.

Basic density should be used only as a general guide to the selection or rejection of a species as a source of pulpwood. It is closely correlated with cell-wall thickness, which in turn governs the flexibility and conformability of the pulp fibre. However, this correlation between basic density and cell-wall thickness is influenced by the ratio of fibres to non-fibrous components and by the presence of extractives. These factors would sometimes result in a species that would be rejected on the grounds of basic density still being retained for actual pulping studies. However, this is not a serious disadvantage, since it means that there is little danger of a potential pulpwood species being rejected solely on the grounds of basic density.

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* Prepared by F. H. Phillips.

** " " A. J. Watson.

Item 6(g) Pulping of hardwoods (NZ)*

Pulping of beech species. - The pulping of small diameter and large diameter samples of the New Zealand Nothofagus species with sodium bisulphite has been examined. The species examined were red beech (N. fusca), hard beech (N. truncata), silver beech (N. menziesii), and mountain beech (N. solandri var cliffortioides).

The species were similar in regard to wood morphology and had fibre lengths of from 0.9 to 1.05 mm, fibre diameters of from 16 to 18 microns, and a lumen to fibre diameter ratio of about 0.64: all the species examined contained about 65% of fibres by volume. The density range for all species was from 29 to 35 lb/cu ft. The pulpwood samples differed from one another chiefly in their content of methanol extractives. The average extractive content of large diameter red beech was about 12%; hard beech contained 8 to 9% of methanol extractives, while silver beech samples and small diameter red beech samples contained only 4 to 5% of methanol soluble materials. Hard beech had a low lignin content of 13 to 15% and a high alpha-cellulose content and differed from the other species examined which had lignin contents of between 17 and 20% and alpha-cellulose contents of from 51 to 52% of oven-dry wood.

In pulping studies with sodium bisulphite it was found that samples with relatively high extractives content gave pulps in lower yield and of higher Kappa number than the pulps obtained from wood of lower extractive content.

Small diameter red beech when pulped with 20% sodium bisulphite gave pulp in yields of from 48 to 50% with a Kappa number range of from 20 to 30, while older age large diameter material gave pulp yields of from 44 to 46% and the pulp generally had a Kappa number of 50 or more. The pulps from small diameter red beech were higher in strength properties than those obtained from large diameter material. Pulps from small diameter red beech had a tear factor 83, a breaking length of 6.7 km, and burst factor of about 40 at 350 C.S.F.

Sodium bisulphite pulps were obtained from hard beech in yields of from 46 to 53%, and pulps had Kappa number 30 or less. The pulps were of poor strength as shown by the following data which relate to pulps beaten for 15,000 revs in the Lampen mill: the pulps had tear factor of 60, breaking lengths of about 5.0 km, burst factor of about 25. Pulps cooked to higher Kappa number had somewhat better strength properties. Pulps produced from silver beech and mountain beech samples were similar to those obtained from small diameter red beech. It was found that beech bisulphite pulps of Kappa number 30 required

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* Prepared by J. M. Uprichard.

about 10% chlorine if they were to be bleached to 85 to 90 brightness. No further work on beech bisulphite pulping was carried out.

Pulping of poplar species. - Two New Zealand grown poplar species, Populus robusta and P. serotina, were examined for their response to pulping by the kraft and by the sodium bisulphite processes. The samples which came from 30 year old trees had about 25 growth rings. The species were similar as regards wood properties. They had an average density of about 23 lb/cu ft, a fibre length of 1.2 mm, a fibre diameter of 21 microns, and a lumen diameter to fibre diameter ratio of 0.75. Both samples contained 65% of fibres by volume, and were low in extractives, the methanol extractive content was about 2.5%.

The poplar samples gave kraft pulps of Kappa number about 16 in yields of from 53 to 55%, and the pulps though they had low tear factor had good tensile strength and burst factor. Pulps beaten for 3750 revs. in the Lampen mill had a tear factor of 100, a breaking length of about 11 km and burst factor of 70. Sodium bisulphite pulps produced from poplar in 55% yield had a low tear factor of 70, but a breaking length of 10 km and burst factor of 60 at the same degree of beating.

ITEM 7 TIMBER CONVERSION

Item 7(a) Research Review

I. DIVISION OF FOREST PRODUCTS*

In the plywood area effort has been roughly divided between aspects of manufacture, properties and application, although in many cases a special feature of manufacturing technique directly affects application and makes it very difficult to separate.

Species evaluation. - Species evaluation work has continued and assessment of peeling, drying, gluing characteristics, veneer quality and yield has now been completed for most of the major species of the British Solomon Islands and Fijian areas. Some assessment of the plywood properties of the major species from these areas has also been made. Logs of many Australian grown species have also been peeled for quality and yield studies, gluing trials and mechanical properties tests. These included brush box, hoop pine, canary ash, yellow walnut, tulip oak, white cheesewood, Pinus laricio, silvertop ash and other eucalypts, yellow carabeen and radiata pine.

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* Prepared by J. W. Gottstein.

The feasibility of peeling very thick veneer was demonstrated in cutting studies which resulted in peeling high quality veneer from three tropical hardwoods to a thickness of 0.5 in. Good quality peeling in this thickness requires species selection for density, green moisture content and structure, but under correct conditions peeler checks were practically eliminated and surface quality was well maintained within the limits usually required for much thinner veneer.

Accurate thickness control of these thick veneers requires very secure dogging and the effect of peeling radius becomes important.

Thick veneers of Campnosperma and Endospermum have been used as a core material with thin covers and distortion has been studied over a range of moisture contents. Laboratory trials have also been made on regrowth ash-type eucalypts and on some logs of plantation Araucaria cunninghamii.

In cooperative studies with our Utilization Section the knife edge recession rate during the peeling of Eucalyptus delegatensis was reduced by 60% through maintaining the knife at a negative potential of 60 volts with respect to the nosebar. These results indicate that, with some species, corrosion can be a dominant cause of knife wear and suggest that the commercial application of this technique could lead to a substantial saving in knife cost in certain veneer cutting operations.

A study of roughness and knife check formation in peeling of 1/10 in. thick Beilschmedia bancroftii has been made.

Adhesive studies. - Our work on tannin adhesives and on the gluing of high density species is being reported separately in Items 7(c) and 7(d). Examination of several species at the 5 and 12% moisture content levels using extensions of 150% of wheaten flour on urea resin solids give satisfactory wood failures with dry bonds in species such as lauan and yellow walnut, but radiata pine and hoop pine would not conform with the dry bond requirements when glued at these moisture contents.

The addition of up to 10% of melamine-formaldehyde to improve veneer moisture content tolerance of commercial adhesives showed no significant effect using both commercial and laboratory formulated hardeners and veneers covering a range of 0-17% moisture content.

The bonding behaviour of CCA treated veneers using PF glues is being studied on hoop pine. Retentions of approximately 0.8 lb/cu ft were used and the tests are designed to show effects of formulation and moisture content. Several preservative formulations are being tested.

The effects of fire retardant substances on bond strength using PF and UF glues have been studied and these will be reported under Item 7(e), and effects of fire retardant treatment of plywood under Item 7(f). Hot-melt adhesives have shown high creep and comparatively low bond strength on wood.

A dye has been developed which is very effective for the location of veneer checks and also very useful for the study of glue line faults (especially in the location of areas where glue transfer has been poor or discontinuities exist).

No samples of cross-linking PVA so far studied have performed satisfactorily in laboratory tests.

Drying studies. - When ash eucalypt veneers are dried at a temperature of 200°F. to veneer moisture contents suitable for reconditioning, the moisture content variation is reasonably satisfactory, although trials indicate that veneer reconditioned immediately after drying does not recover completely.

Reconditioning treatments of ash veneers show that good results can be obtained by steaming within the 15-30% range, but where steam is not used for reconditioning, veneer moisture content becomes far more critical and it is difficult to obtain full recovery. High frequency heating trials for reconditioning on a semi-commercial scale were also not entirely satisfactory.

Methods of determination of increase in moisture content resulting from water spraying of veneers were simplified for commercial use.

Studies on glue line permeabilities show that lower veneer moisture contents give lower permeabilities with film adhesives.

The amount of surface splitting occurring in redrying of CCA treated 3-ply assemblies was controlled to some extent by adjustment of moisture content of veneers before hot pressing, in combination with careful redrying, but results in multi-ply assemblies were less satisfactory.

Steel brush surface electrodes gave quite good moisture content readings without damage to sensitive veneers, but speed of traverse of the electrode across the veneers affected readings at low moisture content.

Certain species of hardwood were found to give very high moisture gradients in 1/8 in. thick veneers when dried at 300°F. Such veneers give misleading readings with both surface and penetrating electrodes for some time after drying.

The amount of residual compression which occurs in the hot pressing of plywood assemblies is of considerable importance and a study has been made of factors which will be reported separately under Item 7(h).

Plywood properties and application. - Extensive work on stability has been carried out both in respect of transverse and longitudinal movement of the individual veneer, transverse, longitudinal and thickness movement of plywood and some comparison with other materials has been made. Longitudinal movement of the veneers of nearly 80 species has been examined. Portion of this work on stability is being reported separately under Item 7(g).

A study of the behaviour of plywood panels in doors and wall sections in cycling trials in our humidity rooms is being carried out and has, in general, given very positive evidence that it is highly desirable that plywood to be used in assemblies of this type should have a fairly high moisture content.

Attention has also been given to decorative values, especially of rotary veneers in grooved assemblies. It has been shown that highly decorative effects can be obtained with random assemblies and the careful use of stains and pigments.

The industry is very interested in marketing a constructional plywood and a lot of attention has been given to this - firstly to studies of the factors that affect quality in manufacture, then to the development of quality control of such and allied production, then to the development of quality control in the industry, and finally in collaboration with our Engineering Section to evaluation of properties.

In property evaluation for engineering work, we have concentrated so far on radiata pine as a method of producing critical defects, we have built these defects into panels and evaluated their importance. Industry is now considering the extent of the defect which will be present and working stresses in relation to these defects are being established on the basis of the amount of defect present. Other species are now being investigated, giving special attention to the manufacturing variables.

Further experiments evaluating effect of manufacturing variables are now being studied in these species and an intense study of mechanical properties will be made as commercial material becomes available.

In the study of the effect of peeling and assembly factors on weathering properties, we have now added North Queensland kauri panels to the silky oak panels which have been exposed for some time. Thickness of outer veneer appears to be the most important factor with unpainted panels.

Panels exposed on the outside of the lecture room have shown the very considerable superiority of overlayed panels under weathering conditions.

The development of a standard for structural plywood in Australia to use the products of some 80 species efficiently and economically and without excessive complexity is something that has worried us since 1958. We believe that some progress is now being made.

The International Standards Organization is now working on a standard for plywood for general purposes and we have endeavoured to contribute.

Lectures have been given to many groups, to University and college students, and industry representatives have spent some time in the Section.

Lectures given to groups in various centres and at the Division have met with considerable success, but at the present time the most satisfactory means of communication seems to be through the issue of short pamphlets and through close discussion with industry technical groups.

One of our most satisfactory means of communication remains by visits as arranged by industry. Study groups in several centres have been moderately successful.

II. NEW ZEALAND*

Moisture content of radiata pine plywood. - A study of the moisture content of radiata pine plywoods under standard conditions, and its response to long and short term atmospheric changes is nearing completion. Matched specimens of various constructions, together with hardboard and solid wood "controls", have been exposed in the testing room and outside under cover and weighed regularly for 54 weeks. Hysteresis is evident in the pattern of differences between E.M.C. before and after exposure but computation of detailed results is incomplete. Other sets are being conditioned at 65% r.h. and exposed to 95% r.h. for periods of 24 hours up to several days to compare E.M.C. and rate of response of veneers and plywoods. From specimens for strength tests it appears that hot pressing (with phenolic resin in this case) may reduce hygroscopicity but some confusion arises from the degree of atmospheric control achieved and the possibility of hysteresis effects from past history. In studies such as these, where differing types and weights of adhesive may be present, it is advisable to consider actual changes in weight as well as percentage values on the oven dry basis.

Miscellaneous. - In industry, a lack of awareness, or of ability to control moisture content in the manufacture of plywood, coreboard, etc., is becoming evident. Contacts with a local firm suggest a need for information relating moisture and pressing conditions for successful bonding, and for stability, e.g. veneered particle board in heated buildings and T.V. cabinets.

Item 7(b) Utilization of eucalypts for veneer and plywood**

Status of eucalypts in the Australian plywood industry. - Four species are peeled in significant quantities. They are Eucalyptus delegatensis, E. regnans, and E. obliqua, all of which are "ash" type eucalypts, and from which a furniture grade of plywood is made, and E. diversicolor which is used for structural plywood. Quarter sliced decorative veneer is produced from the first three species, and from E. patens and E. marginata. At times E. camaldulensis and E. viminalis have been sliced in Victoria.

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* Prepared by C. R. Hellawell.

** " " B. M. McCombe and J. W. Gottstein.

Technical difficulties in production. - Technical difficulties encountered in production have been formidable and in some cases prohibitive. Success of individual operators has been due, in part, to concerted efforts to bring troublesome aspects of production under control and, if necessary, adapting production, and even the end product to suit the raw material. The incentive in each case has been a good supply of relatively low cost logs.

Features of Australian eucalypts which make them difficult to handle are a relatively high density as affecting peeling and gluing, a high green moisture content also affecting peeling and the following which detract from yield and quality of the veneer - free splitting of log ends on cross-cutting, a high incidence of traumatic faults (mainly in trees damaged by bush fires), and susceptibility to collapse in drying.

Peeling. - Veneer of quality suitable for face veneer in a furniture grade of plywood can usually be peeled from the lightest of the eucalypts (air-dry density approximately 40 lb/cu ft) provided billets are preheated and lathe settings are suitable and accurately maintained. With increase in density above 40 lb/cu ft peeling properties deteriorate rapidly and the density limit for furniture grades of plywood may be 45 lb/cu ft. The typical veneer from the denser eucalypts is very loose, contains many surface cracks, and is difficult to reel and handle without breakage, especially when veneer thickness is less than about 1/10 in.

With quarter slicing the density restriction is less and good quality veneer can be cut from species with densities around 50 lb/cu ft (e.g. E. marginata, E. patens).

The high moisture content of eucalypts prevents the use of the high nosebar compressions normally required for good cutting results and contributes marked sensitivity to excessive nosebar compression, with surface tearing occurring readily when the compression limit is exceeded. (Thus the effectiveness of the nosebar in controlling knife checks is limited). Finer than usual tolerances in nosebar-knife alignment are required if settings are to be maintained at optimum values.

Preheating. - With eucalypts preheating of billets to facilitate peeling is an advantage and probably essential. Improvement in cutting quality from heating is probably continuous with increase in temperature up to 200°F. However, heating cannot be used indiscriminately as it causes unwanted thermal degradation effects of increased collapse shrinkage in subsequent drying and woolly veneer surfaces in peeling. Optimum heating schedules can be

established on a trial and error basis adjusting temperature and, to a lesser extent, time, to obtain the best compromise between peeling and drying properties. Optimum heating temperature is likely to be in the range 140°F to 170°F., and optimum heating time between one and three days depending on log diameter. Because log end-splits open and extend appreciably, it is best practice to heat in long lengths so that two or more billets can be cut away from the split ends.

Drying. - Collapse degrade and shrinkage are of some concern in drying peeled veneers of the lighter weight eucalypts; in particular the "ash" type eucalypts which are noted for their high susceptibility to collapse.

Drying degrade takes the form of face checking, buckling, curling of long grain edges, splitting and thickness irregularity. All are associated with differential collapse shrinkage of early wood and late wood, or with differentially heated material.

Collapse shrinkage itself can critically affect veneer yield from logs. For example, gross volume shrinkage of 30% is not uncommon with bad logs of Tasmanian E. obliqua. In such cases more than half of the shrinkage may take place in the thickness (radial) dimension.

With regard to the dense eucalypts, drying behaviour of eight species with density above .50 lb/cu ft has been observed at this laboratory in recent years. Collapse degrade when it occurred was usually minor but transverse shrinkage, commonly around 10%, was still somewhat high.

Drying conditions have a marked influence on collapse and collapse degrade. The critical drying variables are the veneer temperature (wet bulb temperature) in the early stages of drying, and the drying rate. A high veneer temperature and a slow drying rate both favour collapse.

Dried quality of the veneer also depends on peeled quality. Veneers that are loosely cut, either as a result of poor lathe control or lack of preheating, are especially prone to face-checking and splitting.

Gluing. - Problems in gluing eucalypts derive mainly from their high density, and as such are common to the gluing of dense timbers in general. Elaboration on this topic has been reserved for a subsequent paper on the agenda "Gluing of High Density Wood Species".

Special problems with eucalypts are thickness irregularity of veneer due to differential collapse, and the high swelling potential of collapsed wood which makes wet tests difficult to pass.

Regrowth eucalypts. - Scout peeling and drying studies on regrowth eucalypts, mainly E. regnans, were recently made at this laboratory using as test material twelve 39 in. long billets 10 in. to 13 in. in diameter. Although the sample of logs was too small for assessing the potential of this type of material, results were encouraging and better than previously noted for mature logs of the same species.

Shrinkage to 12% moisture content using moderate temperature, high drying rate conditions was generally less than 6% and never more than 7%, indicating that little or no collapse had occurred in drying. Colour was paler than usual, and end popping did not critically affect yield of unsplit veneer. However, attempts to obtain a satisfactory peeling quality without preheating were unsuccessful and most of the billets were heated.

Veneer yields from logs were not determined, but it is estimated that with logs of this quality and size peeled to a 4 in. diameter core, recovery of usable veneer would be approximately 60% on true volume.

Further trials will be undertaken shortly in cooperation with the Victorian Forests Commission.

Hopes for increased utilization. - Scope for research in assisting the development of a eucalypt plywood industry appears to be considerable. Research topics offering some hope of a breakthrough are tightness control in peeling, glue formulations for dense species, control of end popping in cross-cutting and heating, and a practical method for reconditioning collapsed veneer.

A strategy for utilizing dense eucalypts that has already proved successful, is to produce a grade of plywood in which quality requirements for face, back, and core veneer are less restrictive than for a furniture grade of plywood. With veneer thickness 1/12 in. or greater to provide good handling properties and a minimum of repair and salvage operations to upgrade veneer, production costs can be kept relatively low. The outlet for such plywood could be in utility and structural uses which do not require a high quality surface. If necessary, paper overlays could be used to extend the range of application. The greatest difficulty in this field of utilization may be in obtaining adequate bond strength with available glue formulations.

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Item 7(c) Tannin Adhesives (DFP)*

Interest in tannin adhesives has increased both in Australia and overseas. In Australia wattle tannin adhesives based on DFP formulations are being used in increasing quantities and, as a result of the greater interest shown, we are extending our research in this field.

Studies of wattle tannin adhesives are being carried out with the aim of reducing cost still further and of facilitating their use under a wider range of factory conditions. A number of other extracts are currently being evaluated. We have undertaken studies of another commercial tannin in cooperation with the manufacturer and we are also examining the adhesive properties of bark extracts of Australian plantation-grown species.

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* Prepared by K. F. Plomley.

Item 7(c) (New South Wales)

Pinus radiata bark tannin adhesives. - The Division of Wood Technology has cooperated with APM Ltd., and Pyneboard Ltd., in their preparation of an adhesive from this source for trials in particle board manufacture. The decision to prepare the adhesive was taken after an examination, by the Division, of waste bark within APM Ltd., This showed that sufficient tannin of suitable quality would be available to justify its commercial manufacture should the adhesive be suitable for use in particle boards.

Unfortunately the extract has proved too reactive to be used with the existing equipment for adding the adhesive to the wood flakes and we understand that Pyneboard Ltd., is attempting to overcome this problem at the present time.

Wattle bark tannin adhesives. - The Division has developed a plywood adhesive based on imported mimosa tannin. The adhesive has been tested under factory conditions and we consider it to be superior in some respects to tego film and liquid phenolic glues. Its cost, ready to spread, is slightly lower than 100% flour extended urea resin of the following formulation: urea resin (60% solids) 100 lb; wheat flour 100 lb; water 100 lb; hardener 4 lb.

The adhesive is slightly faster in curing than the above urea formulation and should be pressed at about 240° to 250°F. It is completely waterproof, withstanding the 72 hour boiling water test. Pot life is about 4 hours.

With prepressing, the adhesive, although dark in colour does not bleed through thin face veneers of light coloured timber. The Division's new workshop at Putney, a building of 4,000 sq ft in area was sheathed with 3/8" negrohead beech plywood glued with this adhesive and two New South Wales plywood firms have made up commercial plywood using it.

The major problem in using adhesives of this type seems to be the need for much closer control of mixing and the Division is at present working on the simplification of this procedure.

Item 7(d) Gluing of high density wood species*

The effects on bond quality of different adhesive formulations, the priming of the wood surface with low solids resins, surface grooving and sanding, wood moisture content and assembly time were studied in relation to the bonding of several high density wood species with resorcinol-formaldehyde. The species tested were spotted gum, blackbutt, karri and gum topped box.

The results showed that grooving (Whitworth thread form and 20 to 48 threads/in.) was the most important of the factors studied and gave very considerable improvements in failing load and wood failure in comparison with ungrooved specimens. Details of this work have been published in DFP Newsletter no. 337, January-February, 1967.

A study has also been made of the effect of phenol-formaldehyde adhesive formulation on bond quality with a high density veneer species. In this work considerable improvement in bond quality has been achieved by changes in glue formulation, and excellent bonds have been obtained with Eucalyptus sieberi. In addition, studies of resin properties under varying conditions have indicated some probable effects of the adherent on the properties of the glue film.

Item 7(e) Gluing of wood impregnated with fire retardants**

Tests included several types of glues and treatments. Blush tulip oak veneers impregnated with ammonium phosphate-sulphate mix to a retention of 3.8 lb/cu ft were bonded with urea-formaldehyde glue mixes containing various hardeners.

Dry shear results of treated samples were equal to untreated controls, but results after 3-hr soak at 70°C. were considerably lower. Best results were obtained with a melamine-ammonium chloride hardener.

Good dry, but poor wet-strengths were also found when coachwood impregnated with a mix of boric acid and sodium tetraborate pentahydrate to a retention of 2.6 lb/cu ft was glued with a urea resin incorporating a commercial hardener.

A moderate decrease in both wet and dry bond strength was found with a liquid phenol-formaldehyde when used to glue fire-proofed blush tulip oak, and with a phenolic film glue used with treated meranti.

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* Prepared by K. F. Plomley.

** " " K. Hirst.

When "Pyrolith" treated Pinus radiata was glued with a resorcinol-formaldehyde glue, wood failure was lower than with untreated controls, even after curing for 7 days at 120°F.

Similar materials glued with an epoxy glue did not show any detrimental effect of treatment, but wet strength was poor for treated and untreated specimens.

No experiments on the effect of the above mixes on fire resistance have been carried out.

Item 7(f) Effect on bond quality of adding fire retardant substances to glues*

Tricresyl phosphate, antimony trioxide, asbestos or a mono-ammonium phosphate/sodium tetraborate pentahydrate mix were added to urea-formaldehyde and phenol-formaldehyde resins.

Tricresyl phosphate and antimony trioxide added at the rate of 10 parts per 100 of liquid glue lowered bond strength of U.F. glues, but were compatible with P.F. resins. Asbestos powder did not lower the strength materially of urea-formaldehyde resins when added at rates below 20 parts per 100 and of phenolic resins when added at rates below 60 parts per 100.

Ten parts per 100 of the mono-ammonium phosphate/sodium tetraborate pentahydrate mix did not affect the bond strength of urea-formaldehyde glue.

The effect of the substances on fire properties has not yet been evaluated.

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* Prepared by K. Hirst.

Item 7(g) (i) Physical properties of thin panel materials*

Introduction. - Each year the industry is producing an increased amount of laminated composite boards using different types of wood based panel materials, such as veneer, plywood, hardboard, particle board and various plastic impregnated papers.

Such laminated boards usually incorporate a number of desirable properties, but unfortunately experience gathered over a period of years has shown that distortions may occur in some assemblies, either immediately after pressing or later in service.

In many cases it has been possible to explain the cause of distortion and suggest corrective measures from available knowledge. However, it has been apparent that more detailed knowledge of physical properties of panel materials currently used in production of laminated board products would not only be helpful in identifying the causes of distortion but also in designing assemblies for maximum dimensional stability and flatness.

This study was limited to thin (3/8 in. or less) wood-based materials which are used today very frequently in lamination of composite assemblies.

Experimental material included commercially made klinki and coachwood plywood in 3/16 in. and 5/16 in. thickness. Standard and tempered hardboard produced by one manufacturer in 3/16 in. and 5/16 in. thickness and 3/16 in. thick particle board of approximately 45 lb/cu ft density which was manufactured in Portugal from Pinus spp particles.

The experiment provides for a study of:

(a) hygroscopic movement

(b) rate of moisture sorption and desorption within a relative humidity range of 30% to 90% and at 100°F., 80°F. and 60°F

(c) EMC between 0% and 90% R.H.

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* Prepared by A. Stashevski.

Some of the interim results on hygroscopic movement of a very limited sample are shown below:

Material	Percent total movement observed between 0% and 87% R.H. at 100°F.		
	Movement parallel to grain of face	Movement across grain of face	Thickness movement
Klinki plywood	0.21	0.35	5
Coachwood plywood	0.27	0.33	5
Standard hardboard	0.5 mean of both machine directions		7.8
Tempered hardboard	0.55 " " " " "		8
Particle board	0.58 " " " " "		7.5

It has also been found that approximately 80-90% of the total linear hygroscopic movement of the plywood of the two species occurred between 0% and 8-10% moisture content. The same movement pattern has previously been observed in the normal longitudinal shrinkage of some 80 veneer species. Both hardboards showed a linear relationship between hygroscopic movement in the plane of the board and the moisture content. The movement pattern in particle board is somewhat similar to the patterns observed in plywood and hardboard. It is linear up to 12-13% moisture content level, from where it tapers off gradually.

Item 7(g) (ii) Factors affecting flatness of plywood and other laminated sandwich assemblies*

Introduction. - Past studies on distortion of plywood have shown the need for better understanding of the effect of physical and mechanical properties of each individual lamination on the flatness of a laminated assembly.

It is felt that if a mathematical relationship could be established between all factors acting in a laminated sandwich assembly, that this would provide means of designing assemblies for maximum flatness when mixed species are used in assemblies.

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* Prepared by P. U. A. Grossman and A. Stashevski.

Some overseas research workers have developed theoretical approaches to solve this problem, but the premises were not always sound and little attempt has been made to confirm experimentally whether such predictions were reliable.

This study proposes a new theoretical approach to plywood distortion and experimental confirmation.

Theory. - The study is based on estimating the moments of force set up when shrinkage and swelling of individual layers is reduced by mutual restraint of neighbouring material. It takes into account the moisture content of each layer at the time of gluing and later equilibrium, and restrained shrinkage, elastic moduli and relative thicknesses. It neglects shear in the glue-line and within the layer, and does not, in its initial form, allow for stress relaxation.

Requirements have been derived for panels to remain flat after humidity changes. Where these requirements are not met, the magnitude of the expected curvature can be calculated for any number of layers, various thicknesses, mechanical and shrinkage properties and humidities. The unwieldy general resulting equation is approximated by simpler equations, each adequate in a specific case, e.g. three-ply along the grain, corestock across the grain, etc.

Experimental confirmation. - Initial experimentation is being carried out on two types of plywood assemblies:

(a) assemblies with uniform thickness laminations

(b) assemblies where the core material is at least eight times thicker than the cover veneers.

To produce measurable distortions, the experimental assemblies were unbalanced by differences of moisture content, thickness and species in the outer layers. Mechanical and physical properties were measured on matched material.

Curvatures measured after various treatments are being compared with curvatures computed on the basis of the theory from both, the precise and the approximate equations and this should give an estimate of the validity of the theoretical assumptions and of the adequacy for practical purposes of the approximations.

Item 7(h) Compression of hoop pine in plywood assemblies*

Significant thickness losses often occur during hot pressing of veneer assemblies. These losses are dependent on the interaction of moisture content, press temperature, pressing time and species, and in this study some quantitative evaluation of the factors involved was obtained.

The assembly used in compression comprised 16 - 1/16 in. 10.in. square cross laminated veneers of hoop pine as the main species at moisture content levels of 0, 5, 12, 13, 17 and 25%, with temperatures of 55°, 180°, 260° and 285°F. and pressures of 75, 150 and 30 psi.

Check tests were carried out at several moisture contents with silvertop ash and red seraya at 285°F. Compression was observed at 5 minute intervals over a period of one hour. Initial and final thicknesses of the assembly and the initial and final moisture contents of individual veneers were measured.

It has been established from previous work that spring-back was relatively unimportant over the range of experimental conditions. In hoop pine at phenolic pressing temperature of 260-285°F. a remarkable increase in compression occurred between 12 and 17% moisture content. A remarkably large proportion of the total one hour's compression occurred during the first 15 minutes of compression.

In the temperature range 230° - 285°F. the compression-temperature relationship is linear with other variables constant. The rather remarkable increase in compression of hoop pine between moisture contents of 12 and 17% appears to differ from red seraya and silvertop ash, where the increase in compression obtained with moisture content increase appears to be more or less linear.

In exploratory trials in laboratory pressing the quantitative compression data obtained allow a reasonable estimate to be made of the compression that will occur in glued laboratory assemblies, so that estimates can be made for overcoming variation in veneer thickness by compression or in veneers of comparatively uniform thickness ensuring absolute minimum thickness losses in the pressing operation. The rapid increase in compression of hoop pine between 12 and 17% under the conditions of the experiments has not been explained, although there may be some association with the small size of the test piece.

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* Prepared by K. J. Lyngcoln and J. W. Gottstein.

Item 7(i) Fire properties of plywood*

Early fire hazard. - Early fire hazard properties of plywood depend to a large degree on the adhesive used. With casein, P.V.A., elastomeric and extended urea-formaldehyde glues, bond breakdown occurs relatively early; the plywood delaminates with consequent increase of flame spread and heat evolved. Neat urea-formaldehyde and phenol-formaldehyde glues withstand heat much better and give better early fire hazard values.

Thickness of the panel has only a very small effect on early fire hazard and differences are probably not significant.

Treatment with fire retardant salts decreases the early fire hazard considerably; there appears to be no difference if treatment is carried out before or after gluing.

Very low (i.e. very satisfactory) early fire hazard figures have been found for panels painted with suitable fire retardant paints. Surface films of vermiculite retard ignition considerably and confer very good early fire hazard properties. However, gluing difficulties with vermiculite films make application of the latter difficult.

Fire resistance. - The fire resistance of plywood suitably glued is similar to that of solid wood of the same thickness. Pilot experiments have shown that asbestos mats laid below the face veneer may improve fire resistance materially.

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* Prepared by K. Hirst.

ITEM 8. UTILIZATION

Item 8(a) Research review*

The Utilization Group of the Division of Forest Products is at present in a state of transition. Whereas in previous years it was our objective to investigate specific processes in the conversion of timber, such as sawmilling or manufacturing methods, we believe that it is becoming of increasing importance to consider the conversion process as a whole. A major effort is being made to equip the group's professional staff for dealing with the new problems which are now arising from the gradual introduction into the industry of modern production methods concerned with the mechanical conversion of timber.

Following the departure last year of Mr. R. F. Turnbull, Officer-in-Charge of the Section for nearly 40 years, and with a number of officers away overseas, we have for the moment sub-divided the Utilization Section into two groups. One of these is concerned with the process of timber conversion as a whole and administratively attached to our Physics Section, whereas the other is dealing with production methods and attached to our Plywood and Gluing Section. I should like to emphasize that this does not imply that utilization work is being reduced or considered of minor importance; quite the contrary. We consider research into the utilization of timber and production methods of the greatest importance. The shift in emphasis mentioned above is, we believe, best accommodated by an organizational arrangement which crystallizes around the two main functions of this research, namely, the assessment of the conversion process and investigation of the production methods themselves. Some thoughts on data collection will be presented in Item 8(d). We shall undoubtedly have more to report about the development of these new aspects of our utilization work at the next Conference.

LABORATORY INVESTIGATIONS

The mechanism of cutting of wood is basic to most mechanical conversion operations, and continues to receive great attention. Apart from the research in our own laboratory, Dr. W. M. McKenzie is at present working as a senior research fellow in the University of California to investigate basic cutting phenomena. W. D. Woodhead is studying characteristics of wood framed wall structures at the same University.

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* Prepared by W. G. Kauman.

Basic cutting research. - A major experiment completed since the last Conference was concerned with the interaction of rake angle, edge radius, chip thickness, wood species and wood moisture content when cutting in a transverse plane. Experimental cutters were sharpened to the highest possible degree (about 0.2 μ radius) and then blunted to predetermined degrees of bluntness, and the final cutter profiles were assessed by the lead profile method. The results were analysed by computer and are still being evaluated.

Another aspect of this work deals with the friction between the metal of the cutting tool and the wood being cut. The experiment included examination of dry and wet wood surfaces, smooth and rough stainless steel and mild steel surfaces, as well as copper, carbides, plastics and wood itself. Using a strain gauge dynamometer mounted on a lathe in which the wood specimens were being spun, to obtain rubbing speeds up to 1,000 ft/min, it was shown that steel roughness at the highest of these speeds is of minor influence on friction, and that the friction coefficient is reduced at high speed. A paper is in print which presents the major results and an interpretation in theoretical terms.

Finger jointing. - The process developed by Gottstein and Page for finger jointing green timber by means of an electric flash drier has been further examined and is now operational on a laboratory scale. This research will be presented in Item 8(b).

Miscellaneous. - As reported in our Annual and Half Yearly Reports, the Section carried out a number of evaluation tests on experimental scaffold planks and also continued small-scale finishing and exposure tests of various surface treatments. The behaviour of metal fastenings in contact with wood was examined at the same time.

According to interim results, rough sawn radiata boards seemed to be superior to dressed boards and pressure treatment better than dip and brush application. As regards metal in contact with wood, the best results up to date were obtained with aluminium and galvanized iron. Significant differences in corrosion were observed for different species.

SAWMILLING AND CONVERSION STUDIES

The major effort during the period under review was concerned with the application of modern production methods in sawmilling.

During the last Conference, Mr. Page discussed work on logs from immature stands in Tasmania and referred to a research project then initiated in cooperation with the Tasmanian Forestry Commission and the Tasmanian Timber Association. Stage I of this study has now

been brought to a conclusion. It involved the grading and assessment of log quality in relation to end use, and produced a number of results of general interest which will be discussed under Item 8(c). Stage II is a forest inventory which is now under consideration by the Tasmanian Forestry Commission. Stage III will be a study of the suitability of immature ash eucalypts for the manufacture of cases, but, unfortunately, this had to be postponed following the disastrous bush fires in Tasmania earlier this year.

One of the most important aspects of utilization studies is the liaison with the timber conversion industry. During the last year, the Section made a very considerable effort to disseminate the fund of knowledge guilt up over the years by means of two courses on the latest developments in sawmilling equipment and techniques given by Mr. Page to senior executives of the sawmilling industry from all Australian States. These courses were attended by some 55 senior sawmilling men, and each included three days of lectures at the Division and a 10-day conducted tour of sawmills in Victoria and southern New South Wales. A summary of the first course has been published by The Australian Timber Journal in its January issue of this year, and the courses have raised widespread interest. As a result of many requests, we are now considering a further course early next year.

TECHNICAL ASSISTANCE

As in previous years, the Utilization Group continues to be responsible for the provision of technical assistance to many sections of the timber industry and wood users, ranging over applications of timber from clothes pegs to freight containers. Major technical assistance projects included the design or redesign of some 25 sawmills and conversion plants, and evaluation of sawmilling practices in the southern States in cooperation with numerous firms.

Officers of the Section also acted as examiners for courses on timber utilization run by the Hobart Technical College and the Royal Melbourne Institute of Technology, and corrected numerous correspondence papers.

Under the cooperative programme with the Forestry Departments of Fiji and the British Solomon Islands Protectorate, the Group was responsible for sawing 69 logs of 22 species and assessing the properties affecting conversion. Species descriptions were prepared from data provided by the various Sections of the Division, and sent to the cooperating Forestry Departments.

Technical assistance was given to developing countries through a number of trade missions and visitors from various countries in Asia, Africa and South America. At the occasion of the F.A.O. Man-Made Forest Symposium earlier this year, Mr. Page presented an extra-curricular talk on "Conversion of eucalypt logs" which was attended by some 90 conference delegates from Australia and overseas.

Earlier this year, the recently created Australian Sawmill and Related Equipment Manufacturers' Export Association requested the Commonwealth Department of Trade and Industry to carry out a Trade Mission in South America in order to evaluate the potential of the South American timber industry as a market for Australian-made equipment, and nominated Mr. Page to undertake this survey. At the Department's request, the Executive of CSIRO subsequently agreed to make Mr. Page available, and he left on the 16th of July for a 4-months' Mission during which he will spend 12 weeks in a number of South American countries. On the way to and from South America he will look at research establishments and industrial firms in the sawmilling field on the West Coast of the United States and various European countries. He was also invited to spend three days in the State of Hawaii as the guest of the US Forest Service, to assist with problems in the utilization of plantation-grown eucalypts.

Discussion

Cowan: We have carried out two items of practical research in the last twelve months. The first was to find what we called "equivalent recovery diameters", or the diameter of the perfect cylinder which would give equivalent recovery to a given diameter log. A 14 in. (mean diameter) log may give a 48% recovery, taking into account all defects. The same sawing pattern is then applied to a perfect circle to give the same recovery, and it can be said that the diameter of that perfect circle is equivalent in recovery to the diameter of a 14" log. In fact the difference is about 1½". We have done this right throughout diameter range and we have found it very useful to relate sawing patterns to recovery and to provide basic information on the economics of sawing different sizes.

Secondly, we are very concerned with the demands made upon sapwood; this was referred to under Preservation. We must cut scantlings predominantly from sapwood, particularly if we are looking for high quality appearance lumber. If you take a 20' log with taper and take out a squared core, the wings left are tapered and the recovery from such wings is low. Rather than take out a square, we decided to cut parallel with the taper. Theoretically, this leaves a piece tapering from about 1½" square down to zero at the small end,

which usually contains the pith and which is discarded. We would have been happy if the additional recovery of sapwood would pay for the loss which we expected because of the discarded core. We were surprised to find that higher recovery was obtained. In other words, the loss from the discarded core was less than the loss from conventional cutting of the tapered wings. This work was done with 10 paired logs, and we want to take it further as it looks to be quite promising for some of our mills.

We have more details on the equivalent recovery diameters, but these should be used with caution, because they vary for different forests of different average ages.

Item 8(b) (i) Finger jointing*

The influence of scarf angle on joint strength for species of different mechanical properties was further examined. Small samples were cut from finger joints prepared with special cutters to obtain scarf slopes ranging from 1 in 6 to 1 in 20. Tension tests using kauri (Agathis sp.), radiata pine (Pinus radiata), mountain ash (Eucalyptus regnans) and white stringybark (E. eugenioides) indicated that the percentage loss of strength at a given slope does not vary significantly from species to species and ranges from approximately 50% for a slope of 1 in 6 to only about 5% at a slope of 1 in 20.

Investigations on the experimental green finger jointing process showed that a heating period ranging from 12 to 20 sec results in satisfactory drying of the finger surfaces for material around 35–40% moisture content. Some studs made up from green material using the experimental technique are now drying prior to strength testing.

Joints glued with PVA were tested in bending after repeated soaking under spray for 6–7 hr and then drying in a kiln for 17–18 hr. It was found that joints of mountain ash lost strength relatively evenly and that after the twelfth cycle their strength was approximately 65% of that of controls. Radiata pine joints dropped to approximately 55% of the controls after the first cycle and then steadily declined to about 45% after twelve cycles. When tested after the wetting stage of the cycle, the mountain ash dropped immediately to about 60% of the strength of the controls after 1/2 cycle and to approximately 45% after 6-1/2 cycles. Radiata pine dropped immediately to 30% of the strength of the controls after 1/2 cycle and at 6-1/2 cycles was down to only 15%. Joints tested without any glue also had about 15% of the bending strength of control specimens. Some testing on jarrah (E. marginata) and red gum (E. camaldulensis) showed that red gum joints dropped to 75% of the strength of control value after 12 cycles when tested after the drying stage, while jarrah dropped to 65% of the strength of control values after 6-1/2 cycles when tested after the wetting stage.

* Prepared by B. T. Hawkins.

Item 8(b) (ii) The relationship between sizes, grades and volume of sawmill output and their end use in buildings*

In most sawmills the greater proportion of timber recovered from the conversion of eucalypt logs is utilized for building purposes. In this regard the establishment of a sound relationship between available timber and building practice is fundamental in terms of efficiency and conservation of the national asset.

The loss of markets to substitute materials for the construction of industrial buildings has placed the timber industry in a position where it is dependent upon the housing field of the building industry. Therefore, research into this sphere of timber application is of primary importance.

Following the measurement of building work in Brisbane, it was revealed that with seasoned timber sheeting for the average house, 140 super feet of one inch thick green off saw timber was required for each 100 square feet of building area covered. This figure is related to board width and establishes a need for more efficient utilization of the material.

Further research was undertaken in the application of scantling timbers. In this regard, designs of buildings considered to be a representative sample of current practice were selected and subjected to quantity analysis of the elemental components. The respective lengths, sectional sizes and grades of each timber member required for erecting the buildings were measured from the plans, using lengths between the limits of 1 ft and 28 ft. Provision was made for jointing only when timbers were over 28 ft in length.

Timber grading relative to building components was based on Australian Standard 082-1963 for "Sawn Eastern Australian Hardwoods" and the specification of a prominent Queensland housing authority. For the purpose of this report, results obtained from the measurement of the plans of two buildings are stated briefly. These are in terms of wood volume.

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* Prepared by E. J. Hornibrook.

The work followed completion of investigations into the timber production of thirteen sawmills in South Eastern Queensland*. Comparison is made of the grade distribution established from these studies and the elemental quantity analysis. However, at this stage comment is made only on the distribution relationship of lengths recovered.

ANALYSIS OF GRADED LENGTHS IN TWO BUILDINGS

Timber grades	Percentage of lengths in each grade			
	5 ft and under	Over 5 to 10 ft	Over 5 to 20 ft	Over 20 to 28 ft
Building A				
Select	8.335	8.365	1.642	3.981
Standard	19.556	31.705	93.847	84.030
Building	72.109	59.930	4.511	11.989
	100.00	100.00	100.00	100.00
Building B				
Select	10.154	7.062	10.470	
Standard	33.475	10.027	75.052	98.502
Building	56.371	82.911	14.478	1.498
	100.00	100.00	100.00	100.00

* The milling of hardwoods in South East Queensland. Studies in sawmill economics - by N. S. Hinson, and I. F. Horton.

GRADE RELATIONSHIP

Timber grades	Building A	Building B	Variation Percentage B-A	Mean percentage as specified	Grade distribution actual mill output
Select	4.749	6.607	1.858	5.488	41.5
Standard	66.466	64.566	- 1.900	65.710	49.0
Building	28.785	28.827	0.042	28.802	9.5
	100.00	100.00		100.00	100.00

LENGTH RELATIONSHIP

Length groups	Building A	Building B	Variation percentage B-A	Mean percentage as specified	Length distribution actual mill output
5 ft and under	11.436	13.339	1.903	12.194	Short lengths required for building are considerably more than those now available from sawmills
over 5 to 10 ft	26.700	18.578	- 8.122	23.465	
over 10 to 20 ft	38.510	37.634	- 0.876	38.161	
over 20 to 28 ft	23.354	30.449	7.095	26.180	
	100.00	100.00		100.00	

NOTE: It was also interesting to find from the abstracted quantities of timbers specified that heavy concentrations occurred in the 8 ft to 14 ft length range. Similar work on the length distribution of mouldings again revealed a high percentage of short timbers required for building. Percentages are on a volume basis.

The figures given in the Grade Relationship schedule indicate that timber of a much higher quality than that usually specified by leading authorities is being supplied for building. It is believed that to some extent this reflects the over conservative attitude of people responsible for the acceptance of building timbers. Notwithstanding this position many buildings are over designed relative to structural efficiency.

In the applied building research projects carried out by the Queensland Department of Forestry, "building" grade timbers are successfully used more extensively. The scantlings in one building comprised as much as 65% of this low grade. These were applied to roof and ceiling framing as well as in timbers for double sheeted walls. In these circumstances, figures in the "Mean Percentage" and "Mill Output" columns of the "Grade Relationship" schedule show unsatisfactory distribution of timber grades both in building and mill practice.

Greater quantities of building grade timbers should be used to attain full utilization of forest reserves. These may be procured from the huge volume of less popular species with inherent natural characteristics which are not detrimental in terms of efficient building.

The present wastage resulting from specification of excessively high wood quality and sectional size in many building members should be obviated. The more general application of mechanical stress grading of unused timbers will do much to satisfy this necessary development.

Preparation of detailed quantity lists in the initial planning of building projects is an economical operation relative to building costs. The sawmiller should do all in his power to encourage this practice in the building industry and thus regulate the distribution of sawn timber output, over which he now has little control, by promoting the sale of timber components in adequate grades and lengths for building.

Research is being continued for the purpose of further statistical consideration and presentation.

Discussion

Bryant: Since all the Housing Commission homes in Sydney are built of green precut scantling, and there is a tremendous volume of green scantling used in other housing projects in New South Wales, I am in sympathy with the idea of introducing dry scantling, but this

is an urgent problem for the sawmillers in New South Wales. There is very little chance of them getting shorts dried before finger jointing. Is the green finger jointing equipment at a stage where a private sawmilling group in New South Wales could develop it for its own use. We have looked at the use of nail plates to solve this problem, but they were too expensive.

Would there be use in Queensland for a successful method of fingerjointing green material, say to make up studs?

Hornibrook: I don't think there is a need for this. In fact it is probable that logs won't produce the number of shorts that are needed for building, so there is no need for additional costs in fingerjointing. If there is going to be additional cost, it should be in straightening and dimensioning. Straight components of correct or uniform sectional size are more desirable than fingerjointing components.

Huddleston: This matter is of vital importance to the sawmilling industry. Sawmills produce too many shorts because buyers are not prepared to accept timber to the Australian Standard Specifications. I strongly support the Queensland contention that if we can firstly organize the industry to accept the grading rules which they have adopted, and secondly, to sell building components, there would be little use for a finger-jointer to produce building size material.

Item 8(c) Contributions to sawmilling technology*

Sawmill and utilization studies carried out in Tasmania with the cooperation of the Tasmanian Forestry Commission and the Tasmanian Timber Association have produced several contributions of general interest to sawmilling technology.

One of these concerns the minimum size and quality of log required for both general sawmilling and case sawmilling, and the reliability of visible surface log characteristics as an indicator of wood quality and the practicability of using these features to select logs suitable for various end uses.

The conversion of Eucalyptus obliqua regrowth logs in southern Tasmania has been analysed to relate log quality to volume and monetary recovery.

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* Prepared by M. W. Page.

Percentage recoveries were found to be inversely related to the square of the log girth and increased sharply over the girth range 3-5 ft. For a higher site quality, recovery tended towards a constant value for girths greater than about 7 ft, whereas for a lower site quality, there appeared to be a maximum recovery at about 7 ft with a decrease for greater girths.

From preliminary observations in sawmills, it was apparent that the defect imposing the strongest influence on wood quality was so-called "bumps".

Empirical relations expressing recovery as a function of both girth and bumps show that, on the average, each bump decreases the value of sawn timber by 28 cents/100 super ft Hoppus log volume, whereas each foot increase in girth increases this value by 37 cents.

In another study, the equipment and practices employed by the Tasmanian sawmilling industry were investigated.

The production rate of a machine, of a man or of a sawmill is usually expressed in terms of volume of sawn output. However, this is not regarded as the most suitable criterion for comparison because sawn output per unit time is not only influenced by log quality and amount of docking carried out, but also by the average size of sawn timber produced.

Area of sawing per unit time takes into account the number, length and the depths of cuts, and is proposed as the most useful indication of a bench's production potential. Obviously benches sawing at the highest rates may not produce the greatest volume of sawn timber, as some cuts may be wasted by crews who do not convert their work efficiently, or much partly-sawn timber may be discarded because of low wood quality. But benches sawing at the highest rates have the greatest potential to produce sawn timber and the sawn area criterion has, therefore, been adopted as a basis for comparison.

The Figure shows graphically the relationship, derived from studies of approximately 1,500 logs, between sawing task and average size of product. Sawing task has been defined as the area of sawing, namely, the product of length and depth of cutting that it is necessary to perform in order to produce sawn timber.

In the Figure the sawing task is related to log volume rather than sawn volume, as the expression in terms of log volume permits some allowance to be made for the influence of log quality on recovery rates. Hence, this relationship allows sawing rates to be related to log consumption rates and not to the rates of sawn timber output.

Item 8(d) Data collection and processing in conversion studies*

Over the years this Division has conducted many conversion studies, most of which involved the collection of large amounts of data. The subsequent processing used to be a major task and often took much longer than the actual data collection.

The advent of the modern digital computer, however, offers a means of reducing the actual processing time, including the drawing of graphs and statistical analysis, etc. down to the order of a few hours, although some days are often required for data preparation. In addition, computer programmes must be written, but these are generally prepared before the field data come to hand. The Division first used this technique in the latter stages of a recent study of regrowth Eucalyptus obliqua in southern Tasmania. The computer used was a CDC 3200 operated by Computing Research Section of CSIRO as part of its computer network.

It is envisaged that this method of analysis will be used increasingly during most future studies and consequently we are now looking at methods of data collection which will be more compatible with the computer. At present the data are written on suitably printed sheets in the field and these are transferred onto punched cards in the laboratory using an automatic punch.

Work is being conducted to ascertain the feasibility of punching the data directly onto cards in the field. One such method would be to use the IBM "porta-punch" system which involves using a stylus to push out a partly prepunched hole. Other card punching systems involve the use of small portable card punching devices such as the "Hollerith" type hand punch.

Consideration is also being given to a method of recording the data on ordinary portable magnetic tape units in the field with the possibility of transferring this to computer-compatible punched paper or magnetic tape through a data logging system. However, at this stage the direct punching of cards seems to offer the best possibilities, because of the comparative ease of checking and correcting errors.

It also seems likely that automatic devices for measuring such quantities as dimensions of sawn timber or the power used by a saw bench may prove useful and enable the reduction in the number of men involved in conducting a field study.

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* Prepared by B. T. Hawkins.

Item 8(e) Testing of water-repellent preservatives (NSW)

An experiment is in progress to determine the effect on paint serviceability with radiata pine of three minute dips in pentachlorphenol (Woodzone) pentachlorphenol laurate (Woodzone Deepseal) and copper naphthenate (Cuprinol); a three-coat alkyd paint system has been used on the treated timber. Perhaps of more interest and importance, the pentachlorphenol dip is also being used as a primer coat (i.e. with only undercoat and finishing coat over it) as recommended by the marketers of "Woodzone".

Ten panels of each treatment were used and have been exposed at 45° facing north for just over twelve months. Streaks of light brown discoloration are showing through all types of treatment and the untreated controls, the discoloration being most noticeable over knots. Cracks are appearing in one panel of the pentachlorphenol laurate and four of the unprimed pentachlorphenol; on two of the latter some flaking is now starting.

The omission of primer is certainly suspect but it is too early yet to make any public comment.

Mortice and tenon joints (as used by Verrall in the USA) for the determination of relative susceptibilities to fungal attack have been exposed at our Ponnant Hills exposure site for one year but have not yet been assessed.

Item 8(f) Testing of natural finishes (NSW)

Panels of the colour range of Wattyl "Forestwood" stain finishes on sawn brush box have been exposed at 45°, facing north, for twenty two months. They are still in quite good condition though one has faded somewhat; all panels have fine checks throughout their surfaces which are somewhat narrower than those on the uncoated control. It would appear that two coats should give a service life of three years on sawn vertical surfaces.

A small scale comparative test of two creosote stains (Cabot and Pascol "Defense") with two oil stains (Wattyl and Acorn) on sawn blackbutt and dressed radiata pine did not show any marked superiority between systems. The pine has checked badly; in fact one can't help feeling that it is undesirable to encourage people to use young pine in this manner.

Some doubts have been expressed over the effect of water repellent preservatives on subsequent applications of "natural" finish, since both products can have waxes, etc. which may cumulatively affect drying. Test panels of sawn and dressed radiata pine and blackbutt were exposed at 45° six months ago. Dressed panels of both timbers are still sticky on the backs away from the weather but no significant appearance difference is observable between treated and untreated faces.

Cabot Bleaching Oil, a light grey pigmented creosote containing a bleaching agent, is being recommended commercially to people who want their external timbers to weather to a grey colour but do not like the in-between stage of partial weathering. Another use for this type of product is on areas where natural weathering is slow or unlikely, e.g. at the tops of walls protected by eaves overhang. Panels of both sawn and dressed radiata pine, spotted gum, western red cedar and brush box have been exposed for 6 months at 45°. The product has proved to be of benefit although the grey produced is somewhat paler than the natural weathering except on the western red cedar where the untreated panels are still showing quite a lot of the original brown colour on the harder tissue.

Item 8(g) The development of hardfacing materials on saws and cutters (NSW)

The Division of Wood Technology has had under test for some time four types of hardfacing material on saws and cutters with the primary object of assisting production in the timber industry. They are:

(1) Tungsten carbide

(2) Cobalide

(3) Powder spraying

(4) Hard chroming.

1. Tungsten carbide

Although this material has been used for many years in the timber industry, only recently has there been an improvement in the grades of tungsten carbide manufactured by overseas firms. The Division of Wood Technology has tungsten carbide saws and cutters made by four companies under test in large sawmills cutting brush box and mixed hardwoods.

The aim of the study is to check the following: finish of timber, tool life, erosion of cutting edge and cost of resharpening, toughness of alloy, cost, the geometry of the cutters, and sharpening and jointing of the tools.

To date studies on cutters made in the USA with a 45° sharpness angle and a 10° front level gave a tool life of 31,000 super feet of mixed hardwoods. In addition 12" solid tungsten carbide blades are undergoing trials at a Masonite factory in a sheet thicknesser in which 5 of these knives are used. They run for four weeks without sharpening. It is understood that 51" knives are available from USA.

One NSW sawmiller is using tungsten cutters running back to front on brush box to produce a very fine finish on flooring. He uses a 40 HP motor on his machine to achieve this and claims the extra power used is worth it.

Tungsten carbide depositor. - This is a metal coating machine from Japan sold under the trade name of "Depositron" which places a coat of tungsten carbide approximately .004" thick on to the parent metal. The molecules of the tungsten carbide electrode are bonded to the metal surface by an electrical discharge which melts the metal and deposits the hardfacing material. The machine works off a 415 volt supply and retails at $590.

The Division has had promising results from its use on veneer knives, small saws, and on the many tools used by sawmills. It is claimed by one veneer mill to give 4 times the life of steel knives in soft scrubwood timbers. Tests are proceeding on harder plywood species.

2. Cobalide

This material which is a tungsten - cobalt - chromium alloy has been used successfully on flat cutters up to $4\frac{1}{2}$" wide. The alloy is laid in a 1" x $\frac{1}{8}$" channel in a 4" x $\frac{1}{2}$" block of mild steel, by means of a welding torch. The block is then ground off flat, sharpened and slotted to take the cutter bolts.

If the sawmiller has the skill to make them he can produce cutters that will give him about half the life of tungsten carbide for about a quarter the cost, as well as the ability to repair gaps in the edge.

This process was tried on saw teeth without success due to the effect of heat on the structure of the sawtooth, causing the points to crack off. This material is however, excellent for facing feed rollers and conveyor chains.

3. Powder spraying

This new process involves depositing a nickel based alloy powder on to parent metal by means of a special oxy-acetylene torch in which the powder is fed through a funnel into the flame. Attempts to hand-tip teeth have been unsuccessful. When setting the teeth, the coat of hardfacing was destroyed due to its lack of flexibility. However, it has application on gears, rollers etc. as it usually requires no grinding.

4. Hard chroming

Hard chroming has been particularly successful in trials made on large diameter saws cutting a variety of hardwoods on several types of benches. The Division, in cooperation with local sawmillers and saw manufacturers, has developed methods of sharpening the teeth with an air grinding tool.

With careful attention to maintenance of the saws and following recommendations made by the Division, sawmills with the chrome saws have achieved from 8 to 16 hours sawing on hardwoods without changing their saws.

The Table shown below lists some performance figures:

HARD CHROME SAW PERFORMANCE

Saw diam.	Gauge	Operation	Feed speed F.P.M	Saw life hrs.	
42 in.	10	Automatic bench	200–400	9	Brush box, ironbark, grey gum
32 in.	10	Recovery radial arm roundabout	200	24	Brush box, blue gum, grey gum
54 in.	6	Twin log edger	100	28	Turpentine
60 in.	6	Canadian twin rig	60–100	8	Blackbutt, brush box
36 in.	10	Power feed bench with roundabout	200–300	8	Brush box, ironbark, grey gum
42 in.	9	Conventional breast bench	120–160	3½ to 5	Brush box, blackbutt, spotted gum
		Frame saw	2–3	8	Turpentine

The setting, stripping and gulleting of the saws are as for the ordinary steel saw but the sharpening requires the use of a specially designed double cut file, the coarse cut to place the hog on the tooth and the fine cuts to finish off the point.

As mentioned above, a handheld air grinder is particularly successful. This unit has a spindle speed of 16,000 rpm to which is attached a 2" dia. x ½" thick recessed resin bonded wheel (A36 SB11) so that the nut on the arbor does not obscure the view of the point of the tooth when the wheel is grinding the point.

The grinding technique is easily learnt and consists mainly of holding the grinder in two hands, resting one against the saw, and moving it from the heel to the point.

Hard chromium on veneer knives has not been successful and on cutter knives it gave only a slightly longer life than high speed steel.

Item 8(h) Development of a mechanical tree sampler (NSW)

The need to obtain a large number of samples from the living tree in the Commission's plantations of radiata pine has prompted the development of a sampling machine that is powerful and portable.

Previous attempts by other workers have been only partly successful, due to the size of the units required and also to the effect of the extraction method on the samples themselves due to the heat generated in the process and the compressive forces exerted on the timber.

The Division has produced a very flexible machine which consists of two basic units with a total weight of 42 lb fully fuelled.

Part (1) consists of a guide unit with a tree gripping clamp and part (2) of an engine with a mortising bar and chain fixed to a steel frame which serves as a handle and carried two guiding tubes.

The guide is fixed to the tree by three spikes and an adjustable tree gripping chain and consists of two rings one rotating inside the other with four equally spaced holes making it possible to set up for four successive cuts that yield a sample $1\frac{1}{4}$" x 1" and up to 14" deep. Bars up to 20" are available.

The motor is a 4 HP Solo 50 which can work upside down and is easily modified to fit the mortising bar. The bar is automatically oiled.

Extraction of the core is carried out by first inserting a 1" x 1" x $\frac{1}{8}$" angle into the cuts and tapping it sideways with a hammer thus cracking the sample, which is pulled out with a small hook.

Machines have been purchased by the Forest Research Institute, Canberra, Hobart and Melbourne; Forestry School A.N.U; Forest Products Research Centre, Territory of Papua and New Guinea.

The unit is made by John Levy Pty. Ltd., 15 Hutcheson Street, St. Peters, Sydney. It costs about $500.00.

Item 8(i) Log salvage after natural disasters (NSW)

Following a recent "blowdown" of plantation grown pines in northern NSW it became apparent that there was a need for an organization within the Commission to deal with the situation from an administrative as well as a technical point of view.

A committee was formed which includes the Senior Engineer, an Officer of the Economics and Marketing Division and 2 Officers of the Division of Wood Technology.

It was decided that DWT should approach the problem in two parts to provide costs and technical information to the Commission on:

1. The establishment of portable sawmills
2. The storage of large quantities of logs under water spray or ponds.

1. The establishment of portable sawmills

The setting up of these sawmills would be subject to the Commission's approval and would depend on:

(a) The location of the damage

(b) The ability of local sawmills to handle the volume of damaged logs.

In the event of there being no local sawmills available, a specification was prepared for a portable sawmill manufactured by a Sydney engineering firm.

The sawmill has been manufactured in two parts. The breakdown unit, no. 1 bench and motor is attached to two 14" x 6" R.S.J's and can be handled on to a low loader in one unit with lifting rings. (Weight 4½ tons). Auxiliary machinery such as a docking saw, lines etc. weigh another 3 tons. Costs of setting up a camp to house 10 men together with the mill building were also estimated.

Total cost for machinery and establishment of camp was approximately $24000 as at March, 1967.

The provision of contract sawmillers and the marketing of the output would be handled by the Commission's Economics and Marketing Division. The sawmill would be purchased by the Commission and would be available for sale after the emergency.

2. The storage of logs under water

The costs and efficacy of this method are under study at the present time.

The project aims to test and evaluate the procedures of spraying or ponding logs from an engineering and mycological standpoint. It is hoped to utilize dams strategically located in the various plantations for fire fighting as a source of water for either spraying or ponding of the damaged logs.

Item 8(j) Low profile flooring systems (NSW)

In the USA a high proportion of new single unit dwellings are now being built on concrete slabs and in Australia too, there is an increasing desire among architects for the "long low look" with more convenient access between house and garden.

It is not an easy matter to use strip flooring successfully on top of concrete slabs - the long drying time of the concrete causes movement of the floor and termites can travel through quite small cracks in the slab to the wood above. The net result has been the loss of this market for timber to tiles and composition floors.

In the USA the National Lumber Manufacturers' Association sponsored a research project at Washington State University designed to provide a cheaper low profile alternative to the slab using wooden flooring systems. This has resulted in a number of designs which substantially eliminate the existing height requirements of foundation walls and piers. They are published in a study by Talbott*.

The method of construction is to level off the building area, provide good drainage, install the basic plumbing lines and compact the area. After the erection of the external wall shell a continuous moisture barrier is laid over the enclosed ground and precast concrete caps are placed where one would normally have piers. In some cases the soil is poisoned against termites. Construction then proceeds in the normal way. In some of the houses built in America the space between membrane and flooring is used as a plenum for central heating.

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* New Profile Wood Flooring Systems by John W. Talbott, Bull. 277, Division of Industrial Research, Washington State University, Pullman, Washington, USA.

There is considerable interest in these construction methods by the timber industry and both the T.D.C.A. and the Timber Advisory Council have sought the views of the Division. The two main problems relate to termite attack and the possibility of damage to the moisture barrier during construction. We have had some preliminary discussions with architects on design aspects and with Mr. Gay of the CSIRO Division of Entomology on the testing against termite penetration of commercial membranes treated in the laboratory with repellents.

Item 8(k) Improvements to double hung wood windows (NSW)

Mr. Huddleston mentioned that the Division of Wood Technology has worked on a method of rendering double hung wood windows rattle-proof. The method uses plastic inserts in the groove containing the spiral balance, and is very cheap. (30 - 40¢ per window). A test window has had approximately 10,000 cycles without noticeable wear, and if wind and spray tests are successful a Sydney joinery merchant will adopt the method for their windows.

ITEM 9

Item 9(a) Advisory and extension work (DFP)

Over the past 2 years there has been a decrease in enquiries received by Seasoning and Utilization, due no doubt to the increasing activity in the field of enquiry work by both the Forests Commission of Victoria and the Timber Development Association, particularly the former. The increase this year (1966-67) of some 300 in the total for Preservation Section can only be attributed to increasing activity in the industry, and to increasing public awareness of the availability of treated timber and/or treatments generally. This incidentally follows a similar increase last year.

The number of "local" enquiries handled by Preservation and Seasoning Sections is still very substantial. The bulk of the telephone enquiries received are considered to be local, whereas mail enquiries are assessed as non-local. Only these two Sections have been considered as they keep accurate records of all enquiries in categories of 'phone, letter, visitor.

In 1966-67, 57% of the enquiries received by each Section were by telephone; for 1965-66, 55% were by telephone.

Incidentally the Preservation figures show a marked dip coinciding with the entry of the FCV to the enquiry field, as follows:

1960	2102
1961	2148
1962	2614
1963	3134
1964	2823 ⟵ FCV enquiry service commenced
1965	2630
1966	2869
1967	3172

However, in the past 2 years the steady increase has been resumed.

It is considered that redirecting of telephone enquiries is not warranted because (i) in the time taken to give the other contact name and telephone number, the original enquiry may as well be answered and (ii) poor public relations result from shunting enquiries around.

Discussion

Wymond: At past conferences there has been mention of the very high enquiry load that this Division has been carrying. Past discussion has highlighted the fact that we were also handling local enquiries from Victoria in addition to more general ones. On investigating the situation, Mr. Howick and I have produced the interesting figures set out.

Muncey: The total for the whole Division is something of the order of ten thousand per year, but is not precisely clear and in any case depends on definition.

Bryant: Our Preservation Section together with our Information Officer handled three thousand enquiries last year. I should imagine that the figures for our Division as a whole would be approaching those of your Division. Our Wood Structure Section handled some 780 individual pieces of timber for identification in addition to other queries regarding species availability etc.

Watson: 90% of our utilization and wood structure enquiries are by telephone and will average about a thousand a year over the last few years. TDA has been handling more recently. Wood specimens identified would be of the order of three or four thousand, because all specimens coming in for preservative content determination are also identified.

Huddleston: In New South Wales the number of enquiries handled by TDA is steadily mounting. TDA is advertising the fact that it is available to give information on timber, timber usage, and timber availability. They have a small but competent staff engaged on this work. Unfortunately they are not experts and they refer difficult queries to our Division. Although their discussions with our officers may take considerable time, these are not listed as enquiries.

Threader: Are the increases in the Preservation Section paralleled by similar increases in other Sections?

Wymond: Not as far as we can gather. The only other section to keep accurate records is Seasoning Section, and there has been no similar increase there. In fact, in some other sections there has definitely been a decrease, concurrent with your entry into the field.

Threader: When it was first suggested that we enter this field, it was made clear that the Division did not want to lose contact with the public or with the trade, but that it wanted some relief from these enquiries. I believe that the instruction was that outside inspections were to be passed over to the Forest Commission as much as possible. We now get some hundreds of outside inspections and they are very time consuming as apart from travelling, time on the job, and time writing the report, many of them end up in court. This means time consulting solicitors before action, time attending the court waiting for the case to come up, and so on. I therefore doubt whether simple statistics show the real picture. If the Division is still doing outside inspections I wonder whether they are necessary.

We can cope with all the inspections that are offering, as we put just as many staff on as are needed to do the job. Enquiries by telephone and personal visit would number a little over a thousand per year and the inspections only a few hundred although they are very time-consuming. I therefore wonder whether the Division has done all it can to pass this work load over to us. Perhaps the passing of enquiries to the Commission should be pursued a little more vigorously. As a matter of history, CSIRO is very firmly entrenched in this line of business in Victoria, and it is somewhat difficult to obtain a slice of the market. I think we should discuss this to see whether other moves could be made to pass on more work to us. We are quite prepared to do more in this line of business.

Muncey: Did you say that you do not try to avoid court cases?

Threader: No, we don't avoid them, we believe that someone has to provide expert witnesses. People are entitled to the benefit of expert opinion and in many cases we do not know whether it is going to end up in court anyway.

Howick: Since 1963 our policy has been that we do not go out on external inspections unless there is something unusual that we think will benefit us rather than the enquirer. The remainder have been passed over to the Forest Commission.

Huddleston: Our policy in New South Wales is that we only carry out outside inspections when we feel there is something to be gained for the utilization of timber. We do not do borer inspections or anything of that nature unless we feel that we will gain useful information.

If, however, a court case is involved and it would appear that one side or another is going to subpoena an officer of the Division, he is allowed to go out to make an examination.

Ryley: A similar situation applies in Queensland apart from inspections made under the Timber Users Protection Act.

Bryant: We also have two inspectors operating under the Timber Marketing Act who are no longer attached to our Division but attached to our Economics and Marketing Division. They are full time on this sort of inspection.

Harding: We handle about 25 enquiries per week, or about 13 or 15 hundred per year.

We endeavour to provide some degree of outside inspection and for this purpose we have a liaison officer and an entomologist. We do find, however, that a considerable amount of our professional officer's time is taken up by casual enquiries. We also have a series of duplicated handouts and where possible the clerk in the office gives one to enquirers on specific subjects. We ask enquirers if they intend using the information we supply for legal purposes and if litigation is anticipated we will go no further.

Threader: With regard to inspections, preservation would only be number 3 on our list. Seasoning calls would constitute about 50%, utilization 25% and preservation about 17% of our external inspections. It would seem, however, that preservation constitutes the greatest number of enquiries.

Huddleston: I would like to see a closer liaison maintained between organizations so that work is not duplicated and conflicting advice is not given.

Edwards: The preservation sections of the CSIRO and the Division of Wood Technology have very good liaison facilities and particularly successful personal communications between offices in both sections. This results in very little duplication and frequent interchange of ideas.

Huddleston: I would like to see the arrangements which exist in the Preservation Section, where not only is there a close personal liaison but also a free exchange of ideas and correspondence, carried into the other sections of the Division.

If any of the officers of the Preservation Section come into New South Wales to do a plant visit, Mr. Edwards knows about it and very often goes along with them. But we do have officers coming into the State, carrying out an inspection of a plant, writing a report, and the first thing we know about it is when we receive a copy of that report in the laboratory. This is the type of thing I would like to avoid. If you want to visit a plant in New South Wales, we would be very happy to make the arrangements for that visit. We can provide transport and we can probably send along a man who knows the local story in the way that your office wouldn't have any opportunity of learning. By doing this we would keep in closer contact with one another and we would know just what you are advising and the kind of methods you are recommending in our State.

Ryley: As far as Queensland is concerned, arrangements are now very satisfactory. In addition to advising us of correspondence, CSIRO officers now always call in to see us if they are in Brisbane.

Item 9(b) Conference arrangements

Mr. Muncey indicated that the discussion in the Proceedings of this conference would be considerably reduced, and would be reported only where policy or research programme matters were involved. After discussion it was decided to cover discussion on the Preservation items as previously.

With regard to future conferences, Mr. Muncey suggested that consideration be given to holding them at centres other than DFP. It was decided to hold each alternate conference at DFP, the intervening ones being held at places to be decided. The period of approximately 2 years between meetings was considered to be satisfactory.

APPENDIX I

The following four resolutions were carried by the Conference:

Resolution No. 1

This Conference wishes to call attention to the serious problems presented by the heartwood of exotic conifers, particularly in relation to the difficulties of preservative treatment. It notes that active research is proceeding into improved methods of treatment and that suggestions have been made for the location of trees with abnormally low heartwood content and clonal propagation from them. The Conference considers that more precise information is needed as a basis for future research and utilization, and urges that the State forest services take steps to obtain quantitative data on the varying amount and nature of heartwood present in trees of different ages, site qualities and genetic origins.

Moved by Da Costa,
Seconded by Bryant,
Carried

Resolution No. 2

This Conference considers that heart rots in trees used for treated poles and piling constitute a serious hazard to their users, particularly in species of low durability. It urges that steps be taken by the various forest services to obtain quantitative data on the incidence position and nature of heart rots and other internal defects, at least for the major potential pole species and the major producing areas. It also suggests that arrangements be made for the collation of existing qualitative information on heart rots, preferably through the Research Working Group on Forest Pests and Diseases. This resolution to be brought to the attention of the Preservation Committee with the request that they act appropriately.

Moved by Da Costa,
Seconded by Cokley,
Carried

Resolution No. 3

That this Conference considers that continuing inspections are necessary to ensure that no further occurrences of active Hylotrupes attack are present in imported precut houses in Victoria and requests the Forests Commission, Victoria, to use its best endeavours to obtain the the full cooperation of the Housing Commission, Victoria, in adequate inspection and, if necessary, control measures. Inspection of a representative sample should be completed by June, 1968.

Resolution No. 4

Because of the economic significance of the European House Borer, the increasing use of softwoods as a building and furnishing material in Australia, the continuing possibility of entry of this insect and its subsequent establishment and because this insect has been in housing developments in Australia where imported precut houses have been erected, this Conference commends to the Standing Committee of the Australian Forestry Council the national importance of assisting the Commonwealth Quarantine Authorities in preventing the entry of this pest into Australia and of taking positive action to prevent it from becoming established here.

Resolutions 3 & 4 Moved by Beesley

Seconded by Huddleston

Carried

APPENDIX II

REPORT OF THE FIRE RETARDANT COMMITTEE AND SEMINAR ON PROTECTION OF TIMBER IN BUILDINGS AGAINST FIRE

Attendance - Delegates to the Forest Products Conference, and in addition, the following by invitation:

J. Walters;	Public Buildings Dept., South Australia
F. C. Davies;	NSW Board of Fire Commissioners
S. C. Gibbons;	Perth Fire Brigades' Board
C. W. Berkly;	Victorian Dept. of Health
A. Berry;	Building Regulations Committee, Victoria

The topic was introduced by Mr. J. Keough, Commonwealth Experimental Building Station, North Ryde, NSW. (Mr. Keough, in the course of outlining his Station's facilities, showed a series of slides. These have not been reproduced but the text has been adjusted to be as self-explanatory as possible).

Keough: The designing of buildings for fire safety has two aspects. First is the general question of the exercise of commonsense on the part of the designer to achieve a building which is not a fire hazard and which will be a continuing asset to the owner. Second is the responsibility of local government authorities to see that the building does not represent a hazard to the general public and to adjoining buildings. Local government regulations are not intended to safeguard an owner from suffering loss due to fire originating in his premises. Local Government regulations aim to protect the life and safety of persons who might be present in the building and yet have no responsibility for its design, and to protect adjoining premises from suffering damage as a result of a fire which might occur in the building. Accordingly, regulations impose very few restrictions upon single storey domestic residences.

A well written set of regulations will require that surface finishes and structures be able to perform to a certain standard when submitted to nominated tests. If timber can be made to meet these specifications, then the building codes should not discriminate against timber. Certainly some codes rule out materials that are combustible from being used in the structure. This automatically excludes timber because no matter what you do to it, short of petrifying it, you cannot convert it into a material which is non-combustible.

In multi-storied buildings or in complex buildings where local government regulations do apply, you will find that the designer is required to design a structure which will survive the complete burn-out of the contents of the building. In very complex buildings, the designer is required to design the building as a naval architect designs a major vessel. The ship is designed as a series of fire-tight compartments which can be sealed should fire break out in a compartment. The fire can then either be left to burn itself out, or the compartment can be flooded without jeopardizing the rest of the ship. In designing complex, multi-storey buildings each floor slab is required to be able to support its load without collapse and without developing a crack through which flame could pass while all the contents of the floor beneath it are burnt out. The floor must have sufficient thermal resistance to prevent the transmission of heat so that the top side does not reach a temperature which will ignite carpet, lino tiles etc. on the floor surface.

Similarly, walls separating the premises of fellow tenants in a multi-tenancy building, are required to be fire resisting. They must be able to withstand without collapse the complete burn-out of the contents of the compartment, they must not develop a crack through which flames could flow, and they must not transmit enough heat to ignite furniture or combustible material which might be in contact with the wall on the far side.

In order to be able to design such a building, the architect requires to know the properties of the materials which he is going to use, and the properties of the structural members he is going to employ to assemble his overall structure. In order to obtain this information, a series of standard tests have been devised and they are defined in Australian Standard No. A.30 (1958).

The combustibility test is defined in Section 1 of A.30. The cylindrical furnace is stabilized at 750°C and a specimen 2 in. x $1\frac{1}{2}$ in. x $1\frac{1}{2}$ in. is inserted. If the specimen flames or gives off vapours which will flame, or raises the temperature of the furnace by exothermic reaction by 50°C it is defined as combustible. This is a basic property of the material. It can then be submitted to further tests in the form in which it will be used in the building. If it is to be used in a building in a thin, flexible form it has a very high surface to mass ratio and may be a distinct fire hazard.

The flammability apparatus is defined in Section 2 of A.30, and is employed to test fabrics and other thin flexible materials. A strip of the material is tensioned on two brass rails and placed beneath an aluminium canopy. A standard alcohol flame burning 0.1 ml of fuel ignites the base of the material. The rate at which the flame

spreads up 21 in. of the material is timed and the temperatures of the gases in the flue are measured to determine the heat energy released. The material is rated from 0 to 100 in order of flammability depending on rate of flame spread, and the heat evolved.

In Britain, materials for factory linings or factory insulation are regulated, under the Factories Act, on their performance in a test for rate of flame spread on the surface. This test has definite shortcomings. It measures only horizontal flame spread and this tends to eliminate convection effects, and the rate of horizontal spread is almost directly related to the conductivity of the material. We believe that it is not a true representation of the hazard of a building lining and we have made further tests at full scale in a "mock-up" room.

From these studies we devised an empirical test now defined in section 3 of AS.30. It is called the early fire-hazard test of materials. The apparatus used is an incandescent panel burning coal gas and air in 1 in. thick porous refractory concrete. Only the face of the block is raised to red heat. A 24 in. x 18 in. specimen is moved toward the radiator at a defined rate. A small pilot flame located just clear of the surface and at the centre of the specimen ignites the volatiles from the board where, in diffusing with the air, they form a combustible mixture. A thermopile connected to a potentiometer monitors the radiation from the specimen throughout the test.

The trace on the potentiometer is a curve of radiation intensity against time. The record shows (i) the time from the commencement of test till the ignition occurred, (ii) the rate at which the flames spread on the board after ignition, and (iii) the area under the radiation intensity time curve measures the heat the specimen evolved as it burnt. These three functions are measured in the one test, and are used to classify lining materials in order of the hazard they represent at the early stage of the fire. We are working on this test to include a canopy over the apparatus, to entrain all the hot gases that are released in the burning process. These will pass out through a flue and by means of a photo-cell and lamp we will measure the obscuration of a light beam and thus measure the density of the smoke which is released from the boards as they burn. Thus we hope to measure four properties in the one test.

The tests which we have just looked at, the combustibility test, the flammability test and early fire hazard test, were concerned with materials which are combustible. There are other materials to be studied which are non-combustible, but which, nevertheless, are

likely to be damaged by fire. Practically no material we know is "fire-proof", in that if a material is exposed to a sufficiently severe fire for a sufficient length of time it certainly will be damaged.

As exposed steel is heated in a building fire, the yield strength gradually decreases until at about 550°C the strength has fallen to 0.5 of the original ambient yield strength. Our Australian structural code permits a designer to exploit 0.56 of the strength of the guaranteed minimum quality of the steel. Hence steel used to frame our modern buildings must be thermally insulated so that it cannot be raised to critical temperatures. In addition, steel has a fairly high coefficient of thermal expansion and should be insulated so that a fire cannot cause it to increase its dimensions to the extent where it can induce buckling in the structure and bring about failure by changing the stress distribution.

We have tested many types of fire doors, and some years ago tested the first of a new type in which about 15% of the door is timber, the core is asbestos board or other insulating material, it is faced with plywood impregnated with fire retardant chemicals and edged with thin timber stripping. This enables the door perimeter to be planed down to fit the door frame when it is swung. These doors look well, they have all the advantages of the timber finish, and they do not have the disadvantage which steel doors have of buckling badly when they are heated. Ten years ago none of these doors existed in Australia, but today about 95% of the fire doors fitted in buildings are of this type.

Among structures we have tested are load bearing timber floors and timber roof structures. Among the latter is the traditional timber-framed pitched roof, covered with terracotta tiles, sarked with the usual aluminium foil sarking, and with a fire barrier ceiling fixed beneath it. We have tested many of these ceilings over the years and now eight different types of ceiling can protect this type of roof to a level which enables it to qualify for a 1-hr fire resistance rating. This allows timber framing to enter a field from which it was previously excluded, in that it is now permitted as the roof of a three-storey block of flats having several flats on the top storey, the principal being that if the ceiling prevents the timber framing of the roof from being ignited fire will not spread horizontally from the flat in which it breaks out into the adjoining flats.

One of the earlier tests was on a structure which failed to pass the 1-hr. test. Failure occurred at 59 min., although at 58 min. performance was perfect. Within 1 min. the whole of the ceiling had fallen away due to the fact that the heat was conducted from the head of the fixing nails up the shank and caused shrinkage of the timber surrounding the nail shank. The nails lost their withdrawal strength and enabled the whole ceiling system to fall. By increasing the length of the nail shank by $\frac{1}{4}$ in. we were able to get the structure to pass in the next test. These fire resisting structures cannot be described in a few words. There are detailed specifications which must be fulfilled if we are to achieve the desired level of performance. In this case the choice of the wrong length of nail was sufficient to bring about failure.

Report of fire-retardant committee*. - At the last Forest Products Conference, the Committee submitted a brief report of the results of some early burning tests on Australian building timbers and on two hardwood species and two softwood species impregnated with commercial loadings of proprietary fire-retardants. These results have now been more formally presented in a report prepared by Mr. A. W. Moulen of C.E.B.S. under the title of: "Survey of Ignition and Early Burning Properties of Australian Timbers". The publication of this report brought to a halt the initial work of this Committee.

Within the Division of Forest Products, three Sections are directly concerned with the fire resistance of timber and timber structures. The Engineering Section is affected by building regulations which limit the use of timber for certain types of construction, so also is the Section of Plywood & Gluing. The Preservation Section is concerned with the treatment of timber with chemical fire-retardants and their effectiveness. For a number of reasons chemical fire-retardants have not rated high on the research programme of the Preservation Section, and as there was some prospect of results useful to the Committee being obtained incidental to the research programmes of the Engineering and Plywood Sections, I did not push for extra work on behalf of the Committee.

In November, 1966, the opportunity was taken of discussing research into the fire resistance of timber when Messrs. Cokley and Edwards were in Melbourne in connection with other matters. Our deliberations were assisted by Mr. Hirst, from Plywood & Gluing Section. At the time it seemed that:

(i) There was an immediate need for a meaningful acceptance test for plywood treated with fire-retardants (because of the marketing policy of the plywood industry) and there

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* Prepared by J. Beesley.

was some doubt as to the adequacy of the Early Fire Hazard Index (EFH Index) test as prescribed in AS A.30 - Fire Tests of Building Materials and Structures - for this purpose.

(ii) Surface coatings were capable of giving performance results superior to those being obtained from impregnation treatments but surface coatings were (or might be) subject to change through ageing or exposure to dampness. Therefore any acceptance test for surface coatings would have to accommodate this change.

(iii) Acceptance tests for plywood required to have a high resistance to fire should also include reference to the adhesive used.

(iv) Research was needed into the health hazards arising from the presence of CCA-treated wood, (a) during a fire and (b) in the ash and other residues remaining after a fire.

(v) There was a need for a standard or test for the fire endurance (i.e. capacity to continue to perform a useful function under exposure to a fire) for solid timber and structural plywood.

As a result of this meeting, the Chief of the Division was asked to indicate the extent to which the Division might participate in the research needed to answer the questions raised. In his reply the Chief indicated that the Committee should furnish a report to this Conference, touching upon a number of issues including the aims of the Committee, the degree of improvement attained by current commercial practices, the chances (as guessed) of further improvement and work planned. He recognized that answering these questions might cause some further delays, but significantly added, "on the evidence presently available to me, the quest, as I see it (a method of reducing early flame spread on ply or other wood panelling to be later capable of taking a clear finish) may not have an attainable goal. If the chances of success be negligible, then perhaps we should not spend more time on the idea".

The Committee met again in March of this year and agreed that the work so far completed should be published and that the time was opportune for a general discussion on the fire-resistance of timber and timber structures to which a wider audience than the Forest Products Conference should be invited, subject to the approval of the Chief of this Division. The Committee was persuaded that the most pressing present need was to improve the ignition and spread of flame characteristics of plywood, timber linings and decorative woodwork and that this need was more urgent than that of improving the fire-resistance of structural, load-bearing members.

Unfortunately, no further research work has been undertaken but the Committee considers that there is scope for useful investigations into the economic loading of fire-retardant chemicals; the reasons for the apparently better performance of fire-retardants in softwoods, when compared with hardwoods; the maximum EFH Index which should be acceptable under Timber Marketing legislation; the relationship between species and retention of fire-retardant when considered in terms of EFH Index.

In short, how important is it to improve the fire-resisting characteristics of timber and plywood and in what direction should our efforts be now directed?

Discussion

Beesley: The Fire Retardant Committee was set up by a previous Forest Products Conference for the purpose of coordinating the various items of research into fire retardants and to try to get some uniformity of recommendation between the Commonwealth Experimental Building Station, Queensland Department of Forestry, NSW Division of Wood Technology and Division of Forest Products. When our Committee first met it was obvious that we lacked factual information and, with the assistance of the CEBS, we were able to establish early fire hazard indices in accordance with AS A.30, for a number of common Australian building timbers. We included in that test 2 hardwoods and 2 softwoods impregnated with commercial loadings of commercial fire retardants. The tests established that the impregnation had a beneficial effect.

For various reasons we were not able to continue with that investigation and concentrated on the failure under fire of large-section timber beams and on plywood and plywood panels. The general programme on commercial timbers has not been carried on. The main problem is as stated on the last page of the reprint: "How important is it to improve the fire resistance characteristics of timber and plywood and in what direction should our efforts now be directed?"

Keough: I would like to query item (i) at the foot of page 1 of the Committee's report: "that there was need for a meaningful acceptance test for plywood, as there was some doubt as to the adequacy of the Early Fire Hazard Index test". The test was devised to simulate the conditions during the early stages of a fire in a building. It measured the ease with which linings can be caused to ignite; the rate at which they will assist the spread of the fire; and the heat they evolved to contribute to the further development of the fire. I feel that this is a meaningful test, as applicable to

plywood as to other materials. There is an unfortunate tendency for people closely associated with timber to feel that timber needs special treatment, and should not be made to conform to the requirements that we have for all other lining materials. If a test is suitable for grading lining materials, it should be quite suitable for testing plywood.

Hirst: In administering State Acts, at what point should plywood be accepted as "fire-resistant"? Could Mr. Keough indicate the purposes for which an impregnated sheet of plywood with an Early Fire Hazard Index of 48 could be used?

Keough: It is not so much a query of the test, but an interpretation of the scale by which the test grades materials. In Britain, the Standard grades materials into classes 1, 2, 3 and 4. In Australia, we grade material in order of hazard from 0 to 100. It is then up to each regulating authority to decide upon what level of safety it will insist. This level can vary from time to time depending upon the economic welfare of the community. In an affluent society we can insist on materials with a zero hazard classification, but if this represents an economic hardship the level might be raised to 30 or 40. In New South Wales in buildings higher than 150 ft, authorities regulate the types of materials which can be used to line lift cars or fire escape stairs on the basis of this test.

Bryant: I would like to comment on the work published by Moulen. It appears that the only timber which shows any promise of a satisfactory reduction in Early Fire Hazard Index, was P. radiata. The percentage of chemical which is required is so high that the treatment would be quite uneconomic except in special cases.

Muncey: What information is there about how thick (3 in.) pieces of timber stand up to fire and for how long do they stand up?

Keough: Some time ago, it was suggested that we have a look at this question and DFP supplied some heavy beams, and some laminated pine beams. We have carried out two pilot tests, using thermocouples protected by wooden dowels inserted to different depths in various parts of the beam. Both section and strength properties were changed to such an extent that, at the end of 80 min., a precisely engineered beam would have collapsed. The reason why timber beams so seldom appear to fail in fires is that they are so much bigger than is necessary, due to the lack of knowledge of precise timber engineering. The work that is done on engineering design by people such as DFP the more unlikely it becomes that beams of this sort will survive fires. This work has shown that hardwoods appear to be destroyed at an average

rate of about $1\frac{1}{2}$ in. per hour and softwoods at a rate of $1\frac{3}{4}$ to 2 in. per hour. However, the change in the physical properties of the remaining timber is also important.

Jacobs: What happens to wood when it is not charred but when it is heated to over 400°F?

Keough: Quoting data from two "one-off" tests, the cores from two test beams were handed to Division of Wood Technology for tests. They managed to get two reasonable beams out of each of those cores and carried out tests which yielded the following information:

Denison toughness of original beam was 177 in./lb after fire exposure this was reduced to 63% - 112 in./lb. Izod impact of the control sample was 11.5 ft/lb after burning this was reduced to 78% or 9 ft/lb. Maximum compressive strength parallel to the grain of the control sample was 10,900 lb/sq in. and this was reduced to 78% or 8,540 lb/sq in. after burning. Maximum shear strength parallel to the grain was 2800 lb/sq in. for the control and hardly altered (96%) - 2,700 lb/sq in. - on the tested sample. In static bending, the modulus of rupture went from 23,100 down to 61% or 14,100. The modulus of elasticity went from 2.71×10^6 lb/sq in. down to 70%. The stress at proportional limit went from 12,400 lb/sq in. down to 69%. The moisture content went from 14.5% down to 5%. Density at the stated moisture content went from 61 lb/cu ft down to 53 lb/cu ft (i.e. 87%).

Huddleston: I would like to emphasize that those figures represent the permanent reduction in strength at atmospheric temperature. There is another very substantial reduction due to the elevated temperature of the timber under the actual fire conditions.

Hornibrook: In Queensland, we find that local Authorities are quite prepared to have, in a building, unprotected steel that will collapse with fire in preference to timber that will, apparently, stand for longer. Therefore, we are more concerned with obtaining acceptance of our product by local authorities than with the physical performance of a piece of timber in a test.

I think that the Fire Retardant Committee should take note of the attitude of these local building authorities to timber and should look into the question of gaining acceptance for timber under circumstances where it will perform as well as steel or reinforced concrete.

Keough: Exposed structural steel is more likely to suffer fire damage than an over-designed timber frame. I say "over-designed" because, as you develop stress grading and other techniques of timber engineering, timber structures are going to become more vulnerable to fire damage. The steel people face up to this and where fire resistance is required in a structure, they recommend that you encase the steel with a thermal insulating material. This is what timber will have to do, if it wishes to get into the field of multi-storey framed structures from which it has been excluded fairly reasonably by building authorities. In the case of single-storied factory-type buildings, I agree with you that it is unreasonable for building authorities to differentiate between timber and exposed steel.

Huddleston: What are Mr. Keough's views on the proposition that we could get the necessary fire rating for timber structures, by increasing the size of our timbers by, say, 3 in. in each dimension, assuming that timber burns at a uniform rate of $1\frac{1}{2}$ in. per hour.

Keough: If you can afford to over-design to the extent of 3 in. in hardwood, and 4 in. per member in softwood, you would only get a 1 hr rating in large members.

Building regulations require a major multi-storey building, to be a series of discrete fire compartments each capable of surviving the burn-out of the contents.

The philosophy that the building regulation authorities adopt is that a timber structure is not to be relied upon to survive the burn-out of the contents because it is likely to be ignited and then to destroy itself.

Berry: I am connected with the Victorian Building Regulations Committee. We are working on bringing the regulations up to date and are collaborating with the Commonwealth Experimental Building Station. We are contemplating putting something in the regulations regarding what is known as "heavy timber construction". This has been in Canadian and American books for many years. We are considering incorporating designs for a 1-hr or 45 min rating as a maximum.

Davies: Most of these experiments deal with the structural strength retained in heavy beams and members. Is there any appreciable distortion in timber, as there is with steel? Have any experiments been made with encased timber, as is done with steel?

Keough: I will answer the second part of the question. We have carried out quite a number of experiments with encased timber members. There is a 1-hr rating for timber beams encased in fibrous plaster, a rating for timber beams encased in asbestos board and for timber beams encased in pre-cast vermiculite concrete - all established in the last couple of years.

Walters: Modern surface finishes generate a great deal of smoke in a fire and asphyxiation due to this smoke is responsible for much loss of life. In most multi-storied buildings, this smoke is very efficiently circulated by air-conditioning systems. It might be profitable to investigate the burning properties of some of these finishes and their effect on the generation of smoke, particularly in confined areas and institutional buildings.

Edwards: In Queensland and New South Wales there are Timber Marketing Acts which require the Forestry Commissions in those States to issue registrations for fire-retardant treatments for timber where this timber is to be offered for sale as treated with a fire-retardant. What we want is an acceptance test which could be used to supervise the sale of this treated timber and which would bear some relation to the Australian Standard test.

Keough: The Underwriters Laboratories of Chicago established that when timber burns in a building fire it produces considerable volumes of CO, rather than CO_2, which soon raises the level of the atmosphere to a lethal point and the production of CO in fires is a major cause of death. The products of combustion of CCA treated timber are not likely to be of sufficient volume to be more lethal than CO.

Jacobs: There are a number of reasons why research into chemical fire retardants has not rated high on research programmes but there are some prospects that this work could be extended.

The Committee was persuaded that to improve the ignition and spread of flame characteristics of plywood and decorative woodwork was a more urgent need than the preservation of the load-bearing members. There may be other points upon which the research bodies would like some direction.

Berry: In US. they call timber non-combustible if treated in a certain way. Can we have some information on these treatments?

Also, I am interested in shipping crates, bins and pallets. In some cases these are stored in very large quantities in factories and represent an enormous fuel load. Is it not possible to treat the timber in some way to make it fire resistant?

Davies: How permanent are retardant treatments? For example, after an impregnation treatment of fruit crates, would any chemical remain after 12-18 months of ordinary service? Would it be economical and reasonable for the timber industry to ask people to do this simply to use timber?

Edwards: The only treatments which would be satisfactory for pallets and shipping crates are pressure-impregnation treatments, but the fire-retardant chemicals which would be used are, unfortunately, likely to be leached out if freely exposed to the weather. Therefore, we cannot see any satisfactory solution to this.

I think that the efficiency of a fire-retardant impregnated into a wall panel, for example, could be completely destroyed by subsequent surface finishes.

A number of surface fire-retardants are available. Some have been accepted by the Chief Secretary's Department in New South Wales but the important thing is what happens to them after they have been put on and, most importantly, what are the economics of the process?

Keough: The role of most fire-retardant surface coatings for timber is to release a gas which will form a non-combustible mixture with the volatiles from the timber. At the stage at which the gases are released, a gel is also formed, and the action of the gases on the gel is to form a foam. This builds up an insulating layer of cellular charcoal. If you apply over the top of this a paint which sets hard, it will tend to resist the foaming of the gel and will reduce the intumescence. There are also certain types of surface finish which allow flame to spread very rapidly, independently of the substrate.

The only partitions which are regulated by Local Government Authorities are those which (i) enclose public corridors connecting to fire escape stairs; (ii) surround fire escape stairs, lift wells and air-conditioning shafts, and (iii) separate tenants on the one floor from each other. Authorities make no attempt to control the type of partition which a tenant erects within his tenancy. In any big city building, less than 10% of the lineal feet of partition falls under building control. The other 90% is completely at the choice of the tenant or architect.

Therefore, you are worrying about less than 10% of the partitioning in major public buildings and this is a very small fraction of the total partitions in buildings. Let us not lose our sense of perspective, and chase something negligible.

Berry: If partitions to public corridors and partitions between tenants etc. are in one sort of material, the architect or owner will not want a different sort in the rest. He will try to standardize on the lot, and will want all to look the same, so that any partition can go in any position.

Bryant: Would that not be too expensive? In Sydney, it is cheaper to use wood or panel products in areas which are not controlled by the by-laws.

I agree with Mr. Keough, that you are chasing rainbows. I think that this work reported by Moulen indicates that the amount of chemical fire-retardant you have to put into timber to get a reasonable figure is too high. It seems to me that Mr. Hornibrook has raised the only serious problem, and that is a local one. All the States except Queensland have recognized that if you can build single-storied buildings cheaper in timber, you should be allowed to do so. TDCA will have to fight a bit harder if this is not the case.

I think that we must have a closer look at ways of combining timber with materials which will retard the spread of flame, specially as cladding for beams. I do not know what to suggest, nor do I know how my Division can contribute.

Jacobs: Should there be more work by the Building Station on this question of burning beams?

Huddleston: I would like to see more work on fire rated structures. The Building Station has produced a 2-hr fire rated ceiling and a 1-hr fire rated partition, and it has produced a number of rated beams by enclosing them in various materials. This is a more promising approach than an investigation into what happens to a beam when we burn it. How do we combine timber with other materials which will give this type of compartmentalized building which is required by building regulations for fire protection? The fire rated partitions and the fire rated ceilings have been the result of a cooperative project between the fibrous plaster industries and the timber industry through the TDA of New South Wales.

Keough: Who's responsibility is it to do this work? Overseas forest products research laboratories tend to concentrate on a study of bare timber but industrial concerns tend to adopt a more practical approach, recognizing that timber does burn and setting about giving it some protective coating, just as the steel people give steel protection.

The ratings so far developed for timber structures have been the result of cooperative tests at the Building Station with people who have wanted to promote their own products and timber has benefitted incidentally.

Huddleston: The timber industry, just as much as the fibrous plaster industry has a very great interest in this type of structure and I believe that the timber industry should be actively pursuing the development of these fire rated structures based on a timber frame. Before we put this matter to the Timber Development Associations we need suggestions for the type of structure for which we want a rating. Once we get that suggestion, it then becomes a matter of approaching the TDCA and the makers of the other materials to put up the money, and then ask the Building Station to do the work.

Keough: I think it would be advantageous for the Timber Industry to have a demountable fire barrier partition which could be used for lining corridors and separating tenancies. The only type of timber barrier we have at the moment is 3 x 2 studs at 18 in. centres faced on either side with some sort of a board; this is not readily demountable. The regulations require the partition to prevent the passage of fire from one tenancy to the next. There is no reason why it should not be exposed timber. The Canadian authorities will accept as a partition having a 1-hr fire rating, a solid timber partition $5\frac{1}{2}$ in. thick and a floor $5\frac{1}{2}$ in. thick.

Huddleston: We might look at thin plywood partitions backed with copper or aluminium foils as a means of providing a fire rated partition.

Keough: The technique of fitting a metal facing to timber is effective in preventing fire, if the heat is applied locally so that the area not receiving heat is relatively greater than the area receiving heat.

Bryant: I would still like to pursue this question of fire insurance rates. I am not sure that this new fire report form is going to give us the sort of information we want.

Jacobs: The question of the imposition of insurances on timber houses is catastrophic. From the point of view of the owner, it is cheaper to build a fully brick house.

Huddleston: Overseas statistics prove that the loading against the timber house is unjustified, and some statistics from this country also confirm this. In New South Wales the timber industry runs its own insurance company, and we should urge the timber industry to run an insurance company to insure timber buildings.

Jacobs: We have had positive suggestions for improving timber by combining it with other materials and for improving the performance of plywood by facing it with metals. What other suggestions have we for improving the fire behaviour of wood?

Harding: I still believe that there is something to be done with respect to preservative treated timber, which is very important in a number of structures. I think that there is a definite need for work on a preservative treatment which does not carry the disadvantages that CCA does carry.

There is an increasing amount of treated timber being used in buildings and we ought to know something about the significance of this in relation to fire in buildings.

Muncey: The Fire Retardant Committee represents various groups and should look into this.

Jacobs: In their report the Fire Retardant Committee indicates that they consider that there is scope for investigations into the economic loading of fire retardant chemicals, and hoped that this question would be discussed by the Conference.

Would there be general agreement that we support this survey by the Fire Retardant Committee?

Harding: Much mention has been made of the fact that fire retardant chemicals will leach. There are two situations where these preservatives will be used. One where leaching is virtually absent, and the other where it is a major factor. I do not think that we should consider these two together. I think they should be examined separately.

Brown: Some surface coatings are very inflammable, and it might be worth while grading these.

Keough: There was a CEBS document published in 1957 (Special Report No. 18) which listed results for a lot of surface finishes and fire retardant types of coatings.

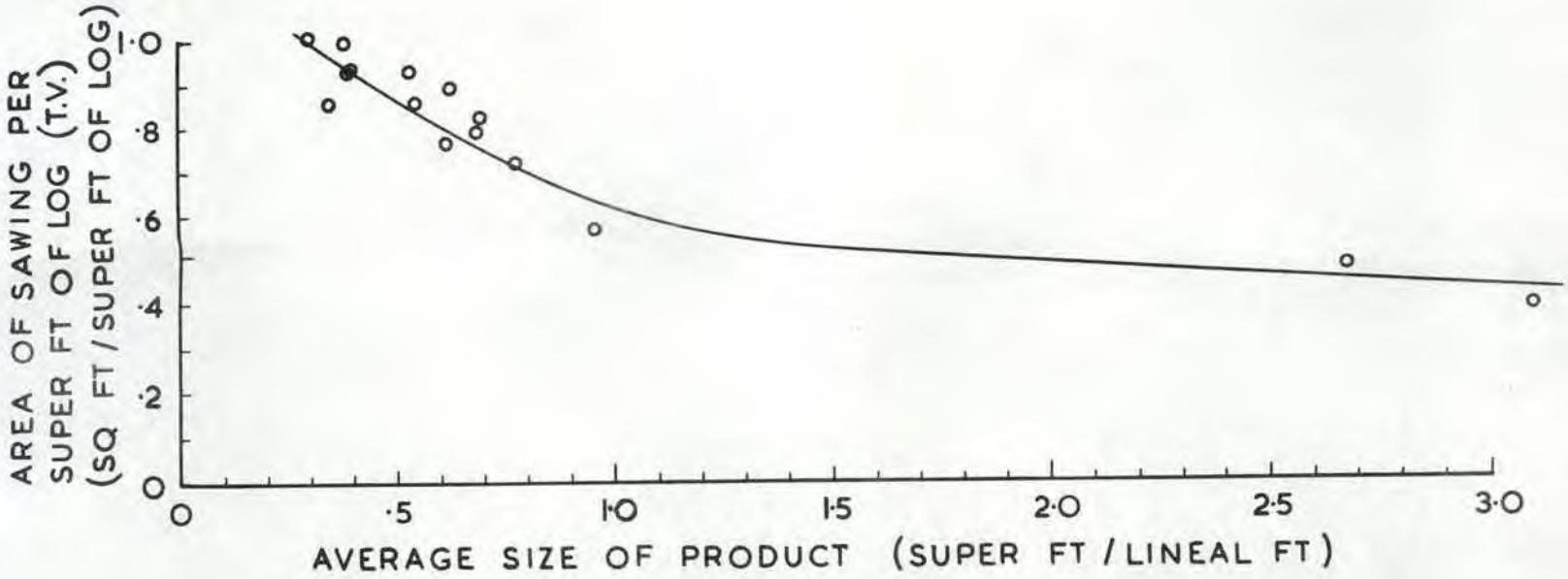
Bryant: Isn't CSIRO doing some work on the use of vermiculite coatings? I wonder whether the Fire Committee could be enlarged by inviting a member of the Building Research Division to join it? The most significant thing that has come out of this meeting is that we should concentrate on the fusion of wood with other materials and it may be that we need the infusion of new blood into the Committee from that Division.

Keough: Some time ago, Mr. Gottstein submitted to us a sheet of plywood faced with vermiculite. This thin film certainly served to insulate the sheet to a certain extent but finally it cracked and allowed all the volatiles to escape at once and we got quite a severe fire from it.

Gottstein: This was a vermiculite paper which gave a flame spread rating of zero but because of its remarkably soft and glossy surface it was most difficult to glue.

Walters: There seems to be a certain prejudice amongst the lay public and authorities against the use of timber. Any further tests which are done on fire retardant timber panels should be comparative tests between timber and other materials which would have the same purpose or function, so that real comparisons could be presented to the authorities. Until this is done, the existing prejudices will persist.

Davies: I am happy to see that the investigations do take into account the ultimate aim of a fire retardant process in providing a non-combustible material, but I hope that the process you do evolve will not result in the generation of noxious fumes.


AREA OF SAWING PER SUPER FT OF LOG (T.V.) (SQ FT / SUPER FT OF LOG)
1·0
·8
·6
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0
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1·5
2·0
2·5
3·0
AVERAGE SIZE OF PRODUCT (SUPER FT / LINEAL FT)

FIGURE 1