C.S.I.R.O.

Forest Products Newsletter

1954##196

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THE PURCHASE OF ELECTRICAL MOISTURE METERS

In recent months the Division of Forest Products has been approached a number of times by purchasers of imported moisture meters which have not been provided with correction figures for use with Australian timbers. Some of these meters had been provided with separate scales for each of the timbers commonly used in Europe or else had been calibrated for use on a European timber such as beech. Although we have published correction data for nearly 200 Australian species, we have not generally been able to help inquirers. This is because our figures are applicable only to meters calibrated for Douglas fir, which is the species on which moisture meters produced in this country have generally been calibrated.

The resistance type of electrical moisture meter, which includes most of the meters used in this country, usually meets the following obvious requirements:

(1) The range of moisture content measurement should be adequate.

(2) The accuracy should be within certain limits.

(3) The instrument should be as light and as portable as possible.

A less obvious but perhaps more important requirement is that the meter readings should be capable of extension to cover all the species of timber which the purchaser may desire to test.

Species correction data provided in the Division's Trade Circular No. 50, "Testing Timber for Moisture Content" (in press), apply only to resistance-type moisture meters calibrated for Douglas fir and using either the twin-blade electrodes with spacing and penetration of about $1\frac{1}{2}$ in. and $\frac{3}{8}$ in. respectively or the four-needle electrode assembly with spacing and penetration of about $1\frac{1}{4}$ in. and 5/16 in. respectively. If the buyer decides on an instrument conforming to these specifications the data provided in the above Trade Circular can be used to extend the range of usefulness of his meter to cover nearly 200 species.

As mentioned above, many resistance-type meters of English and European manufacture are calibrated for timbers other than Douglas fir. If the purchase of such a meter is considered, the buyer should satisfy himself that the necessary correction data for all the species to be tested are supplied with the instrument, because the data supplied in the Division's Trade Circular are no longer applicable.

Correction data for the capacity-type moisture meter may depend on species, density, or both, according to the design of the instrument. As this fact complicates the compilation and application of reliable data and as the Division is not in a position to supply such data, this type of meter is not generally recommended unless the manufacturer can supply all the information necessary for its effective use.

Sawing—In Quest of Efficiency
Part I

By D. S. JONES, Utilization Section

RESEARCH workers in various countries are studying problems connected with the sawing of wood, and many of their findings have a significant bearing on Australian sawing practice. The results are reaching Australia in scientific publications, but the men in the sawmilling industry have not had ready access to this literature. It is desired to bring the more important conclusions reached through scientific research to the notice of the Australian industry and to discuss, as far as possible in a practical manner, how these conclusions bear upon the everyday problems confronting the Australian sawmiller and saw doctor. References to the literature from which the results quoted in this article were extracted will be given at the end of the series.

A number of the facts pointed out herein as having been revealed by research will, of course, be common knowledge to many sawyers and saw doctors. This is inevitable because in the course of evolving their practices most sawmills, especially in the early days of operation, become simple research centres themselves. These mills by a process of trial and error gradually develop methods which are found to be effective under their particular operating conditions. Quite frequently the results they obtain are applicable in a general way to sawing problems wherever they exist. When this occurs the sawmiller has discovered a fact with which the findings of the research scientist will agree. It often happens, however, that the sawmiller thinks a certain method or condition gives him the best results, but because of his limited time and facilities he does not know that something else he has not thought of, or is not able to try, would give him better results. The research man usually has opportunity to study the influence of a large number of factors and may be able to suggest improvements.

This point can be illustrated by an example. Suppose a sawyer feels that the saws used in a No. 1 breast bench do not cut as efficiently as they should. He discusses the problem with the saw doctor, who modifies the tooth profile of the saws until they cut much better. The men concerned are then satisfied that a satisfactory condition has been reached. However, the fault may have been not in the tooth profile, but in the saw speed. Had the pulleys been changed to speed up the saw much better cutting might have been obtained without alteration in tooth profile than was obtained with a tooth profile alteration and no change in speed. A knowledge of scientific research results related to the significance of saw speed on cutting efficiency might have indicated the trouble at once.

Even when research results are available, a certain amount of trial may be necessary in applying them to specific practical problems. This will become evident in later discussions, when some suggestions will be given on trial and error methods that might be employed by the sawyer to improve the efficiency of his sawing.

It is interesting to consider the various ways in which a slight improvement in efficiency might help the sawmiller. Suppose, for example, it was found that the hook angle on the teeth of his circular ripsaws could be increased from 15° to 30°. This would probably effect a power saving of about 10 per cent. Firstly, then, if there were no shortage of power in the mill but power had to be paid for (either directly to the public supply authority or indirectly through fuel costs), a 10 per cent. saving in the power consumption of one or two machines would significantly reduce the sawmiller's annual power bill. Secondly, many mills are powered by a diesel electric, diesel mechanical, or steam plant. It is not unusual for mills which have been enlarged since their original installation to be often operating right up to the power limit, and sometimes even to be short of power. The extra power effectively made available by a 10 per cent. saving on one or two machines would certainly help to relieve the situation. It might mean, for example, that a bench or breaking-down unit could operate continuously. Thirdly, on an independently powered machine, if the sawyer often found that his cutting rate was limited by a power deficiency in the saw motor, the increased hook angle would effectively allow him 10 per cent. more power to handle the difficult cuts. Lastly, if there were no shortage of power, the sawyer might instinctively increase his output owing to the improved cutting efficiency. His cutting rate would rise approximately 10 per cent., and with a No. 1 breast bench, which quite often controls the output of the whole mill, the corresponding production increase might be significant.

Machines for Conducting Sawing Research

Machines used in conducting sawing research generally comprise a saw and motor and a powered mechanism to feed timber into the saw. A common practice in circular sawing research has been to modify a breast bench so that the speed of the saw can be easily altered and the timber fed into the saw by a cable, the speed of which can also be adjusted. Instruments are installed to measure the saw and feed speeds and the power consumed by the saw and feed motors. The power absorbed by friction is eliminated from the results by adopting special techniques. Two laboratories that use this type of equipment in their circular sawing research are the Forest Products Research Laboratory, Princes Risborough, England, and the Central Research Institute for the Mechanical Wood-working Industry, Moscow, Russia. Figure 1 is a photograph of the machine used at Princes Risborough.

Machines used in Canada and the United States of America are of larger proportions, a breaking-down saw and carriage being employed.

Quite often other measurements are made besides saw and feed speeds and power. For example, at the Forest Products Laboratory, Ottawa, Canada, the vertical and horizontal forces on the saw shaft are measured. This information is valuable because it indicates the magnitude and direction of the resultant force on the saw, which allows a study of the forces existing on individual teeth.

The above examples have been drawn from research on circular saws, but the same principles are applied in studying band, frame, or chain sawing.

Some investigators, particularly when studying the effect of tooth shape on the efficiency of sawing, prefer to work with one tooth or one set of teeth only. One method of doing this is to clamp a tooth to a rigid weighted pendulum and allow it to swing into a small

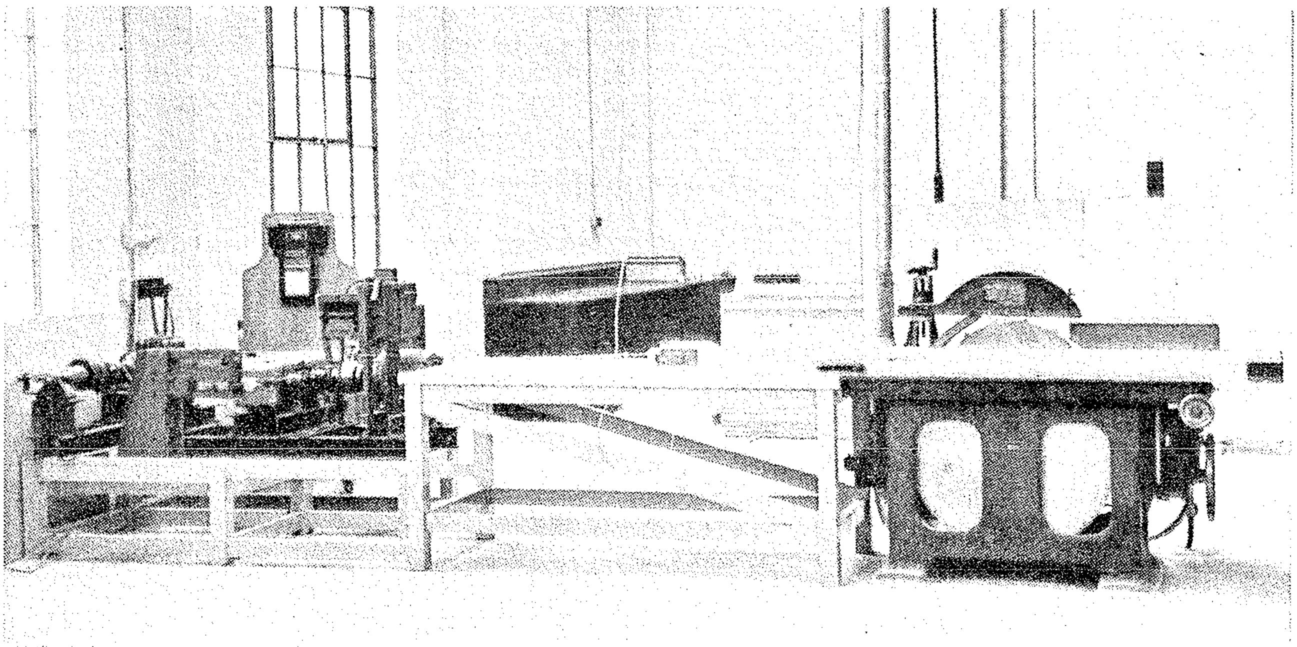


Fig. 1.—Experimental sawbench and feed gear used at Forest Products Research Laboratory, Princes Risborough, England.

piece of wood firmly clamped at the lowest point of travel of the pendulum. Various tooth efficiencies can be compared by measuring the height to which the pendulum swings after cutting through the specimen. This type of instrument is called a pendulum dynamometer. Work has been done with this

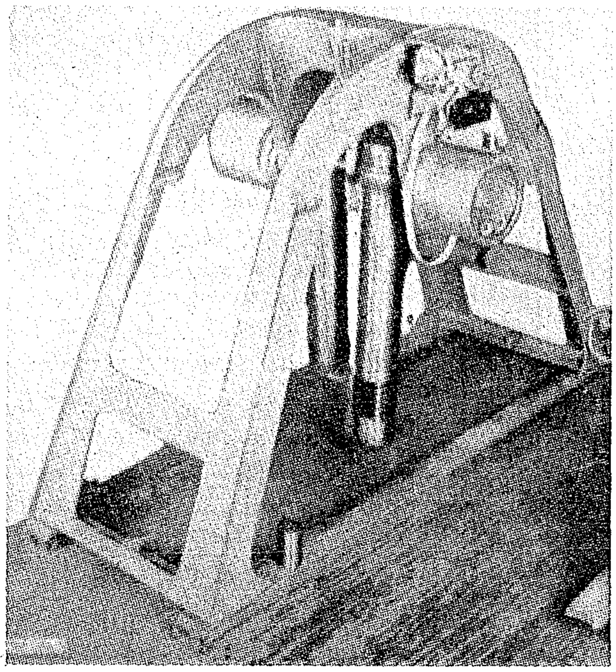


Fig. 2.—Pendulum dynamometer developed for cutting tests in the Forest Products Laboratory, Madison, Wis., U.S.A.

equipment in France and the United States, and laboratories in Norway and Sweden have collaborated in work with a pendulum dynamometer. A photograph of the pendulum dynamometer used at the Forest Products Laboratory, Madison, is shown in Figure 2. Instead of being fixed below the pendulum the specimen is fitted into an opposing pendulum. This provides twice the cutting speed of a single pendulum.

Influence of Tooth Shape on Cutting Efficiency

In the following discussion on tooth shape, the effect of hook angle, clearance angle, bevel angles, and gullet volume and shape on the cutting efficiency of the saw will be discussed separately.

Hook Angle

The hook angle on the teeth of a saw is a variable which has a marked effect on the power required to run the saw. Work done at the Norwegian Institute of Wood Working and Wood Technology, Oslo, on circular ripsaws, revealed that when the hook angle was increased from —10° to 30° there was a definite decrease in the power required to run the saw. A further increase from 30° to 40° effected little change. Other laboratories found that with circular saws a hook angle increase from 15° to 30° gave a saving in power of approximately 12 per cent. Making the hook angle larger than 30° rarely improved the efficiency and sometimes diminished it. At the Forest Products Laboratory, Madison, for example, the power required to run the saw decreased about 10 per cent. as the hook angle was increased from 15° to 28°, but then increased again to its original value when the hook angle was further increased from 28° to 41°.

The loss of efficiency with hook angles greater than about 30° is probably due at least in part to the fact that the tooth becomes weakened to such an extent that it deflects under load and vibrations are set up within the tooth which decrease its ability to cut.

For ripsaws a hook angle of 30° appears to reduce power consumption to a minimum. However, the quality of the cut surface deteriorates as the hook angle of a saw is increased. Many sawmillers could increase hook angle without significantly affecting cutting quality, because other factors are producing surface irregularities far in excess of those that would be caused by hook angle alone. Also, there are very few sawing operations which demand a really smooth sawn surface.

Cross-cut saws usually have a negative hook. This ensures smoother cuts and eliminates the danger of the teeth "grabbing" into the timber and tending to throw the saw back towards the operator.

It is considered by many that the correct angle of hook on the teeth of saws depends upon the timber to be sawn. For example, Harris, of the Forest Products Research Laboratory, Princes Risborough, in his "Handbook of Woodcutting", suggests that for frame saws 5° is suitable in hardwoods, 8° to 12° in the milder timbers, and 15° or more for fast-cutting softwoods. For circular ripsaws and wide bandsaws he suggests 15° in seasoned hardwoods, 20° in green hardwoods, and 25° in softwoods. However, before definite recommendations such as these can be made by the Division of Forest Products, extensive studies on common Australian species are necessary. The Division expects to carry out the necessary investigations in the near future.

The National Sawmilling Association, London, suggests in a chart issued recently, that the hook angle on wide bandsaws be increased with increasing feed speed. Specific values of hook angle are tabulated for various feed speeds.

When the significance of hook angle is appreciated by the sawmiller he may experiment with advantage on fairly old saws, and study how the sawn surface quality and ease of cutting in his mill are influenced by an increased hook angle. He could start off at the lower hook angles and progressively grind the teeth to larger angles (within the limits of adequate tooth strength), making sure that an assessment of cutting efficiency was made by the sawyer for each hook angle on each species handled. He could then adjust the hook angle of his various saws to the angle which gave the easiest cutting and at the same time gave a satisfactory sawn surface.

Clearance Angle

With bandsaws, if the saw and feed speeds are known, the clearance angle required for the top of the tooth to clear the surface which has just been cut by the tooth-tip may be readily calculated, and for the common saw speeds and feed speeds it does not exceed 1° or 2°. This calculation, however, does not allow for the instantaneous swelling of the freshly cut wood against the top of the tooth or for splinters and fragments of sawdust rubbing against the top of the tooth. Experiment has shown, therefore, that the clearance angle should be much greater than 1° or 2°.

Harris's "Handbook of Woodcutting" suggests a clearance angle of 25° for the teeth of frame saws. For circular ripsaws Harris recommends 15° for the harder timbers and up to 25° for the softwoods and "woolly" timbers. Clearance angles specified for the teeth of wide bandsaws are 10° for the harder species and 15° for the medium to soft species.

The Norwegian Institute of Woodworking and Wood Technology, Oslo, found in the laboratory that as the clearance angle of circular ripsaws was increased from 0° to 10°, the power required to run the saw decreased, but for angles beyond this and up to 30° the power increased slightly. This increase was probably due to a weakening of the teeth. They therefore recommend a clearance angle of 7° to 10°.

Workers at the Central Research Institute for the Mechanical Woodworking Industry, Moscow, consider that the most efficient clearance angle for circular ripsaws under their conditions is 16° to 17°. They report a higher consumption of power at values lower than this because of rubbing on the back of the tooth, and higher power at values greater than this because of vibration due to the weakened tooth. The quality of the cut was not affected by a change in clearance angle.

The diversity of opinion regarding clearance angle requirements is probably due to the different cutting conditions in the different laboratories.

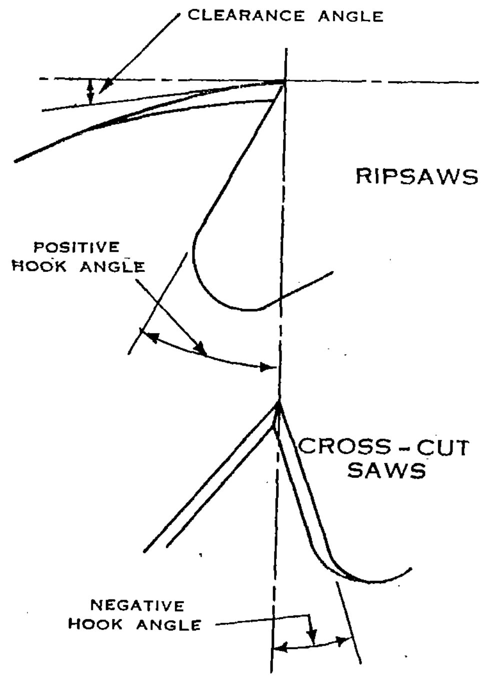


Fig. 3.—Clearance angle and hook angle in ripsaws and cross-cut saws.

Softer woods probably require a larger clearance angle than hardwoods because of the added tendency for the surface freshly cut by the tooth tip to spring elastically against the top of the tooth. Also, clearance angle variations probably have more effect on the power required to feed the timber into the saw than on the power required to cut.

The sawmiller might be able to experiment on his old saws, beginning first with low clearance angles and progressively grinding off to produce higher angles.

Part II of this series will conclude the discussion on the influence of tooth shape on cutting efficiency by studying the effect of bevel angles and gullet volume and shape. Other factors which, together with tooth shape, influence the cutting efficiency of mechanical wood saws will then be introduced.

(To be continued)

DOUBLE-SIDED SAW BENCH GAUGE

RECENT IMPROVEMENTS

By M. W. PAGE, Utilization Section

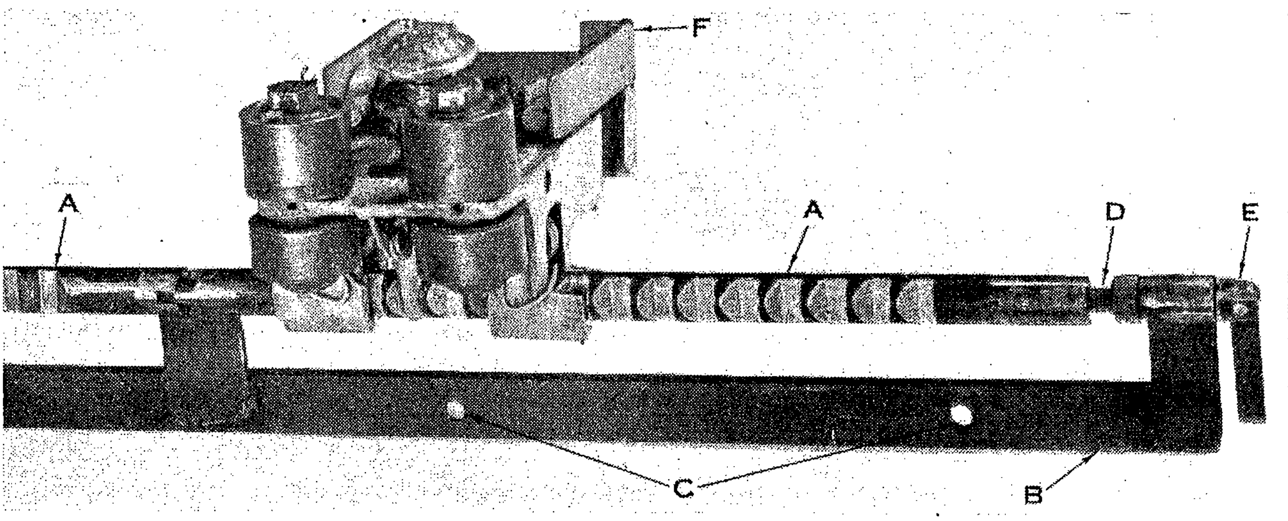
An improved model of the double-sided saw bench gauge described in Forest Products Newsletter No. 192 is now being produced by the Victorian manufacturers.

The new gauge, shown below, consists, as did the previous model, of two main assemblies, the notched bar assembly and the gauge proper. The gauge proper remains unchanged, but the notched bar assembly has been altered to provide considerably more rigidity than did the earlier model. Whereas before the notched bars (*A*) were supported at their extremities by hook-shaped supports on the saw bench frame, they are now carried directly on the bar (*B*) which bolts to the saw bench through holes (*C*). The fractional adjustment screws (*D*) have been moved from below the notched bars to their extremities, thus bringing the gauge proper closer to the supporting holes (*C*). The two notched bars are independently adjustable by the hinged, vice-like handles (*E*), and by this means the gauge is capable of adjustment to any desired fraction on either side of the sawline.

As before, the gauge proper moves readily from one notched bar to the other. Notches are at inch intervals, and all fractions are marked on the hand-piece. In operation the gauge is set with the same motion as one-sided gauges in common use, and has the additional advantage of being movable to either side of the sawline.

The plate fences (*F*) are adjustable to accommodate decreases due to wear in saw diameter, and if required the gauge proper can be removed from the notched bar assembly from either side.

Further information on this gauge can be obtained from the Chief, Division of Forest Products, 69-77 Yarra Bank Road, South Melbourne, S.C.4, or direct from the manufacturers.



THE EFFECT OF SUB-FLOOR HEATING ON WOODEN FLOORS

Summarized by A. P. WYMOND, Information Officer

SUB-FLOOR HEATING as a means of maintaining a comfortable and uniform room temperature, though common in many countries, has not been used to any great extent in Australia. However, in recent years considerable interest has been shown by architects and engineers in this method of heating, especially for schoolrooms and offices and in some cases for private homes.

As little is generally known of the effect of this type of heating on wooden floors, the Division of Forest Products has frequently been consulted for advice.

During 1946 and 1947 the Division carried out investigations on this subject, and in 1947 a report (now out of print) entitled "The Effect of Sub-Floor Heating on 'Ash' Type Flooring", by C. H. Hebblethwaite, C. V. Lansell, and R. G. Skewes, was issued. This report gave details of experiments conducted in conjunction with the State Electricity Commission of Victoria to investigate the behaviour of "ash"-type flooring when sub-floor electric heating elements were used for space heating.

For the purposes of the experiment, a complete floor of average room size (15 ft by 12 ft 6 in.) was laid and a tubular steel electric heating element was installed centrally between each pair of joists and midway between the underside of the floor and the bottom of the joist. These elements were 1 in. in diameter and were continuous for the full length of the joist, being supported over each bearer.

The floor boards were kiln-dried, quarter-sawn 5¼ in. T. and G. mountain ash and alpine ash. The spaces between some of the joists were enclosed by tacking "turnall" (an aluminium reflector sheet) or galvanized iron to the underside of the joists for their full length. This was done to reflect to the floor radiant heat which would otherwise have been lost to the atmosphere.

During the test measurements were made of temperature of the floor surface, temperature in the spaces between joists, moisture content of the boards, and shrinkage of the boards. The rate of power input at the beginning of the test was 10.7 watts per sq. ft. of floor area, but this was later increased to 16.7 watts per sq. ft. in order to obtain greater surface temperature. The experiment was continued over a period of four weeks during which time the heating was applied for varying periods, simulating actual use.

The following figures taken from results of the test give an indication of the temperatures measured:

Period of heating	5 hr
Power input	16.7 W/sq.ft. floor area
Average temperature on floor surface (reflectors fitted under joists)	95.9°F
Average temperature on floor surface (no reflectors)	74°F
Average temperature in air space between floor and reflectors	139°F
Room temperature	73°F
Average moisture content of floor boards at start of experiment	11.8 per cent.
Average moisture content of floor boards after 4 weeks of intermittent heating	Approx. 8 per cent.
Shrinkage	Gaps between adjacent boards increased by amounts up to 1/10 in.

The reduction in moisture content and the accompanying shrinkage are of particular interest. The test established the need for varying the usual recommendation that timber flooring at the time of laying should be at a moisture content midway between the summer and winter conditions.

Under normal unheated conditions, the moisture content ranges generally from 10 to 16 per cent. according to the location and species of timber. When heating is introduced the test shows that drying to 8 per cent. or even less may ensue. Installation of flooring at 8 per cent. moisture content is, however, undesirable because heating is unlikely to be continuous throughout the winter and flooring will tend to pick up moisture while the heaters are not in use. If the period of adjustment is sufficiently long, equilibrium may be reached with normal indoor conditions and in winter a pick-up from 8 to 16 per cent. would cause buckling of the floor. On the other hand, flooring laid at 16 per cent. moisture content would develop large and unsightly gaps when it was dried to 8 per cent. by a heating installation.

Where sub-floor heating is installed floors of "ash"-type eucalypts are recommended to be at 11 per cent. moisture content for Melbourne conditions.

Figures for other species and in other States may be obtained from the Division. The shrinkage and swelling factor may be minimized by laying only fully quartersawn boards, as the factor is less than for backsawn boards. In addition, "cupping" is more likely to occur if backsawn boards are used.

The cramping of the floor during laying is of somewhat greater importance than with unheated floors. If the average moisture content of the boards is somewhat higher than the mean figure recommended, the cramping should be tight, but if lower, then boards should not be cramped tightly, so as to allow for some swelling.

Summary of Conclusions

- Sub-floor heating is a suitable method for providing uniform warmth, especially for schools, kindergartens, etc.
- Heat loss is reduced by the fitting of reflector sheets to the underside of the joists.
- Floor boards should preferably be quartersawn material, in narrow widths not greater than 3¼ in. or 4¼ in.
- Moisture content of floor boards should be midway between the two extremes which will be obtained in service. (Figures may be obtained from the Division.)
- If boards are delivered at the required moisture content, they should be laid and fixed as soon as possible. Otherwise they should be kept in a covered area and well protected with tarpaulins.
- Floors heated in this manner are inevitably subject to movement and some opening at joints is to be expected. This is not of great importance, as a covering such as linoleum is usually used. Excess swelling is to be avoided as it causes cupping of the boards or bowing of the floor.

Obituary

The Division of Forest Products suffered a serious loss by the death on March 3 of Mr. A. J. Thomas, Senior Research Officer in the Timber Utilization Section. "Jack" Thomas joined the Division early in 1932, and rendered valuable service in the fields of timber seasoning and timber utilization. During the war he was seconded to the Timber Control organization and was appointed Assistant Controller (Imports). Subsequently he entered the timber industry and after a very useful and successful seven years, in which his experience was widened considerably, he returned to the Division in November last. He combined with great ability and versatility a candid, friendly, and generous disposition that won him a lasting place in the affections of his colleagues.

Interstate Visitor

On April 8 Mr. B. J. Beggs, an officer of the Western Australian Forests Department, will return to Perth after six months spent in gaining a general knowledge of the research work of the Division of Forest Products. The visit was arranged to further the extension work of the W.A. Department.

Extension of Work to Western Australia

During March, two officers of the Timber Mechanics Section of the Division of Forest Products were transferred to Western Australia to inaugurate a programme of research work at the University, in cooperation with Professor K. L. Cooper, formerly Officer-in-Charge of that Section. The importance of this move and the factors involved in assuring its success will be dealt with in the next number of this Newsletter.

This Newsletter is prepared for general circulation by the Division of Forest Products, C.S.I.R.O., 69-77 Yarra Bank Road, South Melbourne, S.C.4, and will be supplied free on request to members of the timber trade and timber users who wish to keep abreast with current developments in the field of forest products.

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Sawing — In Quest of Efficiency Part II

By D. S. JONES, Utilization Section

IN PART I of this article a description was given of the types of machine used for sawing research, and the influence of hook angle and clearance angle on the efficiency of saws was discussed. That discussion will now be continued with a résumé of the effect of various bevel angles on efficiency.

Top Bevel Angle

Top bevel angle (Fig. 1) is usually applied only to spring-set teeth. Research evidence for the best amount of top bevel is conflicting. The Central Research Institute for the Mechanical Woodworking Industry, Moscow, reports that in its tests on circular ripsaws power consumption decreased as the top bevel angle was increased from 0° to 30°. In their opinion, the only consideration limiting top bevel angle was the blunting of the tooth, and they suggested an arbitrary limit of 45°. The cleanness of the cut was unaffected by a change of top bevel angle.

The "Handbook of Woodcutting" written by Harris of the Forest Products Research Laboratory, Princes Risborough, states that an alternate top bevel of 10° is usually suitable for the teeth of frame-saw blades if they are spring set. For circular ripsaws cutting abrasive timbers it is suggested that the top bevel should not exceed 5°, that it should be 5-10° for dense hardwoods, and

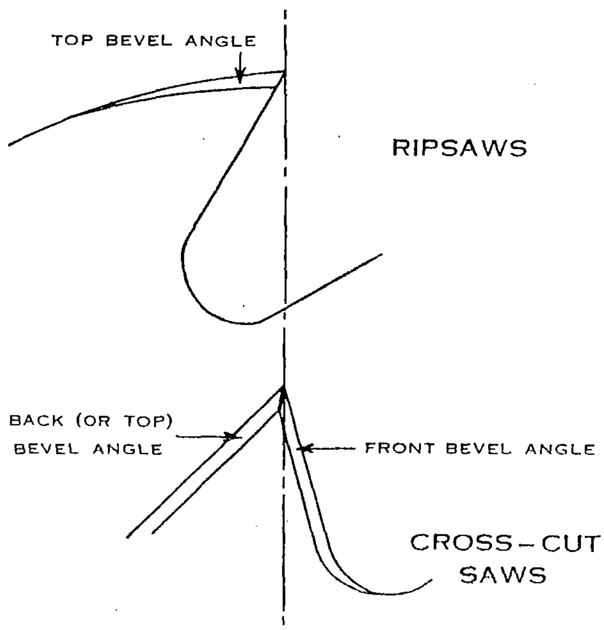

Fig. 1.—Bevel angles for ripsaws and cross-cut saws.

about 15° for the softer species. For cross-cut teeth, the top (or back) bevel should be of the order of 10°.

On the other hand, workers at the Norwegian Institute of Woodworking and Wood Technology, Oslo, found in their experiments that there was almost no noticeable improvement when top bevel angle was increased. They consider top bevel angle is not worth the work done in grinding.

Front Bevel Angle

Front bevel angle is rarely applied except to the teeth of circular cross-cut saws. Harris states that an alternate front bevel of not more than 10° for hardwoods and 15-20° for softwoods should be provided.

is significantly increased by "hogging". The Russians suggest that the top bevel can be ground to as much as 45° without affecting tooth life, and if this is so, the teeth of a normally-angled spring-set ripsaw should be quite durable without hogging. The Division of Forest Products expects to include a study of this subject in its sawing research.

Gullet Volume and Shape

The volume of the gullet must be large enough to accommodate the wood removed by the tip of the tooth under the most extreme cutting conditions likely to occur. When the saw speed, feed speed, and depth of cut are known, it is a simple matter to calculate the volume of wood cut in one cutting cycle by

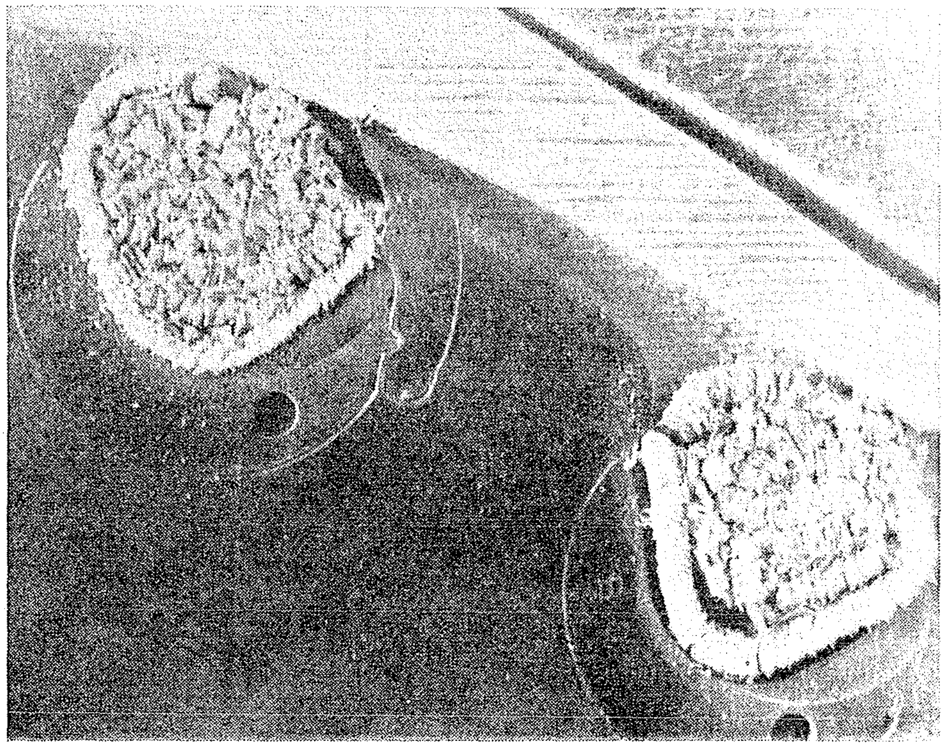

Fig. 2.—Photograph taken at U.S. Forest Products Laboratory of clogged gullets at stalling.

Tooth Hog

Some mention might be made here of the Australian practice of "hogging" the tips of the teeth of spring-set circular ripsaws. Saw doctors feel that the tooth is made more durable by filing back the tip. The writer is not aware of any experimental work being done to determine how cutting efficiency is affected by "hogging", but it is felt that cutting efficiency is most probably impaired. Also, it is doubtful whether the working life of a saw

one tooth and, allowing for the increase in volume of the sawdust over the solid wood from which it was derived, to calculate the minimum gullet volume necessary to carry this theoretical volume of sawdust. Simple rules relating gullet depth to tooth pitch are in common use and if these are adhered to, gullet clogging should rarely occur. A spectacular and interesting photograph, reproduced as Figure 2, was obtained by the Forest Products Laboratory, United States Department of Agriculture, Madison, of the clogged gullets of an inserted tooth circular ripsaw at stalling.

Laboratory workers at Princes Risborough, England, have been able to study the behaviour of sawdust in the tooth gullets of circular saws by using special techniques. To photograph the teeth in action the saw was rotated against a dummy plank on the side opposite the fence, and in this plank was fitted a toughened glass window through which flash photographs were taken of the teeth as they cut. Extremely high-speed flash was required, the flash duration being of the order of 5 millionths of a second. Figures 3 and 4 are examples of these photographs, some of which are printed in Forest Products Research Bulletin No. 27 (1953). The only difference between the cutting conditions for the two photographs was that the feed speed in the first was twice the feed speed in the second. Hence twice as much wood was removed in the first example as in the second.

The action of the sawdust in the gullets was viewed while the saw was in motion by using a stroboscopic lamp timed by a cam on the saw shaft. A description of the motion observed is given in the bulletin mentioned above, as follows:

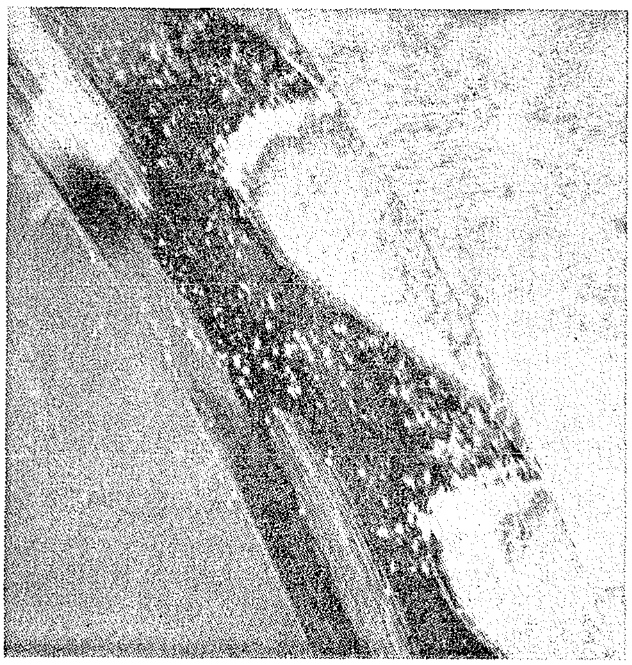

Fig. 3.—Action photograph taken at Princes Risborough Forest Products Laboratory of a 26-in.-dia. saw with 40 swage-set teeth making a cut 6 in. deep at 10,000 ft/min saw speed and 50 ft/min feed speed.

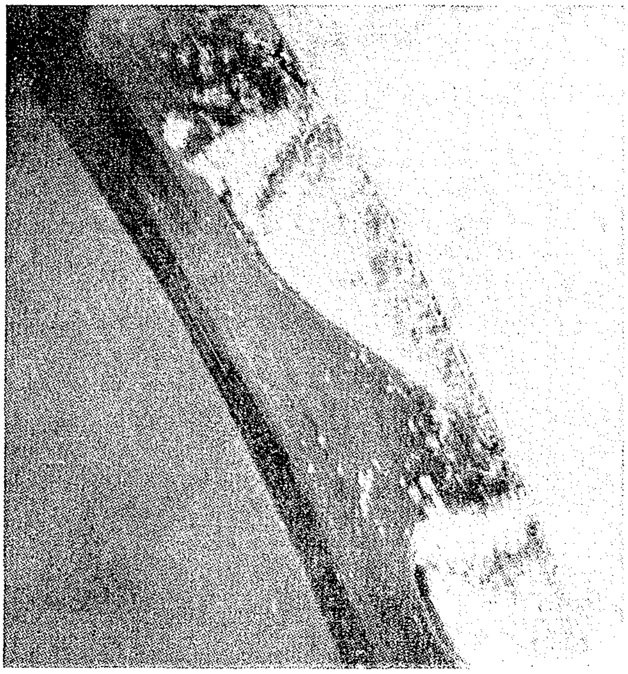

Fig. 4.—The same as Fig. 3, with feed speed 100 ft/min.

". . . As the teeth were seen just before they disappeared below the saw table, the amount of wood that they had cut was approaching the maximum for the cutting conditions employed. Stroboscopic observation showed that the quantity of sawdust retained by the gullet was far less than that anticipated from theoretical considerations. Some sawdust passed out of the gullet from the tooth fronts over the sides of the teeth, but the major escape occurred from the curved portion of the gullet adjoining the tooth front. In general, the sawdust escaping from this part of the gullet appeared to flow in a curved path against the rotation of the saw. It usually passed clear of the base of the following gullet. The movement was very erratic, however, and the sawdust sometimes passed in a shallow curve from one gullet to the next. The quantity of sawdust which escaped increased rapidly as the amount of set on the teeth was increased. A peg-type packing piece was normally employed at table level and the sawdust escaping from the gullets passed unhindered into the exhaust system. There was a considerable build up of sawdust above the more conventional hemp and felt packings. The trapped material tended to pass into the exhaust system by entering gullets spasmodically as they went through the throat piece.

"Nearly all the sawdust found in the gullets was held by the motion of the saw against the tooth front and the curved portion of the gullet adjoining the tooth front. It appeared to reach this position initially by a movement from the cutting edge down the front of the tooth. The sawdust tended to follow the curved bottom of the gullet as far as its junction with the back of the preceding tooth, but before reaching this position the material was usually whirled back against the tooth front by the motion of the saw. The movement of the sawdust in the gullets was very turbulent."

The shape of the gullet as well as its absolute volume has been found to be important. The most critical point is that the gullet should be smoothly curved to prevent cracks due to fatigue failure and to allow smooth flow of the sawdust. This latter feature is given special prominence in certain saw designs.

This concludes the discussion on the effect of tooth shape on the efficiency of saws. In Part III of this series the influence of tooth pitch on cutting efficiency will be studied.

Professional Staff for Wood Industries and Research in Australia

AUSTRALIAN wood-using industries requiring staff with professional qualifications in wood utilization and other forest products subjects have, in common with Government bodies carrying out research in forest products, been hampered in the past by the lack of any specialized training course along these lines. The only way open to the research bodies has been to take people trained in engineering, forestry, or some other branch of science, and supplement that training either in their own laboratories or by sending them overseas. The staff trained in this way then provided the only pool on which industry could call, obviously at the expense of research organizations.

It is of considerable interest, therefore, to note that the Australian Forestry School, at Canberra, is now in a position to enrol students for a Diploma in Forest Technology. The course is divided into two classes, to cater for both undergraduate and graduate students, and is adaptable to the specialization desires of the individual student. As the name implies, it is not limited to the field of forest products but is planned also for students who might wish to specialize in subjects such as forest engineering, forest pathology, or forest entomology, rather than to take a full course in forestry. In the forest products field advanced specialized training will be given in forest utilization, wood technology, and minor forest products.

The significance of the course is that not only does it provide for the first time advanced specialized training in these subjects, but it combines this with a background training in silviculture, forest management, and forest policy.

Individual students interested in a course of this nature, or industrial organizations interested in sponsoring staff men to receive the training, should write for full particulars to The Principal, Australian Forestry School, Canberra, A.C.T.

NEW PUBLICATION

TESTING TIMBER FOR MOISTURE CONTENT

TRADE CIRCULAR No. 50, "Testing Timber for Moisture Content", supersedes Trade Circular No. 45. Copies are available from the Division of Forest Products, C.S.I.R.O., 69-77 Yarra Bank Road, South Melbourne, S.C.4. (*Note*: Trade Circular No. 49 has not yet been issued.)

Forest Products Education in U.S.A.

By E. L. ELLWOOD, Timber Preservation Section

IN the United States a large range in standards and effectiveness of education exists in comparison with, perhaps, the more uniform type of educational system pertaining throughout British Commonwealth countries. There is, therefore, a certain danger in attempting to generalize on a topic such as forest products education.

There are at present in the United States some 25 forestry schools which have been accredited by the American Society of Foresters and the majority of these schools treat forest products with varying degrees of intensity. In addition, there are centres of learning in which aspects of forest products education are carried out which do not properly come under the term forestry school. Examples of these are the Institute of Paper Chemistry at Appleton, Wisconsin, and the Massachusetts Institute of Technology. As far as education of the trade is concerned, special courses in particular aspects of forest products are run from time to time by various government and private laboratories, for example, the United States (Federal) Forest Products Laboratory at Madison, and Timber Engineering Co. at Washington, D.C. Scholarships for specialized short-term training courses are also a feature of these trade-level laboratory training programmes. On the practical level particular mention must also be made of the American Forest Products Research Society which, by means of its regional and national meetings and publications resulting from these, disseminates in easily digestible form the latest developments in the field of forest products to both the trade man and the researcher. This organization too performs much valuable work behind the scenes by the formation of subcommittees to promote and develop various aspects of forest products (one of these being education).

University Education

University training occupies the pre-eminent position in forest products education. In most cases the universities have close association with the trade and in many cases take on project research for companies and associations on a fee or grant basis. Also, while the majority of universities are run by government funds, there are some that are privately endowed or depend for their support largely upon the industry or profession. These factors have an influence on the educational policy.

The university year is normally divided into two working semesters (terms) and a summer semester during which most undergraduate activities close down. The work load of the student (particularly in the case of the undergraduate) is based upon the American "credit" hour. To complete a degree a student must obtain satisfactory grades on subjects amounting to a certain minimum number of credit hours. One credit hour is generally considered to be equivalent to three hours' study, but here again a large variation exists in practice. The various subjects are rated according to their credit hours and the credit hours carried by the undergraduate student amount to approximately 17 per week.

The student is encouraged to participate in extracurricular activities and most schools possess an active forestry club which may sponsor talks, debates, or forums on subjects of general or particular forestry interest.

It is also worthy of note that a few of the leading schools are almost international in the character of their student body, particularly at the graduate level. At Yale, for example, there were no less than seven different countries represented in 1952.

One feature of the system is that, besides a proportion of scholarship aid, self-help is very common and many students are able to support themselves by working. In many instances the work is provided at the school in the field of the student's interest in the form of contract research projects from industry or government organizations.

In comparison again with the British Commonwealth type of education system, the American student does not in general enter university as well founded in the particular field he intends to study. This is compensated for by a greater spread of learning in the primary education. This is continued to some extent in undergraduate courses, where a percentage of elective subjects which may not be related to the field is taken. There is also sometimes less academic freedom than exists here and the pace is less leisurely than pertains in Australian universities.

Undergraduate Training

The normal undergraduate course leading to a B.Sc. or B.S.F. is of four years' duration, with at least one long vacation under supervised field work. Students must satisfy admittance requirements and then spend their first two years primarily studying basic sciences, together with chosen elective courses, which may or may not be related to their main field of study. In the last two years studies centre chiefly around the technology or professional side of the field.

The degree of specialization varies considerably. In some schools only a modicum of forest products study is incorporated with general forestry subjects, in others a separate syllabus is provided for forest products and little or no general forestry is studied. As an example of diversified forest products education the New York State College of Forestry provides four separate programmes, as follows:

Forest Utilization A. Conversion and distribution of lumber and related products. Emphasis is placed on logging, lumbering, manufacture of finished products of wood, and the national and international marketing of them.

Forest Utilization B. Retail merchandising and light construction. Emphasis is placed on selling of lumber and other wood products handled by a retail yard, and materials, economics, and methods of residential and other frame construction.

Wood Technology. Emphasis is placed on the anatomy and technical nature of wood through a study of its cells and its physical and chemical properties.

Pulp and Paper Manufacture. Emphasis is placed on the sciences and engineering basic to the technology of present-day pulp, paper, and related industries.

Courses such as these stem from industrial requirements and economic pressure within the industry resulting from competition within the industry and competition from other industries. There also is a degree of healthy rivalry between the various universities which has a considerable effect on the types of education offered.

The evolution of forest products education has been marked by a tendency towards greater specialization. More time is being given to the technologies in an attempt to satisfy immediate trade requirements for the particular field and, further, to give the student at least some acquaintance with the growing mass of technology in other related fields.

It is considered by some American educators that the B.S. degree does not train the student sufficiently for specialized work, and attempts to remedy this within the structure of a B.S. course tend to put the education on a trade-school rather than a professional level. While this criticism may be valid for some schools it is equally erroneous when applied to others, but overall there appears to be a trend away from the trade-school level.

Graduate Training

Not all schools teaching forest products provide graduate education, while some schools offer graduate education only, e.g. Duke University (N.C.) and Yale University (Conn.). In all, 16 universities offer a master's degree which is obtained in one or two years after completion of the undergraduate course. There is no uniformity of requirements for this degree and it may be taken by study of a wide range of subjects, or by thesis, or study in a narrow field with emphasis on research. In graduate education, although quite an amount of formal lecturing is given, the use of seminars (discussion groups), round table conferences, and project reporting are widespread, the student having to rely more on his own resources than previously. In general, the master's degree is not considered a research degree, but rather it indicates a more intensive study of the particular field.

The doctorate degree is the highest given in American universities and is a research degree occupying three or more years of graduate study. Six universities offer this degree in forest products to selected candidates, but the number of candidates is comparatively small. Again, a proportion of formal lecturing persists, the aim being to completely round out the student in all phases of forest products, and to pursue further subjects of special interest before intensive specialized work is commenced.

Examinations are a feature of the system and constitute a series of hurdles before thesis projects can be commenced. A high degree of flexibility exists in the system and students are under the individual guidance of one or more selected professors who help plan the students' programme of study and criticize their work.

The doctorate of philosophy as awarded by the university specifies that the type of work carried out for this degree must be of fundamental nature, but it is apparent that there is some variation in the interpretation of "fundamental". At Yale the distinction between fundamental and applied work is made by the award of two alternative doctorate degrees—doctorate of forestry (awarded by the forestry school) for applied work, and doctorate of philosophy (awarded by the university) for fundamental work.

Employment

There appears to be an increasing need for the professional forest products worker in American industry as the technology and developmental side of the wood industry becomes more competitive and complex year by year. Industry is employing more men trained in forest products than ever before although, overall, the intake is yet relatively small when compared with other professions. The majority of graduates at the B.S. or M.S. level enter private industry on such work as process or product control, technical sales, or developmental work. According to one survey there is as yet relatively little demand in industry for the highly trained man (Ph.D. level) in product and process research. The majority of men at this level are distributed between teaching, or research in government, private, or trade association laboratories, and in these latter positions training to the level of Ph.D. is generally mandatory.

Although to the knowledge of the author no collective statistics are available on the types of employment, it may be of interest to Australians to study the position of all forestry and forest products graduates from Yale Forestry School. These are as follows:

24%	Government
16%	State and Municipal
44%	Private
16%	Teaching

In the above figures the forest products graduate constitutes the minority, and some adjustment of the percentages would probably result if this group were considered alone.

Overall, there has been a real attempt in American forest products education to come to grips with problems confronting the industry. At the same time, the leading educators are fully alive to the necessity for preserving professional integrity by a proper balance between fundamental and applied research and training.

KING WILLIAM PINE

Name

King William pine is the standard trade common name for the species known botanically as *Athrotaxis selaginoides* D. Don. This species is the only timber representative in the southern hemisphere of the order Taxodiaceae, of which family the best known species in the northern hemisphere is Californian redwood (*Sequoia sempervirens*). The timber of King William pine is very similar in structure and properties to redwood.

Habit and Distribution

This species is found in Tasmania only, being confined chiefly to the western part of the island at higher elevations, 1700-3000 ft. The tree attains a maximum height of 100 ft and a girth breast height of over 12 ft; the average milling tree has a girth breast height of 6-10 ft and a merchantable bole of 20-40 ft.

Timber

The timber is light pink to yellowish pink in colour, pale red when freshly cut but fading on drying. The grain is straight and the texture fine and relatively uniform; growth rings are prominent and the bands of late wood are fairly conspicuous. The timber is light in weight, having an average density of 25.0 lb/cu.ft. when dried to 12 per cent. moisture content. The density range in which 95 per cent. of the material at this moisture content can be expected to fall is 19.2-33.4 lb/cu.ft.

Seasoning

The timber is easy to season and in drying from the green condition to 12 per cent. moisture content, the mean shrinkage figures are 3.8 (tangential) and 1.8 (radial) before reconditioning, and 3.5 (tangential) and 1.4 (radial) after reconditioning.

General

Longitudinal shrinkage in this species may be high owing to the presence of compression wood. This reaction wood is not easy to detect in the timber, but any material with dense bands of late wood extending practically throughout the growth ring should be eliminated when selecting for specialty purposes. Strength properties are normal for the weight of the timber except that it is lower than would be expected in modulus of elasticity. It has been shown to be a very good bending timber, and it has a high reputation for durability.

Uses

This species finds its greatest use in joinery, for doors, window frames, etc. It is used occasionally for the manufacture of oars and sculls, more recently for pattern making, for bent work, drawing boards, wood pipes, vats, slats for Venetian blinds, and sounding boards in violins and pianos. King William pine is suitable for the manufacture of separators but only for stationary batteries to be used for home lighting, radios, etc., where there is no vibration, as its resistance to abrasion is rather low when immersed in sulphuric acid. Suitable clear material is now very difficult to obtain.

Availability

Supplies of the timber are fairly scarce, owing partly to its inaccessibility. However, it is possible to obtain material in a range of boards and manufacturing sizes in short and medium lengths.

Further information on this timber can be obtained from the Chief, Division of Forest Products, 69-77 Yarra Bank Road, South Melbourne, Vic., or from the Commissioner of Forests, Forestry Department, Hobart, Tas.

This Newsletter is prepared for general circulation by the Division of Forest Products, C.S.I.R.O., 69-77 Yarra Bank Road, South Melbourne, S.C.4, and will be supplied free on request to members of the timber trade and timber users who wish to keep abreast with current developments in the field of forest products.

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Centrifugal and Pulsation Drying

Overseas Developments in the Design of Timber Driers

By J. W. GOTTSTEIN and W. G. KAUMAN, Timber Seasoning Section

IN THE SEARCH for methods of getting quicker, better, and/or cheaper drying, research workers and engineers have examined or developed an appreciable number of specialized driers or drying methods in recent years. Such practices as solvent seasoning, vapour drying, chemical seasoning, high-frequency drying, high-temperature drying, vacuum drying, and others have been referred to from time to time and have aroused considerable trade interest. In recent months some publicity, particularly in overseas journals, has also been given to drying by means of centrifuges and by pulsating air flow, or a combination of both. These two methods will be discussed in this article.

Apart from the physical and mechanical characteristics of the timber itself, there are two factors of very considerable importance in timber drying. These are:

- The problem of transferring heat energy to the timber.
- The problem of transfusion of moisture from the inner layers of timber to the surface where evaporation can occur.

In the field of orthodox kiln drying (that is, drying by use of circulating air at controlled temperature and humidity) the problems associated with the first of these factors are fairly complex. If wood always provided a free evaporating surface, then for any set of psychrometric conditions (especially wet-bulb depression) the actual rate of evaporation from the wood surface would be proportional to the air speed. Unfortunately, this free evaporating condition lasts for only a limited time even in the drying of softwood veneers.

In a timber stack, the timber surfaces resting on the strips form a number of small, rectangular ducts. As the air proceeding through the stack passes through these ducts, we find that at low air speeds the temperature and relative humidity of the air vary considerably from the middle of the duct to the timber surface, the variation becoming greater towards the outlet side of the stack. This effect is caused by a sluggish layer of air near the wood surface tending to produce a barrier to the free transfer of heat and moisture. This barrier is known technically as the "boundary layer". It is present whether or not the surface is evaporating freely, but as the evaporation rate from the surface diminishes with continued drying, the relative importance of this boundary layer as it affects the drying rate becomes less and less.

Increased air velocity increases turbulence in the ducts between the timber surfaces and this reduces the thickness of the boundary layer and improves the heat transfer. From time to time consideration has been given to methods of reducing the importance of this layer, but until recently the most practical way of improving heat and moisture transfer at the wood surface has been by increasing the air speed through the ducts. The choice of the actual air speed to be used is, of course, determined by the drying requirements of the particular timber species and its thickness and moisture content as well as by considerations of fan power consumption.

About 1930, several German workers became interested in the possibilities of improving energy transfer through the boundary layer and moisture movement through the drying material by applying a pulsating pressure change to the circulating air. This work was carried out on viscose synthetic sponges and the results were published in German journals in 1934 and 1935 by Messrs. Kiesskalt, Kroell, and Schwartzkopff. In these papers, which are very well presented, the conclusion was drawn that improvement in drying rate was associated with the effect of change in pressure which, by causing air flow in and out of the pores of the material being dried, gave an effective decrease in drying time of up to some 30 per cent. In addition, some improvement of energy transfer through the boundary layer also occurred. The pressure change used was provided by pumping arrangements, and the change in pressure (due to the pulsations) was such that special wall design was necessary to provide adequate reinforcement and avoid structural breakdown. It is perhaps significant that nothing has been heard of any application of this particular process to the drying of timber since those early publications, although at least one of the authors has been associated with a German firm producing timber-drying equipment.

Efforts have also been made at various times to extract moisture from wood by centrifuging. When a stack of timber is placed on a suitably designed turn-table and rotated, centrifugal forces are present which tend to remove free moisture from the timber. In addition the timber stack if suitably designed can act as a crude fan.

In 1927 a patent was granted in the U.S.A. for a rotating dry kiln, but none of this type appears to be in use now. The American kiln expert, H. D. Tiemann, conducted some experiments on centrifugal drying in the 1930s and came to the conclusion that it was futile to attempt to dry timber by centrifugal force alone, except to remove free water from pervious softwoods. Some time later an engineer named Kastmark, in Sweden, designed centrifuges carrying timber stacks and these are being operated on a commercial scale in conjunction with ordinary kilns in a Swedish timber-yard. The principal species dried are Scots pine and spruce. The centrifuge is claimed to have some advantage in shortening kiln-drying times by obviating the necessity to evaporate at least portion of the free water, especially in those cases where considerable water absorption has occurred during log flotation periods.

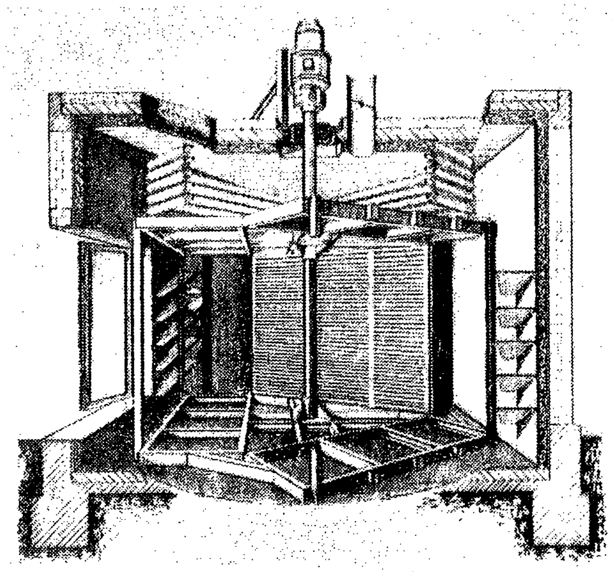

Fig. 1.—Cut away drawing showing a recent design for a three-stack combined centrifugal and pressure pulsation drier.

Kastmark states that the process is of little benefit for drying heartwood or for drying out hygroscopic moisture below the fibre saturation point. It is also understood that the process is of more benefit for the pine than the spruce, the latter normally being of lower moisture content. During centrifuging the drying air is largely rotating with the stack and considerable moisture content variation develops within the length of the drying boards.

In recent years another German firm has entered the field of centrifugal drying for timber and is now producing drying units employing combined centrifugal and pressure pulsation effects. In this design, the drying air is prevented from rotating with the turntable but is passed over heating coils and recirculated through the timber stack by means of a spiral arrangement of baffles. Pressure pulsations are produced during rotation by a system of screens surrounding the turn-table. These screens alternately obstruct and allow tangential escape of air from the timber stack. In addition, this firm supplies an internal-fan cross-circulation unit (condensation type) in which devices for rapid pressure pulsation have been provided. It is claimed that the centrifuge design reduces drying times by about 50 per cent. and the cross-circulation kiln with superimposed pressure variations by about 30 per cent. compared with ordinary air-circulation kilns. Results published by the manufacturer show a uniform distribution of moisture in boards dried in the centrifuge as well as good seasoning quality. The firm has made rather spectacular claims for the process, which has also received some attention in technical journals. Unfortunately, available publications do not present sufficiently detailed information to provide a basis for effective comparison with more orthodox drying units.

Figures 1-3 show some recent designs of centrifugal and pulsation driers published in current (1952-53) European technical journals.

F. Fessel, a German engineer, has examined these recent centrifugal driers and claims that the boundary layer (which the circulating air forms on the surface of the wood) is thrown off by the force resulting from centrifuging. It seems improbable, however, that centrifuging alone will produce this effect. The claim is also made that pulsation of the air flow in the centrifugal drier results in destruction of the boundary layer. That something is possible in this direction was shown by the very much earlier work of Kiesskalt and others referred to above. However, actual pressure changes involved in the more recent design are of a relatively very small order since special pumping equipment is not provided. No data are presented in the available publications to show the influence of the magnitude of pressure variation or of pulsation rate on energy transfer in the boundary layer or on moisture transfusion in the wood.

In the earlier Kiesskalt work on viscose synthetic sponges, results of a detailed investigation were given in which pressure magnitude, pulsation rate, and temperature had been varied independently. These results made it clear that the pulsations were most effective in reducing the drying time when the pores in the surface of the material became emptied as free evaporation ceased to take place. A fairly marked pressure change at a frequency of about 70 cycles per minute was necessary to get maximum improvement. The newer design, using a very small pressure change at a much higher frequency, is not in accordance with the earlier findings, but since the structure of wood is of a very different nature from that of sponges it is again impossible to make an effective comparison on available information.

It is not possible at present, therefore, to estimate the potential importance of this pulsating effect, which may vary for different species. Centrifuging may be of some value in removing free water from permeable timbers but cannot of itself be effective for species of low permeability or for material below fibre saturation point. Combined pulsation and centrifuging have been stated in overseas reports to be of advantage in reduc-

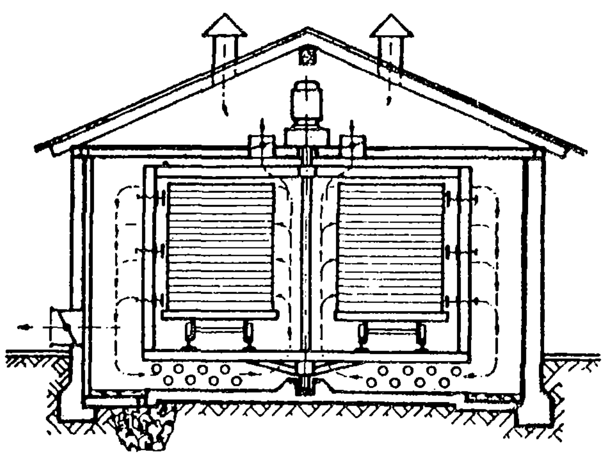

Fig. 2.—Cross-sectional view of a two-stack combined centrifugal and pressure pulsation drier.

ing drying times, but lack of detailed information again makes it impossible to judge at present how effective this process can be for different timbers.

The mechanical difficulties of any centrifugal method are, of course, quite obvious. If centrifuging is to be used, great care must be taken to ensure uniformity of the timber stacks as regards size and weight. Furthermore, the size of boards to be included in stacks must be at least approximately standardized. Special clamping devices must be used to keep the stack in position and to compensate for shrinkage during drying.

An estimate of the full quantitative effect of pulsation and centrifuging and their economic possibilities would require extensive investigation and careful analysis. Even assuming that the pulsation process has special merit for timber drying, recently published reports indicate that design considerations are still very much in a state of flux. At this stage we should be cautious, therefore, when considering the installation of such equipment in preference to orthodox internal-fan cross-circulation driers.

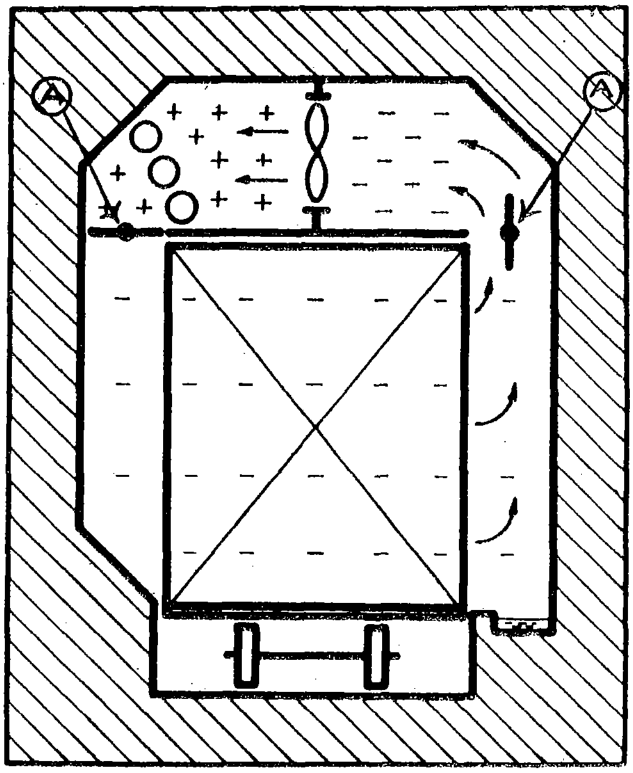

Fig. 3.—Cross-section of a cross-circulation kiln with provision for pressure pulsation. A, *rotating baffles used to produce the pressure pulsations.*

Overseas Visitors to Division of Forest Products

DURING RECENT YEARS the Division has played an active part in training Fellows working in Australia under the Colombo Plan and the United Nations Technical Assistance scheme. At present there are two such visitors with the Division: Dr. M. B. Rahman, of the Pakistan Forest Research Institute, and Mr. D. R. Bayly, of the Sarawak Forest Service. Dr. Rahman's main interests are those of a forest chemist, and Mr. Bayly's those of a forest utilization officer.

Mr. J. F. Behrens, of the U.S.A., is a final-year student of the College of Forestry, University of Washington, who is majoring in forest products and in order to widen his experience is spending the latter half of this year with the Division, where he is filling a staff position in a temporary capacity. Before returning to the United States, Mr. Behrens intends to visit plywood plants in New South Wales and Queensland, this being the work in which his main interests lie.

Mr. D. W. Frankcombe, of Tasmania, is a member of the staff of the Marketing Office of the Tasmanian Forestry Commission and is spending several months with the Division in order to gain experience in timber seasoning and timber preservation. On his return to Tasmania Mr. Frankcombe will include amongst his duties those of a liaison officer with the Division of Forest Products.

Division of Forest Products Staff Notes

TWO SENIOR MEMBERS of the staff, Mr. C. S. Elliot and Dr. H. E. Dadswell, have been appointed as Assistant Chiefs of Division.

MR. ELLIOT, who was formerly Officer-in-Charge of the Timber Seasoning Section, has been engaged on administrative work for some years and will continue these duties.

DR. DADSWELL, who will continue as Officer-in-Charge of the Wood and Fibre Structure Section in addition to his extra-Sectional duties, returned to Australia in August after attending the Eighth International Congress of Botany, which was held in Paris. Dr. Dadswell acted as Rapporteur to a subsection devoted to wood anatomy and also attended a meeting of the International Association of Wood Anatomists, of which he has been Secretary-Treasurer for the past seven years. While overseas he made various official calls in Europe and the United Kingdom and attended a symposium on recent advances in the chemistry and industrial uses of cellulose held at St. Andrews, Scotland.

MR. ALAN GORDON, Officer-in-Charge of the Veneer and Gluing Section of the Division of Forest Products, leaves in September to take up an appointment with New Zealand Forest Products Ltd. Mr. Gordon will be Manager of the Timber Treatments Division supervising seasoning and preservation plants and in addition will be required to provide technical assistance in all fields of timber utilization, having particular regard to forward marketing aspects. He will be stationed at Tokoroa.

Mr. Gordon has been on the staff of the Division since 1938, and his wide knowledge of timber utilization in general as well as his specific knowledge of the plywood industry is recognized throughout the Australian timber industry. For the past twelve months he has made an important contribution by his outstanding work as Executive Officer of the Wooden Case Research Committee.

Furniture Design Competition

IN ORDER to promote the use of New South Wales timbers in furniture manufacture and also to improve the standard of furniture design, the Forestry Commission of New South Wales has just launched a design competition which it is hoping to make an annual event. The first prize is £100, and the second prize is £25.

Full details of the conditions of entry, as well as entry forms, are available from the Division of Wood Technology, Forestry Commission of New South Wales, 96 Harrington Street, Sydney.

Designs must be for articles of furniture predominantly or entirely constructed of wood, and the timber or timbers which are to be specified should be available in commercial quantities from New South Wales forests. Details of these timbers may be obtained from the Division of Wood Technology.

Entries will be accepted from all parts of Australia, from individuals or groups of designers but not from manufacturers as such. An entry shall consist of a set of working drawings and one perspective sketch, in black and white only. There will be no restriction on the number of entries that may be submitted by each designer, but an entry fee of 5*s*. must accompany each entry. Designs shall remain the property of the designer.

From the entries received, the judging panel will first select the best 10 entries. Prototypes of these will then be constructed, and determination of first and second prizes will be made on these prototypes, which will be placed on public exhibition when judging has been completed. Prototypes will be the property of the New South Wales Forestry Commission, but their designers shall have first option to purchase at cost.

Entries will close on December 31, 1954.

<< Content

Sawing — In Quest of Efficiency Part III

By D. S. JONES, Utilization Section

Influence of Tooth Pitch on Cutting Efficiency

THE DISTANCE from tip to tip between the teeth of saws has much more influence on power requirements than is generally realized. The effect of the number of teeth on circular saws on cutting efficiency has been closely studied by a number of overseas laboratories and there is unanimous agreement that a power economy is effected by decreasing the number of teeth.

In the tests on circular plate ripsaws conducted at the Forest Products Research Laboratories, Princes Risborough, the power required for both cutting and feeding decreased as the number of teeth on the saw was reduced below its conventional value. This effect continued until the teeth became overloaded, and then the power increased again. For example, when the number of teeth on a saw which normally carried 80 teeth was reduced to 32, the saving in power at 10,000 ft/min rim speed, 80 ft/min feed speed, and 2 in. depth of cut was 19 per cent. When the feed speed was 40 ft/min the percentage saving over the power required for 80 teeth was 25 per cent. If the number of teeth was only reduced from 80 to 60, the saving in power was only 8 per cent. at 80 ft/min feed speed and 10 per cent. at 40 ft/min feed speed. In short, as long as the teeth were not overloaded, a decrease in the number of teeth effected a power saving and the percentage saving over the power required for the conventional number of teeth was greater at the slower feed speed.

The results obtained in the Princes Risborough laboratory were summarized in tables, and the table representing the percentage power savings at 10,000 ft/min rim speed, 40 ft/min feed speed, and 2 in. depth of cut is reproduced below. This table presents a very clear picture of the effect of reducing the number of teeth on circular saws.

Percentage Saving in Power Obtained by Using Fewer Teeth

Alternative lower number of teeth	80	72	66	60	54	46	40	32
72	4							
~~40~~ 66	7	3						
~~32~~ 60	10	6	3					
~~66~~ 54	14	10	7	4				
~~60~~ 46	18	15	12	8	5			
~~46~~ 40	21	18	15	12	9	4		
~~54~~ 32	25	22	20	17	13	9	5	
20	32	29	27	24	21	17	14	9

Number of teeth on saw

The study at Princes Risborough was pursued even further, 26-in. diameter saws with as few as 4, 8, 12, and 16 teeth being tested. The same trend in power saving held as long as the feed speeds were slow enough for the teeth not to be overloaded. These saws were not considered of any practical value because of the low feed speeds necessary and the poor quality of the sawn surface.

The "Handbook of Woodcutting" by Harris of the Princes Risborough Laboratory states that the tooth pitch of frame saws should usually be larger for softwoods than for hardwoods. Suitable values of tooth pitch for various frame-saw types are given and the recommendation for heavy vertical frame saws cutting hardwood logs is ¾ in. for spring-set teeth and 1 in. for swage-set teeth. Harris writes that for circular ripsawing of softwoods and the milder hardwoods 46 to 54 teeth are suitable, irrespective of diameter, provided the rim speed is of the order of 10,000 ft/min. He considers that it is advisable to increase the number of teeth to 60 or 66 when cutting the denser seasoned hardwoods so that the impact force on each tooth is reduced. When sawing abrasive timbers scraping and rubbing of the teeth should be avoided and a large pitch is therefore essential. Harris states that saws for this work should have no more than 40 teeth. Peg-toothed cross-cut saws should have 90 teeth for general work and 110 teeth if required only for hardwoods.

Referring to Harris's recommendation to increase the number of teeth on a circular ripsaw when cutting the harder species to reduce the force on each tooth, the following facts should be kept in mind. If the size of the teeth is correspondingly reduced with the increase in the number of teeth, then although the force on each tooth is smaller, the cross-sectional area resisting that force is also smaller and the maximum stress in the tooth remains practically the same. Hence the advantage of increasing the number of teeth is gained only if this is done without reducing the size of each tooth.

Workers in Moscow found that with a decrease in the number of teeth on circular ripsaws the cutting power, feeding power, and feeding force decreased. The saws tested were 600 mm (24 in.) diameter and had 72, 66, 56, and 46 teeth. The cutting power decreased in the ratio 1 : 0.92 : 0.89 : 0.83. Hence there was a power saving of 17 per cent. when the number of teeth was reduced from 72 to 46. No appreciable change in cutting quality was detected for the 72-, 66-, and 56-tooth saws, but there was a definite reduction in quality with the 46-tooth saw.

Scientific workers in Archangel, Russia, obtained the advantages of a reduced number of teeth and at the same time were able to retain the cutting quality of the larger number of teeth. This was achieved by merely grinding down the tips of the unwanted teeth 1.5-2 mm (0.059-0.079 in.) instead of removing the whole teeth. Both the shortened teeth and the cutting teeth were set in the same manner. These shortened teeth were said to clean the surface of the cut.

It is considered that a clean cutting action is much more efficient than a scraping and rubbing action. There are so many teeth on the conventional circular saw that each tooth can do no more than rub and scrape the wood. A reduction in the number of teeth allows each tooth to make a positive cut and this fact alone must account for some of the improvement in efficiency. It has also been established that saw teeth lose their keenness much more rapidly if they do not make a clean cut, and therefore too many teeth on a saw will cause premature blunting.

It is interesting to note that as the number of teeth on a saw is reduced the noise made by the saw, both running free and cutting, is reduced. In the Princes Risborough tests it was found that the 20-tooth saw operated at a much lower noise level than the 80-tooth saw. The saw with only four teeth ran so quietly when not cutting that it was considered it could be dangerous to an operator.

A reduction in the number of teeth on a saw necessitates careful preparation of the teeth. There are fewer teeth to do the work and therefore each tooth must do its share accurately and efficiently. This requirement, however, should not act as a deterrent to the adoption of a reduced number of teeth.

This discussion of the effect of tooth pitch on cutting efficiency will be continued in Part IV of this series.

SOUTHERN SASSAFRAS

SOUTHERN SASSAFRAS is the standard trade common name for the timber from trees known botanically as *Atherosperma moschatum* Labill. The tree usually has an upright trunk and symmetrical form. The bark is aromatic, containing a resin and an essential oil.

Habit and Distribution

Southern sassafras is found in Tasmania, Victoria, and south-eastern New South Wales in areas where the rainfall exceeds 40 in. per annum. It usually occurs in creek beds and gullies but in areas with higher rainfall it extends up the slopes. Only in Tasmania, where it sometimes grows to heights of 80 ft and butt diameters of 2 ft 6 in., are the trees extensively exploited for timber production. In Victoria and New South Wales the trees are usually smaller and heights seldom exceed 50 ft.

Timber

The wood is light in colour, generally almost white but sometimes pale grey to light brown. The truewood is sometimes black, and then boards may have "tiger cat" figure. Its texture is fine and uniform and the grain is usually straight. The wood is soft and is light to medium in density, ranging from 30 to 41 lb/cu.ft. and averaging 36 lb/cu.ft. when dried to 12 per cent. moisture content.

Seasoning

It is easy to season, and during drying from the green condition to 12 per cent. moisture content the timber shrinks approximately 6 per cent. on backsawn and 2.5 per cent. on quartersawn faces.

General

This species is readily manufactured to a good finish by hand and machine tools. Practically no sanding is required after dressing. It polishes excellently, requiring little filler, and can be stained to practically any desired colour. The uniform texture of the wood makes it very satisfactory for turnery.

Uses

On account of its comparatively limited availability, chiefly in smaller sizes, the utilization of southern sassafras is practically confined to purposes for which it is naturally well adapted. The very low tannin content of the wood makes it particularly suitable for clothes-pegs and for brush work, especially brushes in which the bristles are attached to the back or handle with metal and which are used in a wet condition as are scrubbing, nail, and kalsomine brushes. It makes a satisfactory bobbin of the larger and heavier type. In the shoe industry it is used, but not exclusively, for shoe heels over 2 in. in height. It is employed in the wooden toy industry on account of its lightness and ability to take a smooth finish, being used for children's building blocks and platforms for toys on wheels. Cask bungs and various types of small ornaments are turned from this timber. It is satisfactory for carving, mouldings, and panelling, and is used for the production of veneers and plywood.

Inquiries regarding specific uses of this timber should be addressed to forestry authorities in each State or to the Chief, Division of Forest Products, 69-77 Yarra Bank Road, South Melbourne, S.C.4.

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Forest Products Newsletter

1954##199

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Sawing — In Quest of Efficiency Part IV

By D. S. JONES, *Utilization Section*

THERE are two factors which limit the extent to which the number of teeth on a saw can be reduced. Firstly, the teeth must not be overloaded at the highest feed speed used, and secondly, the quality of the cut surface must be acceptable. The problem of overloading of spring-set ripsaw teeth has been studied at the Forest Products Research Laboratory, Princes Risborough, and is mentioned by Harris of that laboratory in his publication, "Circular Saws", and also in the Forest Products Research Bulletin No. 27. A spring-set ripsaw tooth is likely to become overloaded immediately it cuts so deeply that there is contact on its inner face.

The approach of this condition can be determined for a particular tooth only when the shape and size of the tooth, the tooth pitch, saw speed, and feed speed are known. However, work done at Princes Risborough suggests that the teeth of circular-plate spring-set ripsaws having a plate thickness of about 1/10 in. become overloaded when the tooth bite reaches about 0.04 in. in medium hardwoods and about 0.05 in. in softwoods. To give the sawmiller some idea of the tooth bite taken out by his saws, the tooth bite of a 44-in. spring-set saw with 72 teeth running at 10,000 ft/min rim speed and 50 ft/min feed speed is 0.016 in. If the teeth were swage-set this bite would be halved. The above calculation is made assuming the timber is fed at mid height between the saw spindle and the top of the saw, which gives a good average value of tooth bite. If the timber is cut lower on the saw the tooth bite is larger, and if it is cut higher the tooth bite is smaller.

Starting from this one value of tooth bite the sawmiller can calculate the tooth bite at mid height for a circular saw of any diameter with any number of teeth and operating at any speed. All that needs to be understood is that if the diameter or feed speed is increased the tooth bite is *increased* proportionately, but if the number of teeth or rim speed is increased the tooth bite is *decreased* proportionately.

For example, if the rim speed of the above circular saw became 7000 ft/min the tooth bite would increase to 0.016 × 10,000/7000

= 0.023 in. If the feed speed at 10,000 ft/min were 100 ft/min the tooth bite would increase to 0.016 × 100/50 = 0.032 in. At 10,000 ft/min rim speed and 50 ft/min feed speed a 44-in. saw with only 20 teeth would have a bite of 0.016 × 72/20 = 0.058 in. The tooth bite of a 60-in. 72-tooth saw at these speeds would be 0.016 × 60/44 = 0.022 in. A 60-in. spring-set saw with 92 teeth running at 9000 ft/min rim speed and 80 ft/min feed speed would have a tooth bite which is given by 0.016 × 60/44 × 72/92 × 10,000/9000 × 80/50 = 0.030 in. If the saw were swage-set the tooth bite would be 0.015 in.

According to the Princes Risborough suggestion, if the spring-set saw were cutting hardwood the tooth bite could safely be increased to 0.04 in., so that the number of teeth could be *reduced* to 92 × 0.03/0.04 = 69, that is, to the nearest convenient number of teeth to 69. Alternatively, the number of teeth on the saw could remain the same and the feed speed be *increased* to 80 × 0.04/0.03 = 110 ft/min. The choice between these two alternatives might be made as follows. If the feed speed is mechanical and is fixed at 80 ft/min, a saving in cutting power at this feed speed can be obtained by reducing the number of teeth to about 69. If the feed speed is not fixed and there is ample power, the number of teeth could remain the same and the feed speed could be increased to about 110 ft/min, thus increasing the production rate.

Using the Princes Risborough values of 0.04 in. for hardwoods and 0.05 in. for softwoods as rough guides to the probable maximum tooth bite allowable on spring-set ripsaws, the sawmiller can study the effect of a variation of tooth number on his saws at existing or proposed speeds. The writer suggests that the same values be taken as guides when swage-set circular ripsaws are considered. While it is felt that the tooth pitch of frame saws and bandsaws could probably be increased with advantage, the work done on these saws is too limited for any recommendation to be made here. Much work needs to be done to determine allowable tooth loads for all types of saw.

In Part V of this series, the second factor limiting the extent to which the number of teeth on a saw can be reduced will be discussed.

OVERSEAS VISIT

Mr. D. S. Jones, of the Utilization Section, sailed for London on the *Strathnaver* on September 18. On arrival in London, he will depart immediately for Stockholm, Sweden, where he will study sawing and sawmilling research techniques for nine months at the Swedish Forest Products Research Laboratory. At the conclusion of this period of study, Mr. Jones will visit similar laboratories on the Continent and at Princes Risborough, England. It is possible that he will return to Australia through the United States of America and Canada where he will observe sawing research methods used in those countries.

Mr. Jones now has the responsibility for the sawing and sawmilling research programme of this Laboratory, and on his return intensive investigations will be commenced by the Division of Forest Products to solve the many problems involved in sawing Australian timbers.

COLLAPSE IN TIMBER

Kiln operators seasoning collapse-susceptible timbers should beware of over-drying kiln charges before reconditioning in a mistaken belief that they thus compensate for moisture regained during reconditioning, and so avoid the cost of redrying. This is a false economy and results only in poor or negligible recovery from collapse. Tests have shown that by reconditioning at 15 per cent., recovery from collapse is about twice that obtained at 11 per cent.

An Automatic Waste Docking Saw

By M. W. Page, Utilization Section

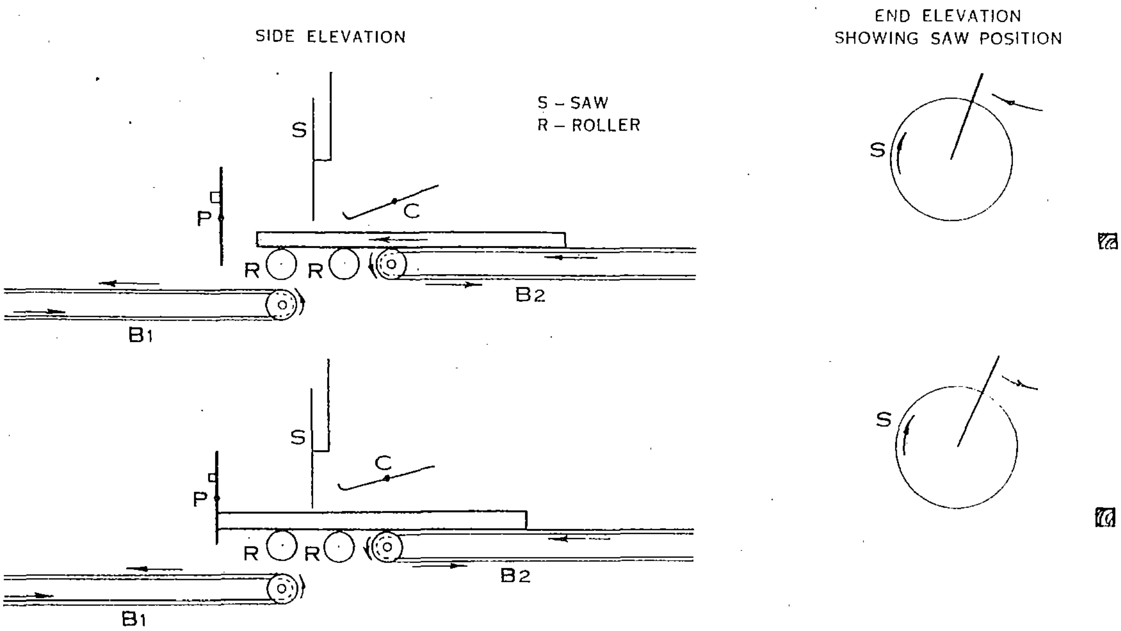
As devices for automatically reducing sawmill waste to convenient lengths either for feeding direct to incinerators or for sale as household fuel are desired in many sawmills, it has been decided to publish details of an automatic docking saw designed and built several years ago by Mr. Hector Ingram, a sawmiller of West Tyers, Vic.

The essentials and operation of this machine are as indicated in Figures 1-5:

B2, an intermittently driven feed belt.
C, a moving spring-loaded clamp-plate that holds down timber of any shape while the saw is cutting.
P, a swinging stop plate against which the piece to be cut off is butted.
R, a firm base for timber at the sawline.
S, a continuously operating pendulum-type circular docking saw.
B1, a continuously running discharge belt.

In addition, means (an overload relay and/or a master switch beside the nearest man) are provided for stopping belts and saw instantly in event of a seizure.

Items *B2, C,* and *P* are controlled by means of wheels and cranks actuated by movements of the saw pendulum, and they can be adjusted for variation in saw diameter.



Figs. 1 and 2.—The piece to be docked is carried by the feed belt until the end overhangs and butts against the stop plate P *located about 1 ft past the sawline.*

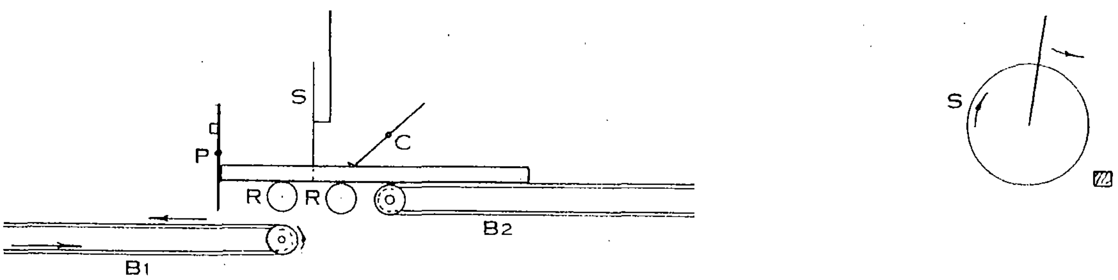


Fig. 3.—As the saw approaches the piece, the feed belt stops and the clamping plate C *moves down under spring pressure to hold the piece firmly against the now stationary feed belt.*

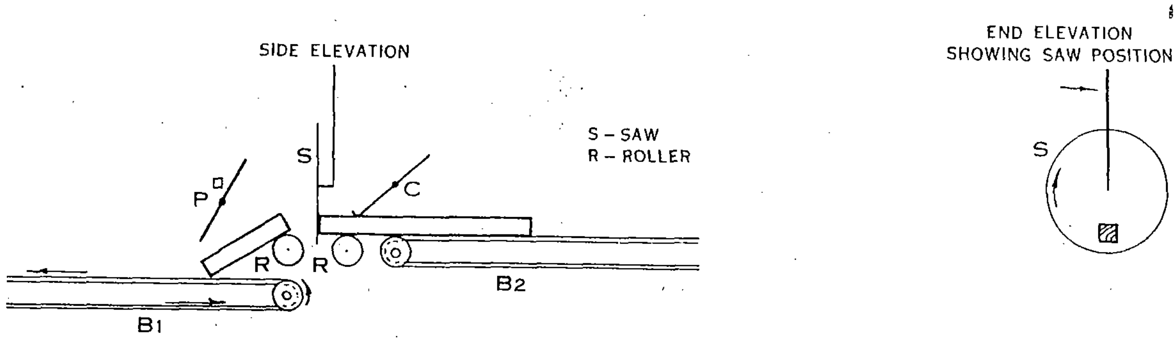


Fig. 4.—Immediately the saw has cut right through the piece, the stop plate P *swings back slightly to allow the docked piece to fall on to the continuously running discharge belt* B1 *located slightly lower than the feed belt* B2. *Meanwhile the saw continues to move down about another* $\frac{3}{4}$ *in.*

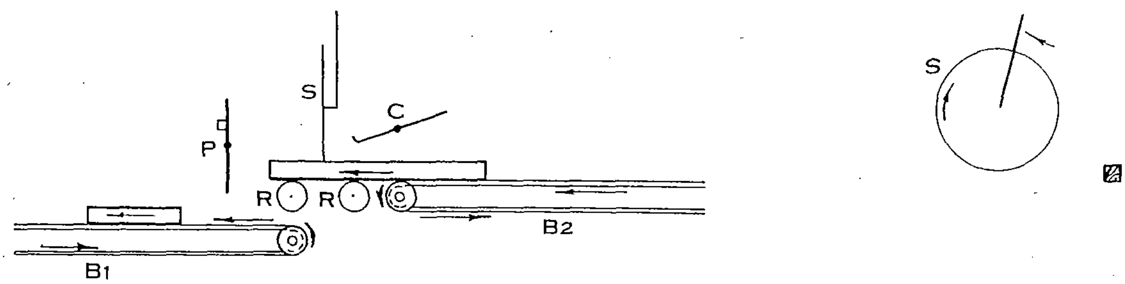


Fig. 5.—The stop plate P *then returns to its original position. When the saw has moved back out of the way, the clamping plate* C *is raised and the feed belt starts again.*

Donations

Officers of the Division have been encouraged by the donations which we have received from industry. These donations have been made in appreciation of the help which we have been able to give toward improved design and methods in industry. In the last financial year a total of about £1600 was received in this way and this was a valuable contribution to our work.

In expressing our appreciation, we are hopeful that our limited funds will be supplemented in this way again during the current year to enable us to continue to give service in this important branch of our work. Donations already received this financial year until the end of August include the following:

Broken Hill Associated Smelters Pty. Ltd.	£150	0	0
Mr. W. Ogden, Daylesford	£5	5	0
Burwood Timber Mills Pty. Ltd.	£3	19	0
Hogg & Co. Ltd., Dunedin, New Zealand	£2	2	0

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Forest Products Newsletter

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NUMBER 200 MELBOURNE NOVEMBER 1954

Pulp and Paper from Tropical Woods

By *A. J. WATSON, Wood Chemistry Section*

SINCE the 1860s, when wood was first used for the manufacture of pulp and paper, most of the world's supply of paper products has been derived from the great forests of softwood timber in the northern hemisphere. In recent years, the shortage of suitable softwoods in some localities has led to the utilization of the hardwoods for paper manufacture. These moves have derived considerable impetus from the development of the Australian pulp and paper industry based on our eucalypt timbers. These native hardwoods were at one time considered quite unsuitable for paper manufacture by those whose experience was limited to the conventional papermaking species. Still more recently, the increased demand for paper has directed attention to the one large area of timber supplies as yet largely untapped, the forest lands of the equatorial belt.

The equatorial forests, unlike those of the temperate zone which frequently consist of almost pure stands of a single species or a number of closely related species, usually contain a wide diversity of timber types. This, in turn, has posed many new problems and considerable investigational work is required before the problem relating to the pulping of tropical woods can be solved.

The Division of Forest Products, in co-operation with the Department of Territories, has been investigating the pulping and paper-making properties of a number of New Guinea woods. These have been selected from timbers of the mangrove areas, certain of the rain forest species, and the genus *Araucaria*, of which the hoop and klinki pines are found in the New Guinea highlands. These pines are of particular interest because they are soft-woods growing in the predominantly hard-wood forests of New Guinea. Their most striking feature is the length of their fibres, which are frequently over 0.35 in. in contrast to the hardwood fibres of about 0.04 in. The hoop and klinki pine fibres are long even by comparison with those of the northern hemi-sphere softwoods, which have fibre lengths of 0.1-0.2 in. The fibre length has an important bearing on the tearing strength of a paper. long fibres giving papers with a high resis-tance to tearing.

Investigations have shown that pulps made from hoop pine and klinki pine by the sul-phate process give paper with very high tear-ing strength, considerably higher than that of papers made from the northern hemisphere softwoods, which are noted for their high tearing strength. Other strength properties of papers made from hoop and klinki pines are comparable to those from the conventional papermaking species. Hoop pine and klinki pine are so similar in their pulping and paper-making characteristics that, from a pulping viewpoint, they can be treated as a single species.

Instead of making papers wholly from the *Araucaria* pulp, it may be mixed with hard-wood pulps produced either from New Guinea hardwoods or from Australian eucalypts. Hardwood pulps, owing largely to their short fibres, give papers with rather low tearing strengths, but this may be rectified by the addition of some long-fibred pulp when making the paper. *Araucaria* pulp has been found to be superior to the long-fibred pulps normally used for this purpose. The *Araucaria* spp. are at present being used for the production of plywood in New Guinea. This industry requires large clean logs and there is a certain amount of undersize and low-grade wood which would be suitable for pulping and which at present is waste material. There should be good prospects for a pulping industry, based on this waste material and the thinnings from plantations at present being established, to produce a high-grade pulp with good strength properties.

The mangroves which have been examined can be regarded as possible future sources of pulp and paper. Their successful utilization will require the development of methods of timber extraction from mangrove swamps which are now being opened up to supply mangrove bark for tanning extract. These forests and even more so the rain forests contain a great variety of timber but it has been found that quite diverse types may be pulped by the sulphate process under identical conditions, thus reducing the culling of un-suitable species. The pulps from these species vary in their properties but the combined pulps would probably yield paper similar in properties to those obtained from hardwood species pulped in Australia and elsewhere.

Preliminary investigations have also shown that some of the light-coloured low-density timbers might yield a groundwood pulp suit-able for conversion to newsprint. The suc-cessful utilization of these fast-growing tropi-cal woods for groundwood production would be a welcome addition to the world's supply of newsprint.

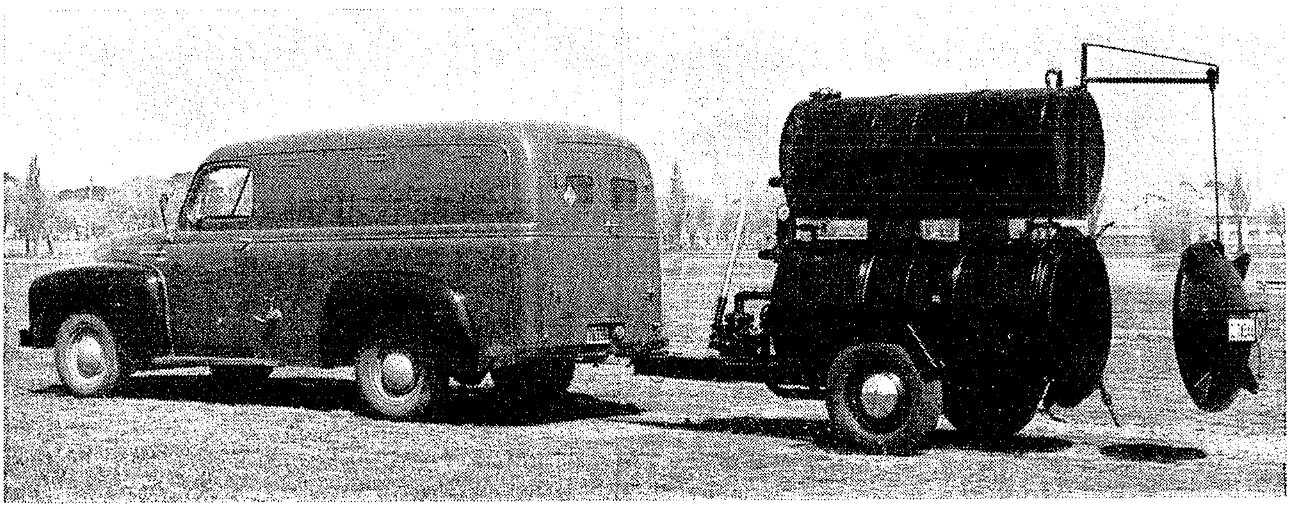
Portable Treating Plant for Fence Posts

By P. J. MOGLIA, Preservation Section

For many years, the Division of Forest Products has been advocating preservative treatments for non-durable timbers, especially where these are intended for use where the decay and/or termite hazard is high. It is well known that the sapwood, in particular, of most timbers is very susceptible to decay, irrespective of whether the heartwood is classed as durable or non-durable. However, it has been demonstrated in tests carried out both by this Division and by other organizations overseas that even sapwood, when properly treated, can be made as durable as the heartwood of our best timbers. It is a fact also that whereas the heartwood of most Australian timbers can be treated satisfactorily only in expensive high-pressure (1000 lb/sq. in.) plants, the sapwood can be treated very simply.

To meet the rising cost and growing scarcity of durable timber for fence posts, this Division recommends the use of treated small round posts of approximately 3 in. to 5 in. diameter. Provided that the sapwood is intact and is given a thorough treatment with a reliable preservative, such as creosote or 5 per cent. pentachlorphenol in oil, a round post may be expected to last as long as one split from the most durable timber.

In a C.S.I.R.O. Leaflet to be issued shortly, the Division will advocate the use of three methods of fence-post treatment, viz.—hot and cold bath, prolonged cold soaking, and low-pressure soaking. The last method is a variation of the cold soak whereby the process is greatly accelerated by the use of pressures up to 10 lb/sq. in. To demonstrate the last two treatment methods, a portable plant suitable for treating up to 50 round posts at one time has been designed and constructed.



Portable treating plant showing door suspension.

A cylinder 3 ft in diameter and 6 ft long is mounted horizontally on a trailer chassis. It is designed for pressures up to 10 lb/sq. in., at which pressure the sapwood of most species treats readily, and is fitted with a quick-sealing door at one end. Directly above is a smaller tank of lighter construction which holds enough preservative to fill the cylinder when the full charge of posts is in place. A high-capacity hand pump is provided which is used to fill the upper tank from drums or for emptying the cylinder.

In low-pressure treatments, the need for a motor-driven pump for applying the pressure is avoided by installing a 44-gal drum high up on a windmill stand or in a tree. A ½-in. plastic hose 30 ft long is provided to connect this drum to the cylinder. Provision is made for filling the drum by use of the hand pump.

With a 20-ft head, satisfactory treatment can be given to the sapwood of most eucalypts in 24 hr or less, for the greater part of which the plant can be left unattended. Rounds of *Pinus radiata* (which make excellent posts) may be treated by soaking without pressure, but with low pressures treatment can be given in a few hours.

At present the plant is being thoroughly tested in the field, after which it will be available for demonstration to interested parties. Application should be made to the Chief, Division of Forest Products, from whom information on all aspects of fence-post treatment may be obtained.

MOISTURE CONTENT

A MOISTURE METER with standard short blades can often be used to get an approximation of moisture content at the centre of stock 2 in. or 3 in. thick by first driving two spaced nails into the core and resting the hammer blades on the nail heads, the meter then being operated in the usual way. Remember, however, that the nail spacing must be the same as the hammer blade spacing, the nails should be spaced across the grain and not along it, and a correction of −1½ *per cent.* should be made before making the species correction.

STEAM LEAKS

How much steam are you losing from steam leaks around your kiln?

A simple approximate rule for estimating steam flow through a given opening is, "to the steam gauge pressure in lb/sq. in. add 15 (this gives the approximate absolute pressure). Multiply this value by the area of the opening in sq. in. and divide by 70 in." For example, the steam lost from a ⅛-in. diameter hole, with steam at 50 lb/sq. in. gauge pressure, approximates 40 lb of steam per hour—equivalent to a little more than one boiler horse power.

Sawing — In Quest of Efficiency Part V

By D. S. JONES, Utilization Section

As the number of teeth on a saw is reduced the quality of the cut surface deteriorates, so although it is advantageous to decrease the number of teeth as much as possible consistent with reasonable tooth loads, this reduction must be undertaken with due regard to the quality of cut produced. With cross-cut saws particularly, it is necessary to have sufficient teeth to prevent roughness and splintering, and the power consumption of these saws is usually of secondary importance to obtaining a clean cut.

It was shown in Part I of this series that an increase of hook angle also has an adverse effect on cutting quality, and the combined effects of increasing hook angle and increasing tooth pitch may produce an intolerably rough surface. If a bad cutting quality prohibits the full adoption of both these measures, a choice between them needs to be made on the grounds of their relative desirability. This choice might be based on the following facts. An increase in the hook angle on the teeth of a saw will decrease the power required to run the saw, but at the same time the teeth will tend to be weakened and the quality of the cut surface will deteriorate. A decrease in the number of teeth on a saw will decrease the power required to run the saw, will allow the teeth to be strengthened, and will increase the life of the teeth by securing a more efficient cutting action, but the cutting quality will be adversely affected. If the unwanted teeth are shortened rather than eliminated, a much better sawn surface might result. It appears that reducing the number of cutting teeth would normally be preferred to increasing the hook angle.

In Part I of this series, it was suggested that the sawmiller might experiment on old saws until he finds the hook angle that gives at the same time the easiest cutting and a satisfactory sawn surface. If he desires to test the additional effect of a tooth reduction, he could use two old saws which had been ground to the best hook angle, cut off every second tooth on one, and grind down the tips of every second tooth about 0.06-0.08 in. on the other. The shortened teeth are set the same as the cutting teeth. Sawing trials would then indicate cutting efficiency and sawn surface quality and these results, together with tooth bite calculations, would assist the sawmiller to decide if one or both of the saws were satisfactory or if a further modification of hook angle or tooth number needed to be made.

It is hoped that the Division of Forest Products will eventually be able to specify values of these variables suited to Australian conditions. Laboratory experiments supplemented by full-scale sawmill trials will secure the necessary information.

In Part VI of this series a brief outline of the theory underlying the phenomena associated with decreasing the number of teeth on a saw will be given.

DONATIONS

APART from contributions towards co-operative work, the following donations from industry were received by the Division of Forest Products during September:

A.S.E.A. Electric Pty. Ltd., Melbourne	£10 10 0
R. G. Williams & Co., Melbourne (builders of McCashney Incinerators)	£50 0 0
W. Phelan & Sons Pty. Ltd., Maryborough, Vic.	£50 0 0

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SUPERHEATED STEAM SEASONING

Equilibrium Moisture Content and Drying Control

By W. G. KAUMAN, Seasoning Section

THE quest for rapid yet safe and economical seasoning methods has led European designers to evolve a number of high-temperature drying kilns since the end of the 1939-45 war. These kilns operate at temperatures from about 180 to about 260°F (usually above 212°F) with the drying medium either pure steam or a mixture of steam and air. They are generally referred to as "high-temperature" or "superheated-steam" kilns.

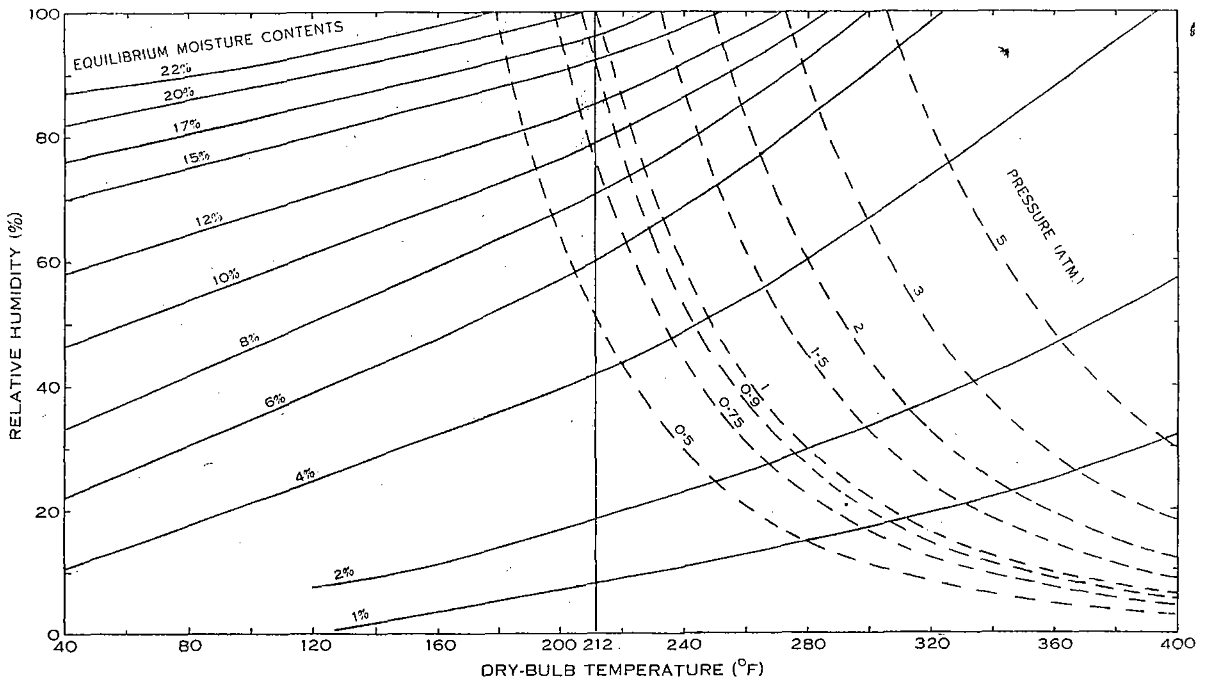
Although this process is often presented as a revolutionary innovation, it does not involve any new scientific principles and is by no means a fresh development. Superheated steam is simply steam heated above 212°F, and is no different in nature from the unsaturated water vapour atmosphere used in kiln drying below 212°F or in air drying. As early as 1912 "superheated-steam" kilns were in operation on the west coast of the United States of America; they were, however, subject to heavy corrosion and the steam demand was very high because circulation was obtained by steam jets. They were superseded by the then developing internal-fan kilns.

In latest high-temperature kilns internal fans are used for circulation.

E.M.C. in Superheated Steam and Steam-air Mixtures

Pure steam at 212°F and normal atmospheric pressure is saturated, the relative humidity being 100 per cent. Pure steam heated above 212°F with pressure kept at atmospheric is "superheated" and is unsaturated. It may, therefore, be said to have a "relative humidity" less than 100 per cent.; for instance, at 250°F "relative humidity" is 50 per cent. It was shown experimentally by M. Grumach (1950), formerly of this Division, that wood exposed to pure superheated steam attains definite equilibrium moisture contents (E.M.C.s). For instance, superheating to 215°F gives a wood E.M.C. of 15 per cent. whereas at 244°F the E.M.C. is 5 per cent. Other workers obtained similar results.

In superheated steam-air mixtures, relative humidities and E.M.C.s are even lower than the values in pure superheated steam, the latter being the maximum that can be attained



E.M.C. chart covering temperature range to 400°F.
(Copies of this chart may be obtained on application to the Chief, Division of Forest Products, C.S.I.R.O., 69-77 Yarra Bank Road, South Melbourne, S.C.4, Vic.)

at any given temperature and atmospheric pressure. If the pressure is reduced (keeping temperature and composition of the drying atmosphere constant), the relative humidity and E.M.C. decrease. If it is raised, they increase.

The diagram shows a conventional E.M.C. chart which has been extrapolated to a dry-bulb temperature of 400°F. The intersections of the dotted curves on the right-hand side of the chart with the abscissae and E.M.C. curves give the maximum relative humidity and maximum E.M.C. for any dry-bulb temperature at various pressures.

It is interesting to note that the curve for 0.9 atmosphere corresponds to conditions about 3000 ft above sea-level, and the curve for 0.75 atmosphere approximates to conditions on the summit of Mt. Kosciusko (7300 ft). The altitude of a plant would thus have a considerable influence on the E.M.C. conditions. The E.M.C. in pure superheated steam at 215°F, for instance, would be about 17 per cent. at sea-level, 12 per cent. at 3000 ft. and 8 per cent. on Mt. Kosciusko.

Drying Control

Conditions in a superheated steam kiln are controlled by dry- and wet-bulb thermometers. In pure superheated steam, the wet-bulb temperature (at atmospheric pressure) is always 212°F, whereas in a superheated steam-air mixture the wet-bulb temperature is lower than 212°F. The wet-bulb temperature of a superheated steam-air atmosphere can be measured without difficulty with appropriate instrumentation.

A frequently-used procedure for kiln operation is to heat the timber to 212°F in a saturated atmosphere. This steam atmosphere is then superheated at atmospheric pressure to a temperature designed to give the appropriate E.M.C. After a predetermined time, the vents are opened to admit some air and thus lower the E.M.C. without increasing the temperature. After an additional period the heaters are switched off and drying is finished by using the heat stored in the timber.

Even with the theoretical knowledge now available, the process is far from being a universal solution for all drying problems. Although the seasoning of certain softwoods can be accelerated very considerably, the risk of poor moisture distribution and severe stresses in the dried timber is thereby increased, so that for drying to "joinery quality" an appropriate final conditioning treatment is essential. Hardwoods usually degrade severely, although some species may be amenable after preliminary air drying. Manufacturers of superheated steam kilns often claim completely automatic operation, but this would be possible only for uniform material. The process would, therefore, appear to have specialized application, and its value would have to be carefully assessed for every individual case.

Sawing — In Quest of Efficiency Part VI

By D. S. JONES, Utilization Section

THE last few articles of this series have discussed the influence of tooth pitch on cutting efficiency. It is felt that before this discussion is concluded the sawmiller will be interested to read an account of the fundamental principles underlying the economy effected by an increase in tooth pitch. These principles have been clearly detailed by L. H. Reineke of the U.S. Forest Products Laboratory in his article, "Sawteeth in Action", and by the French Institut National du Bois in their Brochure Technique No. 9 (September 1952). In simple terms the argument proceeds as follows.

The work done in cutting with a saw can be divided into five elements:

(1) The work required to sever the wood fibres.

(2) The work required to shear the severed chips from the sides of the kerf.

(3) The work required to break the chips into small pieces.

(4) The work required to remove this broken material (sawdust) from the kerf.

(5) Friction.

The work required in one revolution of the saw to sever the wood fibres depends upon the aggregate distance travelled in cutting by all the teeth during one revolution. This aggregate distance can be altered only by altering the number of teeth on the saw, and the severing work per revolution therefore depends only on the number of teeth. If the number of teeth is reduced, the severing work is reduced. The work required per revolution to shear the chips from the kerf and to break up and remove the sheared material depends upon the amount of material removed in one revolution of the saw. This can be altered only by changing the feed speed, hence work elements (2), (3), and (4) depend only upon the feed speed. If the feed speed is reduced, this work is reduced. It should be noted that the work required per revolution to sever the fibres depends on the aggregate distance travelled by the teeth only to a first approximation. For example, the speed at which the teeth cut the fibres may have some effect on the work done. Similarly, other minor variables probably influence the work elements (2), (3), and (4), but these influences can be considered here as comparatively minute. Friction will be neglected in this discussion.

Now, if the number of teeth on a saw is reduced and all other conditions including feed speed remain the same, the amount of material removed remains the same and the work done in one revolution of the saw to shear, break up, and remove the chips is the same. But the aggregate distance travelled by the teeth is reduced and hence the work done in severing the fibres is reduced. There is, therefore, a decrease in the total work done in one revolution of the saw and for the same saw speed there would be a decrease in the power required to run the saw. If the feed speed is also reduced, the work to shear, break up, and remove the chips is reduced and there is an additional decrease in the work done in one revolution of the saw. This is manifested in an additional power saving. Thus it is seen that the experimental results can be adequately explained by theoretical considerations.

Influence of Tooth Set on Cutting Efficiency — Amount of Set

C. J. Telford, of the U.S. Forest Products Laboratory, Madison, Wis., established that cutting torque varied directly with kerf width provided there was adequate clearance between the wood and the body of the saw. Hence, at the same saw speed the power varied directly with kerf width. There are two reasons, therefore, why the kerf width of saws should be kept to a minimum, firstly to minimize power requirements, and secondly to reduce waste. Hence, for any given blade thickness the set should be kept to a minimum consistent with free running of the saw.

The Russian investigators (Kayukova and Konyukhov) sought to determine the best set for circular saws. Using 24-in. diameter saws 0.102 in. thick (12 gauge approx.) they found, for the two softwood species sawn, that a set of 0.5 mm (0.019 in.) on each side gave the least cutting power and feeding power. For smaller sets the power was higher because of increased friction between the saw and the sawn surface, while for larger sets friction was decreased but the volume of wood cut was so much greater that power was increased. Saws of the same diameter but of different gauge were tested and the best set remained the same. When the moisture content of the sawn timber increased from 18 to 30 per cent. there was a decrease in the power required, but the best set was still about 0.019 in. It was found also that the quality of the cut decreased when the set was increased, the quality being worse with large swage-sets than with large spring-sets. Spring-sets of up to 1.0 mm (0.039 in.) on each side gave good surfaces, while swage-sets of 0.75 mm (0.029 in.) or more did not always give a good-quality product. This was because the tips tended to break off and score the surface when swaged more than 0.75 mm on each side. The definition of a "good-quality product" was one that was suitable for export. The surface was probably much better than our sawmills would be expected to produce in a normal mill run.

In the "Handbook of Woodcutting" Harris maintains that the amount of set "should be slightly greater for soft, woolly or gummy timbers than for ordinary hardwoods". He considers that for vertical frame saws a suitable average value is 0.015 in. on either side, but under some circumstances more set may be necessary. For circular-plate ripsaws two formulae are given from which the correct set is to be calculated. They are:

$$S = 0.1t + 0.0002D$$

for hardwoods and

$$S = 0.15t + 0.0002D$$

for softwoods, where S = set (in.), t = thickness of sawplate (in.), and D = diameter of saw (in.). Calculating from these formulae, the set for a 24-in. saw 0.102 in. thick is 0.015 in. on each side for hardwoods and 0.020 in. for softwoods. The value obtained for softwoods is almost identical with the best set determined by the Russians who cut softwood species. It will be noticed, however, that these formulae provide more set for heavier gauges, whereas Russian experiments indicated that there was a best set for circular saws irrespective of the gauge.

Harris's recommendation for pendulum cross-cut saws is 0.02-0.03 in. on each side, depending on saw diameter and timber species. A set of 0.01-0.02 in. is recommended for wide bandsaws cutting softwoods, and 0.008-0.012 in. for hardwoods.

Saw doctors rarely have reliable data to specify the best set for their particular sawing conditions. They often resort to some arbitrary method of gauging the set and apply that value to all the conditions they meet in the mill. The Division of Forest Products hopes to investigate this problem in its sawing research programme, but in the meantime the above information extracted from the reports of work done overseas may assist the saw doctor or sawmiller to make a little more than a guess at the necessary value of set.

DONATIONS

The following donations were received by the Division during October:

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